MELISSA

Contract Number: ESTEC/CONTRACT: 15671/01/NL/ND

Technical Note: 72.4

Control System Demonstrator Data Package

Version: 1

Issue: 1



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NTE Document Number:	MEL-3100-D0-043-NTE
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Document Change Log

Version	Issue	Date	Observations
1	0	23/04/04	New document
1	1	28/07/04	Editorial changes



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1 SCOPE

This document contains the Control System Demonstrator data package as defined in the WP 3300 of the MELISSA, Adaptation for Space, Phase 1 Statement of Work [A1].

The Control System Demonstrator implements the new Control System Architecture defined in the earlier phases of this contract for the specific cases of MELISSA's compartments III and IVa.

This document corresponds to the Technical Note # 72.4 defined in [A1]

2 APPLICABLE DOCUMENTS

- [A1] MELISSA. Adaptation for Space, Phase 1. Statement of Work.TOS-MCT/2000/2977/ln/CL. Issue 5. April 2001.
- [A2] MELISSA. Adaptation for Space-Phase 1. Proposal issued by NTE. MEL-0000-OF-001-NTE. Issue 2. October 2001.

3 DATA PACKAGE ORGANIZATION AND CONTENTS

The Control System Demonstrator data package is organised following the work package structure defined in [A1]. It is divided in the following four volumes:

- VOLUME I: Test Plan and Procedure, as per WP 3310
- VOLUME II: Hardware Set-up and Documentation, as per WP 3320
- VOLUME III: Test Performance, as per WP 3330
- VOLUME IV: Test Results Evaluation, as per WP 3340

The data package contents is summarised in Figure 1.

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Figure 1: Data Package Organisation

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4 VOLUME I

This volume contains the Test Plan and Procedures used to verify and validate the Control System Demonstrator implementation.

4.1 Volume Ia

Tests are carried out in two stages. First, System tests performed at NTE's premises over the Control System Demonstrator using ancillary hardware to simulate the interfaces with the plant's sensors and actuators. The purpose of this test is to validate the HW and SW implementation before releasing the Demonstrator for its installation and connection to the Plant. Plan and Procedure are documented in the:

Control System Demonstrator System Test Plan and Procedure, ref. MEL-3310-PL-024-NTE.

4.2 Volume Ib

Following the System Tests whose results are evaluated in the corresponding Test Review sessions the Demonstrator is brought to the MELISSA Plant in the UAB's premises and connected with the bioreactors for compartments III and IVa. The demonstrator is subject to some functional tests for its operational validation in the Plant. These tests are compiled in the:

Control System Demonstrator Test Plan and Procedure, ref. MEL-3310-PL-039-NTE.

5 VOLUME II

This volume contains all the documentation related to the design of the Demonstrator.

5.1 Volume IIa

The HW design, providing details on the mechanical design and configuration of the Demonstrator's racks as well a complete description of the electrical design is compiled in the:

Control System Demonstrator Hardware Design Document, ref. MEL-3320-RP-020-NTE.

5.2 Volume IIb

The SW design, consisting of the Supervision SW, the local control SW implemented in the PLCs and the specific SW of the local touchscreen is described in

Control System Demonstrator Software Design Document, ref. MEL-3320-RP-025-NTE.

5.3 Volume IIc

Operation guidelines for the Demonstrator's users, addressing also some troubleshooting and maintenance issues are provided in

Control System Demonstrator Operations Manual, ref. MEL-3320-HB-042-NTE.

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5.4 Volume IId

Finally the following drawings are also included:

Electrical Schematics, Rack III, ref. MEL-3320-DR-034-NTE Electrical Connections, Rack III, ref. MEL-3320-DR-037-NTE Mechanical Design, Rack III, ref. MEL-3320-DR-035-NTE

Electrical Schematics, Rack IV, ref. MEL-3320-DR-027-NTE Electrical Connections, Rack IV, ref. MEL-3320-DR-038-NTE Mechanical Design, Rack IV, ref. MEL-3320-DR-036-NTE

6 VOLUME III

This volume contains the reporting corresponding to the System tests performed at NTE. It basically consists of the electronic transcription of the "as run noted procedures". The report is compiled in:

Control System Demonstrator System Test Report, ref. MEL-3330-RP-030-NTE.

7 VOLUME IV

This volume contains the reporting of the test results obtained after the tests performed on the Control System Demonstrator once connected to the MELISSA Plant. These results, have been validated by Sherpa Engineering (former ADERSA), for what concerns the system outputs in relation to the compartments III and IVa control laws. Test incidences are explained and finally conclusions on the Demonstrator performance are also stated. This is compiled in:

Control System DemonstratorFunctional Test Results and Evaluation, ref. MEL-3340-RP-040-NTE.

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MELISSA

Contract Number: ESTEC/CONTRACT: 15671/01/NL/ND

Technical Note: 72.4 VOLUME I-a

Control System Demonstrator System Test Plan and Procedure

Version: 1

Issue: 1



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NTE Document Number:	MEL-3310-PL-024-NTE
Written by:	Jordi Duatis
Revised by:	Joan Mas
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Approved by:	Joan Mas



Version	Issue	Date	Observations
Draft	0	26 Feb'03	Created
		24 Sept'03	Fixed value ranges and typos after procedures
			execution.
			Added TP to check initial values and sensor /
			actuator link errors.
			Added MEL-CIV-TC-0404 to check over
			temperature alarm action.
			Added MEL-CIV-TP-07 to check initial values
			Added MEL-CIV-TP-08 to check errors on
			current analogue signal inputs
	1	01 Oct'03	Added MEL-CIV-TP-09 to check operational
			modes.
	2	11 Nov'03	Added CIII Test Procedures.
	3	03 Feb'04	Updated after TIR CIII_7 resolution.
	4	05 March'04	Reviewed
1	0	19 April '04	First release (for ESA review)
1	1	28 July '04	Includes ESA comments dated 21/07/04

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1 SCOPE

This document contains the System Test Plan and Procedure for the MELISSA Control System Demonstrator developed by NTE. The System Tests procedures herein defined are to be conducted over the Demonstrator hardware at NTE's facilities. In this case the Control System Demonstrator interfaces with the MELISSA plant's sensors and actuators are simulated with auxiliary test equipment.

This Test Plan and Procedure is part of Technical Note 72.4.

The MELISSA Control System Demonstrator object of the tests comprises the software and hardware necessary to perform the control of the Compartment III and Compartment IVa. The Demonstrator implements the same functionality as the previously existing Control System but following the requirements and guidelines specified in [R1] and [R2]. The Demonstrator's architecture is shown in Figure 1.

The MELISSA Control System can be broken down into the following subsystems:

- Local control: implementing the low-level control loops.
- Master Control: implementing the global loop Control Laws.
- Supervision: allowing the configuration and monitoring of system status, and alarm reporting
- Human Machine Interface (HMI): allowing the supervision of system status from the same plant.

Functional tests to be conducted at the UAB's premises, once the Demonstrator is connected to the MELISSA plant, are compiled in the Control System Demonstrator Test Plan and Procedures [R7].

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Figure 1: Control System Demonstrator architecture

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<u>2.1 Applicable documents</u>

- [A1] MELISSA. Adaptation for Space, Phase 1. Statement of Work. TOS-MCT/2000/2977/ln/CL. Issue 5. April 2001.
- [A2] MELISSA. Adaptation for Space-Phase 1. Proposal issued by NTE. MEL-0000-OF-001-NTE. Issue 2. October 2001.

2.2 Reference Documents

- [R1] MEL-3100-SP-010-NTE, Definition of the control requirements for the MELISSA Loop. TN 72.2, v.1.2, November 2002.
- [R2] MEL-3200-RP-014-NTE, MELISSA Control System Architecture and Trade-off. TN 72.3, v. 1.0, February 2003.
- [R3] Nitrifying Compartment Studies. TN 25.310. UAB, September 1996.
- [R4] Set-up of the Photosynthetic Pilot Reactor. TN. 37.2. UAB, April 1998.
- [R5] MEL-3320-RP-020-NTE, Control System Demonstrator Hardware Design Document, TN 72.4 Volume IIa, v. 1.1, July 2004
- [R6] MEL-3320-RP-025-NTE, Control System Demonstrator Software Design Document, TN 72.4 Volume IIb, v. 1.1, July 2004
- [R7] MEL-3310-PL-039-NTE, Control System Demonstrator Test Plan and Procedure, TN 72.4 Volume Ib, v.1.1 July 2004
- [R8] MEL-3330-RP-030-NTE, Control System Demonstrator System Test Report, TN 72.4 Volume III, v. 1.1, July 2004
- [R9] MEL-3320-HB-042-NTE, Control System Demonstrator Operations Manual, TN 72.4 Volume IIc, v. 1.1, July 2004

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3 ACRONYMS LIST

AC	Alternate Current
APS	Adjustable Power Supply
DC	Direct Current
DW	Dry wheight
FG	Function Generator
GND	Ground
HDD	Hardware Design Document
HMI	Human Machine Interface
MM	MultiMeter
OSC	Oscilloscope
PLC	Programmable Logic Controller
SDD	Software Design Document
TC	Test Case
TP	Test Procedure
UAB	Universitat Autònoma de Barcelona
V&V	Validation and Verification

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4 SYSTEM TEST PLAN

4.1 Introduction

The objective of this Test Plan is to validate and verify that the functionality described in the MELISSA Control System Demonstrator Hardware Design Document (HDD) and MELISSA Control System Demonstrator Software Design Document (SDD) is implemented as defined. That is, hardware elements exist, are placed and interconnected as specified in the HDD and control actions are performed as defined, and can be supervised from the Supervision as stated in the SDD.

The system is developed in two phases. First, the software and hardware corresponding to the Compartment IVa is developed, integrated and deployed, followed by Compartment III. Due to this sequence of events, System Tests are also planned two phases. First, tests for Compartment IV will be conducted followed by tests on Compartment III.

The baseline for defining the present test plan and procedure is:

- HDD: MELISSA Test Control System Hardware Design Document
- **SDD**: MELISSA Test Control System Software Design Document
- **CIII and CIV Rack**: Racks of Compartments III and IVa, which allocate PLC controllers and electronics to interface with sensors and actuators and for power distribution.
- **CIII and CIV Local Control**: PLC software for Local Control of Compartments III and IVa.
- **Master Control**: Control Laws software for the Master Control of Compartments III and IVa (Running in the Supervision Server).
- **Supervision Software**: Supervision Software for the Supervision of Compartments III and IVa (Supervision engine runs in the Supervision Server, Supervision displays run in the Supervision client).
- **HMI**: Human Machine Interface software running in the Magelis display for the compartments CIII and CIVa.

The System Test of the Compartments III and IVa will consist of:

- 1. Identification that all modules defined in the HDD are properly implemented for the CIII and CIV Racks.
- 2. Verification that all connections among electrical elements inside the Racks are performed according to the HDD.
- 3. Verification of the system functions following the process described in this plan.

All tests defined here in are to be conducted at NTE's premises.

4.2 Items under Test

- CIV Rack: verify integration, and mechanical and electrical interfaces
- CIII Rack: verify integration, and mechanical and electrical interfaces
- Local Control: verify control actions are performed as specified.
- Master Control: verify control actions are performed as specified.
- **Supervision Software** : verify control actions can be monitored from the Supervision Software as specified.

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HMI: Verify that control actions can be supervised for the HMI as specified.

4.3 Features to be tested

- Internal Electrical interfaces between the Rack elements.
- Electrical isolation.
- Hardware and software development, integration and deployment performed according to the HDD and SDD.
- Software Interfaces between:
 - CIV PLC and the Supervision Server.
 - CIV PLC and the HMI
 - CIII PLC and the Supervision Server
 - CIII PLC and the HMI

4.4 Features not to be tested

Control algorithms, algorithm parameters and alarms are taken directly from the current control system and therefore their effectiveness is not verified.

Performance, stress and non-nominal conditions (out of the alarm conditions specified in the SDD) are not verified.

4.5 Approach

The HDD defines the implementation of the electrical and mechanical interfaces internal to the CIII and CIV Racks. From this document, a set of procedures is developed to verify that all elements specified in the HDD are implemented in the corresponding racks. In addition, procedures are added to verify electrical interfaces between the different elements placed in the rack and electrical isolation with respect to ground (GND).

The SDD defines the functionality of the Local Control algorithms, the Master Control algorithms and the Supervision and HMI displays. A set of procedures is developed to verify that this functionality is implemented as defined from a functional test approach.

4.6 Item pass/fail criteria

Test items will pass the System Test if the test procedures expected outputs were achieved.

4.7 Suspension criteria and resumption requirements

System test verification campaign will be suspended either if no compliance to specifications or critical errors/problems that avoid to progress on the verification are found.

System test verification campaign will resume when an evidence of resolution of the noncompliance or errors found is available.

4.8 Testing Tasks

The following testing tasks will be performed separately for each Rack:

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- 1. Electrical interface verification: Before powering the rack a point to point conductivity and isolation test must be performed according to procedures: MEL-CIV-TP-01 and MEL-CIV-TP-02 for compartment CIV and MEL-CIII-TP-01 and MEL-CIII-TP-02 for compartment CIII.
- 2. Power the rack
- 3. Connect in a local network the Supervision Server, the HMI, Supervision client and the rack.
- 4. Perform a *ping test* to each system to verify network connection is OK.
- 5. Update PLC software (if changed).
- 6. Update Master Control Software (if changed).
- 7. Update Supervision software (if changed).
- 8. Start Supervision Server software
- 9. Start Supervision Client software
- 10. Run the test procedures.
- 11. Generate the Test Report.

4.9 Test Deliverables

The following documents will be generated during the System Test:

- The V&V Plan (this document)
- Test Procedures (included in this document)
- Test Cases (included in this document)
- Test reports with the results of run tests ([R8])

4.10Environmental Needs

As the tests are performed with the Control System Demonstrator not connected to the plant it is necessary to simulate the plant's sensors and an acquisition system to read actuator responses are needed.

The generation of sensors signals will be performed using Adjustable Power Supplies (APS) and a Function Generator (FG).

The acquisition of signals will be performed using a multi-meter (MM) and an Oscilloscope (OSC) where necessary.

Figure 2 displays the hardware configuration to be used for conducting the tests.



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Figure 2: Test configuration

Device	Description
MEL_SWITCH01	Ethernet Switch placed in the Supervision Rack.
MEL_SUPV_CLI01	Supervision client Desktop PC.
MEL_SUPV_SERV01	Supervision Server placed in the Supervision Rack.
MEL_HMI	Human Machine Interface
CIV_ETHER	Ethernet connector placed in the corresponding Rack
CIII_ETHER	
CIV_AC_OUT	220 VAC switched power connector placed in the corresponding Rack.
CIII_AC_OUT	
CIV_CP	Connection panel of signals for sensor/actuators placed in the corresponding
CIII_CP	Rack.

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5 COMPARTMENT VIa SYSTEM TEST PROCEDURES

Test Procedures are implemented to verify the system from a functional approach. Therefore, each Test Procedure (TP) verifies a high level function (as for example biomass regulation for a compartment). Test Procedures include one or more Test Cases (TC) that shall be executed as part of the procedure.

Identifier	Name	Description
MEL-CIV-TP-01	Point to point connectivity test	Test point to point connectivity for the electrical
		interfaces.
MEL-CIV-TP-02	Electrical Isolation	Test electrical isolation
MEL-CIV-TP-03	Check Interfaces End to End	Test value ranges, communication with the supervision,
		supervision displays
MEL-CIV-TP-04	Biomass Production	Test biomass production control law
	Regulation	
MEL-CIV-TP-05	Gas Flow Regulation	Test gas flow rate regulation
MEL-CIV-TP-06	pH Regulation	Test pH regulation
MEL-CIV-TP-07	Initial values	Test parameters initial values when PLC is restarted
MEL-CIV-TP-08	Sensor/Actuator Link Errors	Test errors on sensors / actuators links are handled as
		specified.
MEL-CIV-TP-09	Operational modes	Test changes in outputs caused by changing the
		operational mode (OFF, AUTO, MAN)

These Test Procedures are specified in the following sections:

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5.1 MEL-CIV-TP-01: Point to point connectivity test procedure

5.1.1 Purpose

- Identify all components are deployed as specified in the HDD.
- Verify electrical connections are implemented as defined in the HDD.

5.1.2 Description

CAUTION This test procedure must be executed without powering the rack.

This test procedure is performed using a device that checks the electrical connectivity between two points (e.g. a multi-meter). Connections to check for Compartment IVa are specified in the ANNEX A. This ANNEX defines a template that shall be included as part of the Test Report.

5.1.3 Expected outcome

All connections specified in the template are checked OK.

5.1.4 Procedure steps

1. Check all connections specified in the template and mark if there is conductivity or not.

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5.2 MEL-CIV-TP-02: Electrical isolation

5.2.1 Purpose

Check that electrical isolation between AC L and GND and AG N and GND is performed according to applicable regulations.

5.2.2 Description

CAUTION This test procedure must be executed without powering the rack.

This test procedure is performed using a device that insulates 1500 V between AC L and GND and AC N and GND during a fixed period of time (60 seconds) to check that isolation in cabling, connectors and 220 VAC powered devices, is properly dimensioned.

5.2.3 Special requirements

A Dielectric Withstanding Voltage Tester device is needed to execute this test procedure. The device outputs 1500 V during a limited time and controls current is not over a defined value.

5.2.4 Expected outcome

Device response indicates test passed OK.

5.2.5 Procedure steps

- 1. Program device to output 1500 V during 60 seconds and limited current to 30 mA.
- 2. Connect device output to CIV_AC_IN pin 01 (AC L) and CIV_AC_IN pin 03 (GND).
- 3. Activate device to perform the verification.
- 4. Connect device output to CIV_AC_IN pin 02(AC N and CIV_AC_IN pin 03 (GND).
- 5. Activate device to perform the verification.
- 6. Annotate verification results.

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5.3 MEL-CIV-TP-03 Check Interfaces end-to-end

5.3.1 Purpose

Check that signals applied to inputs are transmitted to Supervision and values fixed by the Supervision are transmitted to outputs adequately, with the correct ranges.

5.3.2 Features to be tested

Verify integration and functionality of the following items:

- PLC Rack I/O Interface (CIV_CP)
- Supervision PLC Interface (Software interface)

5.3.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIV-TC-0301	Check analogue inputs
MEL-CIV-TC-0302	Check analogue outputs
MEL-CIV-TC-0303	Check digital inputs

5.3.4 Special Requirements

To execute this procedure following devices will be necessary:

- Multimeter (to measure analogue outputs)
- Adjustable Power Supply (to generate known values)
- Resistances 1 Kohm (to allow measuring 4-20 mA outputs)

The values can be monitored from the Supervision Real Time Database display (iFix Database Manager application).

Table of inputs / outputs

Variable Name	Tp.	N.	Description	Connector	Pin	Signal	Range
CIV_MV_CxAbs	AI	01	Analogue input for biomass concentration measurement in light absorbance units	CIV_CP	001 005	+ -	4 – 20 mA
CIV_MV_M1	AI	02	Scale 1		009 013	+ -	4 – 20 mA
CIV_MV_M2	AI	03	Scale 2		017 021	+ -	4 – 20 mA
CIV_MV_P	AI	04	Pressure measurement		025 029	+ -	4 – 20 mA
CIV_MV_pH	AI	05	pH measurement		033 037	+	4 – 20 mA
CIV_MV_T	AI	06	Temperature measurement		041 045	+ -	4 – 20 mA

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Variable Name	Tp.	N.	Description	Connector	Pin	Signal	Range
CIV_MGO_02	AI	07	O2 measurement at gas output		049 053	+ -	4 – 20 mA
CIV_MGO_CO2	AI	08	CO2 measurement at gas output		057 061	+ -	4 – 20 mA
CIV_MV_DO	AI	09	Percent of DO saturation in the reactor		065 069	+ -	4 – 20 mA
CIV_MV_FrGas	AI	13	Gas flow at compartment input		097 101	+ -	0 – 5 V
CIV_MGO_FrGas	AI	14	Gas flow at output		105 109	+ -	0 – 5 V
CIV_MV_FrCO2	AI	15	CO2 flow measurement		113 117	+ -	0 – 5 V
CIV_MGI_FrGas	AI	16	Gas flow at external input		121 125	+ -	0 – 5 V
CIV_SP_FrCO2	AO	01	CO2 Flow rate set-point		129 133	+ -	0 – 5 V
CIV_SP_Fgi	AO	02	Gas input Flow rate set-point		137 141	+ -	0 – 5 V
CIV_SP_Fgo	AO	03	Gas output Flow rate set-point		145 149	+ -	0 – 5 V
CIV_SP_Fgex	AO	04	Gas external input Flow rate set-point		153 157	+ -	0 – 5 V
CIV_SP_Li1	AO	05	Liquid input tank 1 Flow rate set-point		161 165	+ -	0 – 5 V
CIV_SP_Li2	AO	06	Liquid input tank 2 Flow rate set-point		169 173	+ -	0 – 5 V
CIV_SP_LO	AO	07	Liquid output Flow rate Control set- point		177 181	+ -	0 – 5 V
CIV_SP_Bs	AO	09	Base Flow rate set-point		193 197	+ -	4 – 20 mA
CIV_SP_Ls	AO	10	Light supply Radiation set-point		201 205	+ -	4 – 20 mA
CIV_SP_Ac	AO	11	Acid Flow rate set-point		209 213	+ -	4 – 20 mA
CIV_CAL_CO2O2	DI	01	Calibration indicator		42 46	+ -	0 – 24 V
CIV_ERR_CO2O2	DI	02	Error indicator		50 54	+ -	0 – 24 V
CIV_SCL1_CO2O2	DI	03	Using scale 1 indicator		58 62	+ -	0 – 24 V
CIV_SCL2_CO2O2	DI	04	Using scale 2 indicator		66 70	+ -	0 – 24 V

5.3.5 Procedure Steps

Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.

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5.3.6 MEL-TC-CIV-0301: Check analogue inputs

TC Ide	ntifier	MEL-TC-CIV-0301	Purpose:	Verify that analogue inpu	ts are connected, acquired, supervised an	d ranged as specified		
Functions	s Tested	Interface between CIV_C	$CP - CIV_PLC - S$	Supervision				
Descri	ption	Known values applied to	analogue inputs s	shall be displayed in the Supervision ranged as sp	pecified.			
Special Re	equisites:	Values to apply / check r	nust be between th	the indicated range				
Test	er:							
Store we			Francistad realiza					
Step no	Apply	1 5 m A aumont		$\frac{1}{1}$ Description	laved value (Diamaga			
1	Apply	4 - 5 mA current		IV_MV_CXADS) and check the disp	inayed value (Biolinass	0 - 0.2		
	Concer	itration in DW un	its) in the Si	upervision screen MEL_CIV_Ma	ain and MEL_CIV_BP.			
2	Apply	19 – 20 mA curren	nt to AI 01 ((CIV_MV_CxAbs) and check the d	isplayed value (Biomass	1.8 - 2		
	Concer	ntration in DW un	its) in the Su	upervision screen MEL_CIV_Ma	ain and MEL_CIV_BP.			
3	Apply	4 - 5 mA current	to AI 02 (CI	IV MV M1) and check the disp	laved value (Tank1 Level)	0 - 15		
	in the S	Supervision screer	MEL CIV	' BP	3			
1	Apply	10 20 m A current	1000000000000000000000000000000000000	<u>(CIV_MV_M1) and check the di</u>	enloved value (Tank1	135 150		
4	Apply	19 = 20 IIIA cuile.	$\frac{11110}{100} \text{ A1} 02$	(CIV_IVIV_IVII) and check the di	splayed value (Talik1	155 - 150		
	Level)	in the Supervision	i screen ME	L_CIV_BP.				
5	Apply	4 - 5 mA current	to AI 03 (CI	IV_MV_M2) and check the disp.	layed value (Tank2 Level)	0 – 15		
	in the S	Supervision screen	<u> MEL_CIV</u>	/_BP.				
6	Apply	19 - 20 mA curren	nt to AI 03 ((CIV_MV_M2) and check the dis	splayed value (Tank2	135 - 150		
	Level)	in the Supervisior	n screen ME	EL CIV BP.				
7	Apply	4 - 5 mA current	to AI 04 (CI	IV MV P) and check the displa	ved value (Pressure) in the	0 - 0.15		
,	Superv	ision screens MEI	CIV Mai	in and MEL CIV Gas	jeu value (Pressure) in ale	0 0.12		
0	Ample	$\frac{10}{10} 20 = 1$	L_CIV_IVIan	(CIV MV D) and shealt the diam	laved velve (Dressure) in	1 45 1 5		
ð	Apply	19 - 20 mA curren		(CIV_WIV_P) and check the disp	blayed value (Pressure) in	1.45 - 1.5		
	the Sup	pervision screens	MEL_CIV_I	Main and MEL_CIV_Gas.				
9	Apply	4 - 5 mA current	to AI 05 (CI	IV_MV_pH) and check the displ	ayed value (pH) in the	0 - 1.4		
	Superv	ision screens MEI	L_CIV_Main	in and MEL_CIV_pH.				
10	Apply	19 - 20 mA currer	played value (pH) in the	12.6 - 14				
10	Superv	vision screens MFL CIV Main and MFL CIV nH						
11	Apply	$\frac{1}{1}$ 5 mA current	\underline{L} \underline{L}	IV MV T) and check the display	ved value (Temperature) in	0 15		
11	Apply			A STATE AND	yeu value (Temperature) III	0-15		
	the Sup	bervision screen N	IEL_CIV_N	viain, wiEL_CIV_Temp				
12	Apply	a 19 - 20 mA curr	ent to AI 06	5 (CIV_MV_T) and check the dis	played value	145 - 150		

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	(Temperature) in the Supervision screen MEL_CIV_Main, MEL_CIV_Temp		
13	Apply 4 – 5 mA current to AI 07 (CIV_MGO_O2) and check the displayed value (O2 output) in	0-2.5	
	the Supervision screen MEL_CIV_Main, MEL_CIV_Gas.		
14	Apply 19 – 20 mA current to AI 07 (CIV_MGO_O2) and check the displayed value (O2 output)	22.5 - 25	
	in the Supervision screens MEL_CIV_Main, MEL_CIV_Gas.		
15	Apply 4 – 5 mA current to AI 08 (CIV_MGO_CO2) and check the displayed value (CO2	0-50	
	output) in the Supervision screens MEL_CIV_Main, MEL_CIV_Gas.		
16	Apply 19 – 20 mA current to AI 08 (CIV_MGO_CO2) and check the displayed value (CO2	450 - 500	
	output) in the Supervision screens MEL_CIV_Main, MEL_CIV_Gas.		
17	Apply 4 – 5 mA current to AI 09 (CIV_MV_DO) and check the displayed value (DO) in the	0 – 10	
	Supervision screen MEL_CIV_Gas.		
18	Apply 19 - 20 mA current to AI 09 (CIV_MV_DO) and check the displayed value (DO) in the	90 - 100	
	Supervision screen MEL_CIV_Gas.		
19	Apply 0 – 0.2 V to AI 13 (CIV_MV_FrGas) and check the displayed value (FR-CI) in the	0-3	
	Supervision screen MEL_CIV_Gas.		
20	Apply a 4.8 – 5 V to AI 13 (CIV_MV_FrGas) and check the displayed value (FR-CI) in the	27 – 30	
	Supervision screen MEL_CIV_Gas.		
21	Apply 0 – 0.2 V to AI 14 (CIV_MGO_FrGas) and check the displayed value (FR-GO) in the	0 – 3	
	Supervision screen MEL_CIV_Gas.		
22	Apply 4.8 – 5 V to AI 14 (CIV_MGO_FrGas) and check the displayed value (FR-GO) in the	27 - 30	
	Supervision screen MEL_CIV_Gas.		
23	Apply 0 – 0.2 V to AI 15 (CIV_MV_FrCO2) and check the displayed value (FR-CO2) in the	0 - 0.5	
	Supervision screen MEL_CIV_Gas.		
24	Apply 4.8 – 5 V to AI 15 (CIV_MV_FrCO2) and check the displayed value (FR-CO2) in the	4.5 - 5	
	Supervision screen MEL_CIV_Gas.		
25	Apply 0 – 0.2 V to AI 16 (CIV_MGI_FrGas) and check the displayed value (FR-GI) in the	0 – 3	
	Supervision screen MEL_CIV_Gas.		
26	Apply 4.8 – 5 V to AI 16 (CIV_MGI_FrGas) and check the displayed value (FR-GI) in the	27 - 30	
	Supervision screen MEL_CIV_Gas.		

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5.3.7 MEL-TC-CIV-0302: Check analogue outputs

TC Ide	TC Identifier MEL-TC-CIV-0302 Purpose: Verify that analogue inputs are connected, acquired and supervised as specified								
Function	ns Tested			Interface between CIV_CP – CI	V_PLC – Supervision				
Descri	iption	Known values applied to will be checked by other	o Supervision varia r TC.	bles shall be translated to the analogue outputs w	vithin the ranges specified. Only outputs w	with direct set-points are ch	necked, the rest		
Special R	equisites:								
Test	ter:			Date:					
				Course of Actions					
Step no				Description		Expected value	OK/NOK		
1	In the s	supervision screer	n MEL_CIV_	_pH set the value 0 to "Fixed CO	2 Flow Rate" and measure	0 V ±0.01			
	AO 01	output volts.							
2	In the s	supervision screer	n MEL_CIV_	_pH set the value 5 to "Fixed CO	2 Flow Rate" and measure	5 V ±0.01			
	AO 01	output volts.							
3	In the s	supervision screer	MEL CIV	Gas set the value 0 to "Gas Inpu	It Flow Rate" and measure	0 V +0 01			
_	AO 02	output volts.				0 1 20.01			
4	In the s	supervision screer	MEL CIV	Gas set the value 30 to "Gas Inp	out Flow Rate" and	5 V +0 01			
	measur	e AO 02 output v	volts.			0 1 20.01			
5	In the s	supervision screen	out Flow Rate" and	0 V +0.01					
	measur	e AO 03 output v	olts.			0 / _0.01			
6	In the s	supervision screer	n MEL_CIV_	_Gas set the value 30 to "Gas Ou	tput Flow Rate" and	5 V ±0.01			
	measure AO 03 output volts.								
7	In the s	supervision screer	MEL_CIV_	Gas set the value 0 to "Air Flow	Rate" and measure AO	0 V ±0.01			
	04 outp	out volts.							
8	In the s	supervision screen	n MEL_CIV_	Gas set the value 30 to "Air Flow	w Rate" and measure AO	5 V ±0.01			
	04 outp	04 output volts.							
9	Apply	a resistance 1Koh	ım between A	AO 10+ and AO 10-					
10	With th	e iFix Database l	Manager set	the value 0 to CIV_SSP_LIGHT	and measure AO 10	4 V ±0.1			
	output	volts	-						
11	With th	ne iFix Database I	Manager set	the value 1 to CIV_SSP_ LIGHT	and measure AO 10	20 V ±0.1			
	output	volts							

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5.3.8 MEL-TC-CIV-0303: Check digital inputs

TC Ide	ntifier	MEL-TC-CIV-0303 Purpose: Verify that digital inputs are connected, acquired and supervised as specified						
Functions	s Tested			Interface between CIV_CI	P – CIV_PLC – Supervision			
Descri	ption	Status set to digital inpu	ts shall be translate	l to the supervision as specified.				
Special Re	cial Requisites:							
Test	ter:			Dates				
				Course of Actions				
Step no				Description		Expected value	OK/NOK	
1	Set DI	01 in open circuit	t and check in	n supervision screen MEL_C	IV_Gas, indicator	Disabled		
	"Calibr	ating"						
2	Set DI 01 in closed circuit and check in supervision screen MEL_CIV_Gas, indicator Enable							
	"Calibr	ating"						
3	Set DI	02 in open circuit	t and check in	n supervision screen MEL_C	CIV_Gas, indicator "Error"	Disabled		
4	Set DI	02 in closed circu	uit and check	in supervision screen MEL_	CIV_Gas, indicator "Error"	Enabled		
5	Set DI 03 in open circuit and check in supervision screen MEL_CIV_Gas, indicator "Scale1" Disabled							
6	Set DI 03 in closed circuit and check in supervision screen MEL_CIV_Gas, indicator "Scale1" Enabled							
7	Set DI	04 in open circui	t and check in	n supervision screen MEL_C	CIV_Gas, indicator "Scale2"	Disabled		
8	Set DI	04 in closed circu	uit and check	in supervision screen MEL_	CIV_Gas, indicator "Scale2"	Enabled		

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5.4 MEL-CIV-TP-04 Biomass production regulation

5.4.1 Purpose

Biomass production regulation is performed by a software component running in the Supervision Server. This software component uses the Supervision software (iFix) to interface with the Local Control (PLC). The Local Control translates the setting points provided by he Supervision to the actuators and acquires sensor values sending proper values back to the Supervision.

5.4.2 Features to be tested

Verify integration and functionality of the following items:

- CIV Biomass Production Software Component: CIV_BP_CL
- Supervision displays:
 - MEL_CIV_Main: Display of the most important values of the CIV compartment.
 - MEL_CIV_BP: Biomass Production Loop display.
- Local Control (PLC) program sections:
 - CIV_PLCSW_Biomass: Biomass measurement.
 - CIV_PLCSW_Liquid: Liquid flow regulation.
 - CIV_PLCSW_Light: Light regulation.
- PLC Rack I/O Interface
- Supervision PLC Interface
- CIV BP Software Component Supervision Interface

5.4.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIV-TC-0301	Biomass sensor cleaning
MEL-CIV-TC-0302	Liquid flow regulation
MEL-CIV-TC-0303	Verify light regulation
MEL-CIV-TC-0304	Over pressure alarm

5.4.4 Special Requirements

Table of I/O that participates in the Biomass Production loop: Ty (Type) = RL: Relay, AI: Analogue Input, AO: Analogue Output

Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIV_RL_Cx	RL	03	Relay output to activate	CIV_AC_OUT	01	AC L	220 VAC
			aeration of biomass sensor		03	AC N	
			for cleaning		05	GND	
CIV_MV_CxAbs	AI	01	Analogue input for biomass	CIV_CP	001	+	4 – 20 mA
			concentration measurement				
			in light absorbance units		005	-	
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Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIV_MV_T	AI	06	06 Temperature measurement	CIV_CP	041	+	4 – 20 mA
					045	-	
CIV_SP_Li1	AO	05	Analogue output to fix liquid	CIV_CP	161	+	0 – 5 V
			input pump i set-point		165	-	
CIV_SP_Li2	AO	06	Analogue output to fix liquid	CIV_CP	169	+	0 – 5 V
			input pump z set-point		173	-	
CIV_SP_LO	AO 0	07	Analogue output to fix liquid output pump set-point	CIV_CP	177	+	0 – 5 V
					181	-	
CIV_RL_Li1	RL 01 Relay pump	Relay to activate liquid input	CIV_CP	170	+	24V	
			pump i		174	-	
CIV_RL_Li2	RL C	RL 02	02 Relay to activate liquid input pump 2	CIV_CP	178	+	24V
					182	-	
CIV_MV_M1	AI	02	Analogue input to acquire	CIV_CP	009	+	4 – 20 mA
			mass of liquid input tank 1		013	-	
CIV_MV_M2	AI	03	Analogue input to acquire	CIV_CP	017	+	4 – 20 mA
			mass of liquid input tank 2		021	-	
CIV_SP_Ls	AO ´	AO 10 Analogue output to provide light regulation set-point	CIV_CP	201	+	4 – 20 mA	
			light regulation set-point		205	-]

Devices needed in this test procedure:

- 2 Adjustable Power Supply (APS) to provide current / voltage to analogue inputs
- 1 Multimeter to measure analogue current / voltage outputs
- 1 Oscilloscope to measure output transitory

5.4.5 Procedure Steps

- Set Biomass loop operation mode to AUTO.
- Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.


5.4.6 MEL-TC-CIV-0401: Verify biomass sensor cleaning

TC Ide	ntifier	MEL-TC-CIV-0401 Purpose:	Verify that output to activate valve to clean the biomass sensor is	activated as specified and Bi	iomass value is m	aintained.	
Items 7	Fested	CIV_PLCSW_Biomass, MEL_CIV_BP, M	EL_CIV_MAIN				
Descri	ption	Every 5 minutes the digital output 03 shall	be activated during 5 seconds. During this time, and 5 seconds after, the biomass sense	or acquired value must be ma	untained.		
Special Re	equisites:	An APS is used to simulate the Biomass sensor.					
		Check supervision values in MEL_CIV_BI					
Test	ter:		Date:				
			Course of Actions				
Step no		Description			OK/NOK	Comments	
1	Set 2.9	- 3.1 V to AI 01 (CIV_MV_C	1 gr/l ±0.1				
	the value of Biomass concentration						
2	Check	eck by inspection AIR value is opened every 5 minutes during 5 seconds.					
3	During the time the value is open modify AI 01 input and check value of Biomass concentration						
	is not changed in the supervision.						
4	Immediately after AIR value is closed modify AI 01 and check by inspection value is not						
	changed during 5 seconds after the valve is closed.						
5	Check that if value is modified 5 seconds after AIR value is closed Biomass Concentration						
	value is	s changed as well.					

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5.4.7 MEL-TC-CIV-0402: Liquid flow regulation

Items Tested CIV_PLCSW_Liquid, CIV_BP_CL, CIV_PLCSW_Light, MEL_CIV_BP, MEL_ Description Flow rate set point and light set point are provided from the Supervision, by the so in case input media tanks are empty, and transfer the light setting point to the light Special Requisites: Two APS (APS1, APS2) are needed to simulate scale sensors of liquid input tank Use MEL_CIV_MAIN and MEL_CIV_BP supervision displays Use a multimeter to measure analogue values Tester: D	_CIV_MAIN oftware module CIV_BP_CL. t regulator device. s. ate: urse of Actions	. The PLC shall regulate the	active input pump, flo	w rate of output pump and activate alarm
Description Flow rate set point and light set point are provided from the Supervision, by the so in case input media tanks are empty, and transfer the light setting point to the light Special Requisites: Two APS (APS1, APS2) are needed to simulate scale sensors of liquid input tank Use MEL_CIV_MAIN and MEL_CIV_BP supervision displays Use a multimeter to measure analogue values Tester: D	oftware module CIV_BP_CL. t regulator device. s. ate: Irse of Actions	. The PLC shall regulate the	active input pump, flo	w rate of output pump and activate alarm
Special Requisites: Two APS (APS1, APS2) are needed to simulate scale sensors of liquid input tank Use MEL_CIV_MAIN and MEL_CIV_BP supervision displays Use a multimeter to measure analogue values Tester: D	ate:			
Tester: Tester:	ate:			
Use a multimeter to measure analogue values D Tester: D	ate: Irse of Actions			
Tester: D	ate: 1rse of Actions	-		
~	urse of Actions			
Cou				
Step no Description		Expected value	OK	Comments
1 Apply with APS1 17 – 19 mA to AI 02 (CIV_MLI_M1) check	in the supervision	130 liters ±15		
display MEL_CIV_BP the Tank 1 level.	-			
2 Apply with APS2 14 – 15 mA to AI 01 (CIV_MV_CxAbs) che	eck in the	1.5 g/l ±0.2		
supervision display MEL CIV BP the Biomass concentration		6		
3 Apply a 1Kohm resistor to AO 10 (CIV SP Ls)				
4 In the MEL_CIV_MAIN display check Biomass concentration	1	1.5 g/l±0.2		
5 In the MEL CIV BP display set Liquid input pump 1 calibrati	on parameters to	0		
A=18.315, B=11.0989				
6 In the MEL CIV BP display set Liquid input pump 2 calibrati	on parameters to			
A=16.103, B=0.8534	1			
7 In the MEL_CIV_BP display set Liquid output pump calibration	on parameters to			
A=20, B=10	1			
8 In the MEL_CIV_BP display set minimum volume to switch in	nput tank to 10			
liters	-			
9 In the MEL_CIV_BP display set:				
- Biomass production set-point to 1.2 gr/l				
- Liquid input flow rate set-point to 0.7 1/h				
Using the iFix Database Manager set CIV SSP LIGHTWM to	68.5844 and			
$CIV_SSP_LIFR = 0.7$				
10 Adjust APS2 to obtain a Biomass Concentration of 1.36±0.01	gr/l (check in			
MEL_CIV_BP)				

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TP Identifie	er	TP-TC-CIV-0402	Purpose:	Verify that flow set points are transmitted to input output p	umps according to specifications.		
Items Tester	d	CIV_PLCSW_Liquid, CIV_PLCSW_Li	CIV_BP_CL, CIV_	PLCSW_Light, MEL_CIV_BP, MEL_CIV_MAIN			. <u> </u>
Description		Flow rate set point and in case input media tanl	light set point are price of the set point are price of the set point are set of the set	ovided from the Supervision, by the software module CIV_E ansfer the light setting point to the light regulator device.	BP_CL. The PLC shall regulate the a	ctive input pump, flow rat	e of output pump and activate alarm
Special Req	uisites:	Two APS (APS1, APS2	2) are needed to sim	ulate scale sensors of liquid input tanks.			
		Use MEL_CIV_MAIN Use a multimeter to me	and MEL_CIV_BI asure analogue valu	s s s s s s s s s s s s s s s s s s s			
11	From th	ne Supervision iF	Fix Scheduler	configure as Foreground task and fire			
	schedul	led event CIV_C	TRLLAW_B	P			
12	Check i	in the MEL_CIV	_BP display	the Level 1 liquid input flow rate set poir	nt 0.77 l/h ±0.01		
13	Check i	in the MEL_CIV	_BP display	the % actuation of input pump 1	25.20% ±0.01		
14	Measure voltage output in CIV_SP_Li1 (AO 05)			1.26 V ±0.1			
15	Check i	in the MEL_CIV	_BP display	the output flow rate (must be $+10\%$ of the	$0.84 \text{ l/h} \pm 0.01$		
	liquid in	nput flow rate)					
16	Check in the MEL_CIV_BP display the % actuation of output pump			he % actuation of output pump	26.8% ±0.2		
17	Measure voltage output in CIV_SP_LO (AO 07)			1.34 V ±0.1			
18	Check in the MEL_CIV_BP display the liquid input pump1 status			Enabled (green)			
19	Check in the MEL_CIV_BP display the liquid input pump2status			Disabled (red)			
20	Check in the MEL_CIV_BP display the output light set-point		217.61 w/m2 ±1				
21	In the M	MEL_CIV_MAI	N display che	ck light set-point (Light intensity)	217.61 w/m2 ±1		
22	In the M	MEL_CIV_BP di	splay check l	ight regulator actuation set point %	83.52% ±2		
23	Measur	e voltage output	in CIV_SP_I	Ls (AO 10)	17.36 V ±0.2		
24	From th	ne Supervision iF	Fix Scheduler	display fire scheduled event			
	CIV_C	TRLLAW_BP a	gain				
25	Check i	in the MEL_CIV	_BP display	the output light set-point	223.00 w/m2		
					±0.01		
26	Discon	nect APS2 from .	AI 01 and set	output to 17-18 mA			
27	Apply v	with APS2 17-18	mA to AI 03	B (CIV_MLI_M2)			
28	Check i	in the MEL_CIV	_BP display	the tank 2 level	130 liters ±15		
29	Set APS1 output to $4 - 5$ mA.						
30	Check in the MEL_CIV_BP display the tank 1 level 51			5 liters ±5			
31	Check in the MEL_CIV_BP display the input pump 1 Disabled						
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TP Identifi	er	TP-TC-CIV-0402	Purpose:	Verify that flow set points are transmitted	l to input output pumps ac	cording to specifications.		
Items Teste	d	CIV_PLCSW_Liquid, 0	CIV_BP_CL, CIV_	PLCSW_Light, MEL_CIV_BP, MEL_CIV	_MAIN			
Description	scription Flow rate set point and light set point are provided from the Supervision, by the software module CIV_BP_CL. The PLC shall regulate the active input pump, flow rate of output pump and activate in case input media tanks are empty, and transfer the light setting point to the light regulator device.					mp, flow rate of output pump and activate alarm		
Special Requisites: Two APS (APS1, APS2) are needed to simulate scale sensors of liquid input tanks. Use MEL_CIV_MAIN and MEL_CIV_BP supervision displays Use a multimeter to measure analogue values								
32	Check in the MEL_CIV_BP display the input pump 2					Enabled		
33	Set APS2 output to 4 - 5 mA							
34	Check in the MEL_CIV_BP display the tank 2 level				5 liters ±5			
35	Check in the MEL_CIV_BP display the input pump 1				Disabled			
36	Check in the MEL_CIV_BP display the input pump 2				Disabled			
37	Check in the MEL_CIV_BP display the output pump actuation				0%			
38	Measur	re voltage output	in CIV_SP_	LO (AO 07)		0 V ±0.01		

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5.4.8 MEL-TC-CIV-0403: Light index

TP Identifi	er	TP-TC-CIV-0403	Purpose:	Verify that when the light ind	dex set point char	iges, a ramp is applie	d to set point output to smooth	the variation.	
Functions T	Tested	CIV_PLCSW_Light, N	MEL_CIV_BP						
Description		Light set point changes	s are applied using a	a ramp that changes from 0 to 1	in 15 seconds.				
Special Req	uisites:	Use an oscilloscope (C	OSC) to measure rar	np.					
Tester: Date:									
	Course of Actions								
Step no	o no Description				Expected value	OK/NOK	Comments		
1	Apply a	ply a 1 Kohm resistor to AO 10							
2	Connec	nect the OSC channel 1 to TB_ACO pin 2 (-) and pin 5 (+) to monitor AO 10				onitor AO 10			
	(AO 4 :	mA => 0,4 V / A	AO 20 mA =>	> 2V) . Time div 5 sec	conds. V div	v 0.5 V			
3	Set in t	t in the CIV SSP Light variable in the iFix Data Manager display the value 0.				the value 0.	0,4 V ±0.01		
	Wait until output voltage in AO 10 goes down to 4V.								
4	Set in t	he CIV_SSP_Li	V_SSP_Light variable in the MEL_CIV_TEST_01 display the value			ay the value	2 V ±0.1		
	1. Wait	until output vol	t voltage in AO 10 goes up to 20V.						
5	Check	in the OSC the o	output voltage	e changed from 0,4V	to 2V in 15:	±0.2 seconds.			

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5.4.9 MEL-TC-CIV-0404: Over temperature alarm

TP Identifie	er	TP-TC-CIV-0404	Purpose:	Verify that when the over ten	nperature alarm is	on light supply is	set to a safety value		
Functions T	Tested	CIV_PLCSW_Light, C	IV_PLCSW_T, MI	EL_CIV_Temp					
Description		When an over temperat	ure is detected, ligh	t supply is set to a low value to	avoid over heatin	g			
Special Requisites: Use an APS to apply voltages									
Tester: Date:									
	Course of Actions								
Step no	Description				Expected value	OK/NOK	Comments		
1	In the MEL_CIV_Temp supervision screen set Temperature set point to 27 °C				to 27 °C				
2	2 Apply with the APS $1.9 - 2.1$ V to AI 06				37.5 ±4 °C				
3 Check the over temperature alarm is displayed in the Alarm area of the				e					
	Supervision screen								
4	4 Check in MEL_CIV_BP light supply actuation				10%				

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5.5 MEL-CIV-TP-05 Gas Flow Regulation

5.5.1 Purpose

Gas flow regulation controls pressure in the compartment and gas input/output set-points. Two modes of operation are defined:

- Control action enabled: if the pressure increases over a defined value, the controller commands the output gas valve to open 10% over the set point. If the pressure decreases below a defined value, the controller commands the input gas valve to open 10% over the set point.
- Control action disabled: Gas input / output flows are set directly from the supervision.

In addition the pressure valve is opened if pressure value goes over the max. allowed pressure.

5.5.2 Features to be tested

Verify integration and functionality of the following items:

- Supervision displays:
 - MEL_CIV_Main: Display of the most important values of the CIV compartment.
 - MEL_CIV_Gas: Biomass Production Loop display.
- Local Control (PLC) program sections:
 - CIV_PLCSW_Gas: Gas flow regulation.
- PLC Rack I/O Interface
- Supervision PLC Interface

5.5.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIV-TC-0501	Control action enabled
MEL-CIV-TC-0502	Pressure safety valve activation
MEL-CIV-TC-0503	Check over pressure alarm

5.5.4 Special Requirements

Table of I/O that participates in the Gas regulation loop: Ty (Type) = RL: Relay, AI: Analogue Input, AO: Analogue Output

Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIV_MGI_FrGas	AI	13	Gas flow at external	CIV_CP	097	+	0 – 5 V
			input		101	-	
CIV_MGO_FrGas	AI	14	Gas flow at output	CIV_CP	105	+	0 – 5 V

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Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
					109	-	
CIV_MV_FrGas	AI	16	Gas flow at	CIV_CP	121	+	0 – 5 V
			compartment input		125	-	
CIV_MV_P	AI	04	Pressure measurement	CIV_CP	025	+	4 – 20 mA
					029	-	
CIV_SP_Fgi	AO	02	Gas flow at input regulation	CIV_CP	137	+	0 – 5 V
					141	-	
CIV_SP_Fgo	AO	03	Gas flow at output	CIV_CP	145	+	0 – 5 V
			regulation		149	-	
CIV_SP_Fgex	AO	04	Gas flow external input	CIV_CP	153	+	0 – 5 V
			regulation		157	-	
CIV_RL_Fg	RL	04	Pressure safety valve	CIV_AC_OUT	07	AC L	220 VAC
	activation			09	AC N		
					11	GND	

Devices needed in this test procedure:

- Adjustable Power Supply (APS)
- Multi-meter

5.5.5 Procedure Steps

- Set Gas loop operation mode to AUTO.
- Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.



5.5.6 MEL-TC-CIV-0501: Control action enabled

TC Ide	ntifier	MEL-TC-CIV-0501	Purpose:		Verify that set points are modified by the PLC in case of over/under pressure								
Function	s Tested	CIV_PLCSW_Gas, MEL_	_CIV_GAS										
Descri	ption	In case of overpressure out pressure is 0.01 under the r	tput flow increme nominal value.	ents a 10%, in case of under pr	ressure input flow	increments a 10%. Over pres	ssure is when pre	essure is 0.01 over the no	ominal value, a	nd under pressure is when			
Special R	equisites:	An APS is used to simulat	te the pressure ser	nsor.									
-	•	Use the multi-meter to mea	asure currents and	d voltages.									
		Check supervision values i	in MEL_CIV_Ga	S									
Test	ter:				Date:								
					Course of A	Actions							
Step no				Description				Expected value	OK/NOK	Comments			
1	In the I	MEL_CIV_Gas set	the max al	lowed pressure value	e to 1.1 bar								
2	In the I	MEL_CIV_Gas se	t the nomin	al pressure 1.0 bar									
3	In the l	MEL_CIV_Gas set	L_CIV_Gas set the AIR input flow rate to 10 nLm										
4	Apply	with the APS 3.66-	-3.68 V to 0	CIV_MV_P (AI 04)	and check p	pressure value in	1	± 0.005 bar					
	MEL_C	CIV_Gas.	V_Gas.										
5	Measur	are CIV_SP_Fgex (AO 04) voltage 1.66±0.01 V											
6	In the l	MEL_CIV_Gas set the gas input flow rate to 20 nLm											
7	Measur	e CIV_SP_Fgi (A0	O 02) voltag	ge			3	.33±0.01 V					
8	In the l	MEL_CIV_Gas set	the gas out	put flow rate to 12 r	nLm								
9	Measur	e CIV_SP_Fgo (A	O 03) volta	ge			2	±0.01 V					
10	Check	in MEL_CIV_Gas	display the	over pressure & un	der pressure	indicators	Ľ	Disabled					
11	Modify	APS value to 3.69	9-3.72 V an	d check pressure val	ue in MEL_	_CIV_Gas.	1	.015±0.005 bar					
12	Check	in MEL_CIV_Gas	display the	over pressure indica	ator		E	Enabled					
13	Measur	e CIV_SP_Fgo (A	O 03) volta	ge (shall be 10% ov	er set point	measured in 9)	2	.2±0.02 V					
14	Modify	APS value to 3.59	9 -3.62 V ar	nd check pressure va	lue in MEL	_CIV_Gas.	0	.98±0.005 bar					
15	Check	in MEL_CIV_Gas display the under pressure indicator Enabled											
16	Measur	ure CIV_SP_Fgex (AO 04) voltage (shall be 10% over set point measured in 5) 1.82±0.02 V											
17	Measur	re CIV_SP_Fgi (AO 02) voltage (shall be 10% over set point measured in 7) 3.66±0.02 V											
18	Apply	with the APS 3.67	-3.69 V to	CIV_MV_P (AI 04)	and check	pressure value in	1	.005 ±0.005 bar					
	MEL_C	CIV_Gas.											

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TC Ider	ntifier	MEL-TC-CIV-0501	Purpose:	Verify that set points are modified by the PLC in	n case of over/under pressure						
Functions	s Tested	CIV_PLCSW_Gas, MEL_Cl	IV_GAS								
Descrij	ption	In case of overpressure output flow increments a 10%, in case of under pressure input flow increments a 10%. Over pressure is when pressure is 0.01 over the nominal value, and under pressure is when pressure is 0.01 under the nominal value.									
Special Re	equisites:	An APS is used to simulate the pressure sensor. Use the multi-meter to measure currents and voltages. Check supervision values in MEL_CIV_Gas									
19	Check	heck in MEL_CIV_Gas display the under pressure indicator Disabled									
20	Check	in MEL_CIV_Gas d	lisplay the	over pressure indicator	Disabled						
21	Measur	ure CIV_SP_Fgex (AO 04) voltage (initial value) 1.66±0.02 V									
22	Measur	sure CIV_SP_Fgi (AO 02) voltage (initial value) 3.33±0.02 V									
23	Measur	re CIV_SP_Fgo (AO	0 03) volta	ge (initial value)	2.00±0.02 V						

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5.5.7 MEL-TC-CIV-0502: Pressure safety valve activation

TC Ide	ntifier	MEL-TC-CIV-0502	Purpose:		Veri	fy that pressure safety valve i	is activated in case	e of an high overpressu	ire	
Function	s Tested	CIV_PLCSW_Gas, MEL	_CIV_GAS							
Descri	ption	In case pressure is over the	e max allowed pr	essure, the pressure safety valve	shall be opened	l until pressure is nominal				
Special R	equisites:	An APS is used to simula	te the pressure ser	ISOF.						
		Use the multi-meter to me	in MEL CIV Co	i voltages.						
Tog	-	Check supervision values	III MEL_CIV_Ga	8	Data					
Tes	ler:	l			Date:	Actions				
				D : 4	Course of A	Actions		F (1)	OKANOK	a b
Step no	T .1 1		1 11	Description				Expected value	OK/NOK	Comments
1	In the I	MEL_CIV_Gas set the max allowed pressure value to 1.1 bar								
2	In the I	ne MEL_CIV_Gas set the nominal pressure 1.0 bar								
3	In the I	the MEL_CIV_Gas set the external input flow rate to 10 nLm								
4	Apply	Apply with the APS 3.66–3.68 V to CIV_MV_P (AI 04) and check pressure value in 1±0.005 bar								
	MEL_O	CIV_Gas.			-					
5	In the I	MEL_CIV_Gas ch	eck safety v	alve status			C	losed		
6	Modify	APS value to 4.2	-4.5 V and c	heck pressure value in	n MEL_C	IV_Gas.	1.	25±0.05 bar		
7	In the l	MEL_CIV_Gas ch	eck safety v	alve status			0	pen (green)		
8	Measu	re output Voltage A	AC CIV_RL	_Fg (CIV_AC_OUT	08,10)		22	20 VEF ±10%		
9	Modify	Iodify APS value to 3.70 - 3.72 V and check pressure value in MEL_CIV_Gas.1.015±0.005 I						015±0.005 bar		
10	In the I	MEL_CIV_Gas check safety valve status Open								
11	Apply	with the APS 3.64	3.66 V to C	IV_MV_P (AI 04) an	nd check p	ressure value in	0.	995±0.005 bar		
	MEL_C	CIV_Gas.								
12	In the I	MEL_CIV_Gas ch	eck safety v	alve status			C	losed		

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5.5.8 MEL-TC-CIV-0503: Check over pressure alarm

TC Ide	ntifier	MEL-TC-CIV-0503	Purpose:			Verify that over pressure alar	rm is activated				
Function	s Tested	CIV_PLCSW_Gas, MEL_	_CIV_GAS								
Descri	ption	When an overpressure occ	urs during more t	han 5 seconds, the over pressu	re alarm shall be	activated.					
Special Re	equisites:	An APS is used to simulat	e the pressure ser	isor.							
		Check supervision values i	in MEL_CIV_Ga	S							
Test	ter:		Date:								
			Course of Actions								
Step no		Description Expec							Comments		
1	In the MEL_CIV_Gas set the max allowed pressure value to 1.1 bar										
2	In the M	MEL_CIV_Gas se	t the nomin	al pressure 1.0 bar							
3	In the M	MEL_CIV_Gas set	the AIR in	out flow rate to 10 n	Lm						
4	Apply	with the APS 4.2-4	.5 V to CIV	_MV_P (AI 04) and	l check pres	ssure value in	1.25±0.05 bar				
	MEL_C	CIV_Gas.									
5	After 5	econds check the MEL_CIV_Gas alarms. Verify that over pressure alarm has been									
	indicate	ed.		-	-						

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5.6 MEL-CIV-TP-06 pH Regulation

5.6.1 Purpose

pH regulation controls the pH in the compartment. A pH probe measures pH and in case of deviation, several actions can be taken depending on the current operation mode:

- Only CO2: When the pH is over the set point, additional CO2 is added. A PID controls CO2 addition.
- CO2 and basic medium: When pH is over the set point, CO2 is added, when is under basic medium is added. A proportional controller controls basic medium addition.
- Acid and basic media. When pH is over the set point, acid media is added, when is under, basic media is added. A proportional controller controls both, basic and acid, media.

In addition a fixed quantity of CO2 can be added independently of the control action.

5.6.2 Features to be tested

Verify integration and functionality of the following items:

- Supervision displays:
 - MEL_CIV_Main: Display of the most important values of the CIV compartment.
 - MEL_CIV_pH: pH regulation display.
- Local Control (PLC) program sections:
 - CIV_PLCSW_pH: pH regulation.
- PLC Rack I/O Interface
- Supervision PLC Interface

5.6.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIV-TC-0601	Only CO2
MEL-CIV-TC-0602	CO2 and additional base medium
MEL-CIV-TC-0603	Base and Acid additional media
MEL-CIV-TC-0604	Check pH alarm

5.6.4 Special Requirements

Table of I/O that participates in the Gas regulation loop:

Ty (Type) = RL: Relay, AI: Analogue Input, AO: Analogue Output

Variable Name	Ту	Ν.	Description		Connect	or	Pin	Signal	Range
CIV_MV_pH	AI	05	pH measurement		CIV_CP		033	+	4 – 20 mA
							037	-	
CIV_SP_FrCO	CIV_SP_FrCO2 AO 01 CO2 flow regula		egulation	CIV_CP		129	+	0 – 5 V	
				T					
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Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
					133	-	
CIV_SP_Bs	AO	09	Additional Base source	CIV_CP	193	+	4 – 20 mA
					197	-	
CIV_SP_Ac	AO	11	Additional Acid source	CIV_CP	209	+	4 – 20 mA
			Tor ph regulation		213	-	1

Devices needed in this test procedure:

- Adjustable Power Supply (APS)
- Multi-meter (MM)
- Oscilloscope (OSC)

5.6.5 Procedure Steps

- Set pH loop operation mode to AUTO.
- Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.



5.6.6 MEL-TC-CIV-0601: Regulate pH with CO2 only

TC Ide	ntifier	MEL-TC-CIV-0601	EL-TC-CIV-0601 Purpose: Verify that CO2 flow meter regulates CO2 input to maintain pH set point						
Function	s Tested	CIV_PLCSW_pH, MEL	_CIV_pH						
Descri	ption	With the control action n	node CO2 Only, th	e pH is regulated adding CO2.	Control action is	performed by means of a PID			
Special Re	equisites:	Use the multi-meter to m	easure currents an	d voltages.					
		Use the OSC to display (CIV SP CO2 (CC	2 regulation PID output in AO	01)				
		Check supervision values	s in MEL_CIV_pH	[,				
		Concept SW is used to m	nodify enable/disa	ole PID parameters					
Test	er:				Date:				
				D	Course of A	Actions		OWNOW	<i>a</i>
Step no	T (1)		.1 . 1	Description	(0,1)		Expected value	OK/NOK	Comments
1	In the I	In the WIEL_CIV_pri set the control action mode 1 (CO2 Only)							
2	In the M	MEL_CIV_pH set	t the pH set p	point to 6.5					
3	In the MEL_CIV_pH set the CO2 flow meter PID parameters to P=5, I=100, D=0.01								
4	With th	With the Concept tool connect to the PLC and open CIV_PLCSW_pH section.							
5	In Con	In Concept set "FALSE" to EN_I, EN_D (only proportional part of the PID is enabled)							
6	With th	Vith the FG apply a squared wave with duty cycle = 50%, Amp= 0.1 ± 0.05 V, Offset = 2.7 ± 0.05							
	(2.7-2.9	θ) and f=0.1 Hz to	OCIV_MV_I	oH (AI 05)	· •				
7	Check	in the MEL_CIV_	pH display	pH value is between	the range		5.95 ±0.1 to		
					-		6.65 ±0.1 pH		
8	Measu	re CIV_SP_FrCO	2 (AO 01) o	utput MAX			0.75 ±0.3 V		
9	In Con	cept set "FALSE"	to EN_P, E	N_D and "TRUE" to	EN_I (onl	ly Integrative part of the			
	PID is	enabled)							
10	In the I	FG increment Am	p = 0.5 to in	crease integrative ac	tion				
11	Measu	Ieasure CIV_SP_FrCO2 (AO 01) output MAX 0.35±0.1 V							
12	In Con	cept set "FALSE"	' to EN_P, E	N_I and "TRUE" to	EN_D (on	ly Derivative part of the			
	PID is	enabled)							
13	With th	ne FG modify to a	triangle way	ve with same parame	ters				
13	Measu	re CIV_SP_FrCO	$2(\overline{AO 01})$ or	utput MAX			0.035±0.05 V		

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5.6.7 MEL-TC-CIV-0602: CO2 and additional base medium

TC Ide	ntifier	MEL-TC-CIV-0602	MEL-TC-CIV-0602 Purpose: Verify that Base pump is activated when pH is under set-point and CO2 flowmeter is activated when pH is over set-point						
Function	s Tested	CIV_PLCSW_pH, MEL	_CIV_pH						
Descri	ption	With the control action m	node 2 CO2 + Base	media, the pH is regulated ad	ding CO2 when J	pH is over the set point and Base media w	hen pH is under the set-poi	nt. A PID contr	oller regulates CO2 flow and
		a P (proportional) control	ller controls Base p	ump.					
Special Re	equisites:	Use the multi-meter to m	easure currents and	voltages.					
		Use the FG to simulate va	ariations in the pH.						
		Check supervision values	s in MEL_CIV_pH			Γ			
Test	er:				Date:				
					Course of A	Actions			
Step no				Description		Expected value	OK/NOK		
1	In the MEL_CIV_pH set the control action mode 2 (CO2 + Base)								
2	In the M	In the MEL_CIV_pH set the pH set point to 6.5							
3	In the M	the MEL_CIV_pH set the CO2 flow meter PID parameters to P=5, I=100, D=0.01							
4	With th	e FG apply a squa	ared wave wi	th duty cycle = 50%	, Amp=0.1:	± 0.05 V, Offset = 2.7 ± 0.05			
	(2.7-2.9) and $f=0.1$ Hz to	CIV_MV_p	H (AI 05)	· 1	·			
5	Check i	in the MEL_CIV_	pH display p	H value is between	the range		5.95 ±0.1 to		
	6.65 ±0.1 pH								
6	Apply a 1 Kohm resistor to AO 09								
7	Measur	sure CIV_SP_Bs (AO 09) output MAX 12.8 ±1 V							
8	Check	in the MEL_CIV_	pH display l	Base pump actuation	1		55±5 %		

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5.6.8 MEL-TC-CIV-0603: Base and Acid additional media

TC Ide	ntifier	MEL-TC-CIV-0603 Purpose: Verify that Base pump is activated when pH is under set-point and Acid pump is activated when pH is over set-point							
Function	s Tested	CIV_PLCSW_pH, MEL_CIV_pH							
Descri	ption	With the control action mode 2 CO2 + Base media, the pH is regulated adding CO2 when pH is over the set point and Base media v	hen pH is under the set-poi	nt. A PID contro	ller regulates CO2 flow and				
		a P (proportional) controller controls Base pump.							
Special Re	equisites:	Use the multi-meter to measure currents and voltages.							
	Use the FG to simulate variations in the pH.								
		Check supervision values in MEL_CIV_pH							
Test	er:	Date:							
		Course of Actions							
Step no		Description	Expected value	OK/NOK	Comments				
1	In the MEL_CIV_pH set the control action mode 3 (Base + Acid)								
2	In the MEL_CIV_pH set the pH set point to 6.5								
3	In the M	n the MEL_CIV_pH set the CO2 flow meter PID parameters to P=5, I=100, D=0.01							
4	With th	ie FG apply a squared wave with duty cycle = 50%, Amp= 0.1 ± 0.05 V, Offset = 2.8 ± 0.05							
	(2.8-3.0)) and f=0.1 Hz to CIV_MV_pH (AI 05)							
5	Check	in the MEL_CIV_pH display pH value is between the range	6.30 ±0.1 to						
	7.00 ±0.1								
6	Apply a	a 1 Kohm resistor to AO 11							
8	Measur	asure CIV_SP_Ac (AO 11) Output MAX 13±1 V							
9	Check	in the MEL_CIV_pH display acid pump actuation	50 ±5 %						

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5.6.9 MEL-TC-CIV-0604: Check pH alarm

TC Ide	ntifier	MEL-TC-CIV-0604	Purpose:		Verify that w	when pH is out of the nominal value during	g a period of time an alarm i	is generated	
Function	s Tested	CIV_PLCSW_pH, MEL	CIV_PLCSW_pH, MEL_CIV_pH						
Descri	ption	When pH is over or unde	When pH is over or under the set point +/- dead band, during more than 15 minutes continuously, an alarm is generated and Supervision shall display the alarm condition.						
Special Re	equisites:	Use APS to generate the	Jse APS to generate the pH value						
Test	ter:		Date:						
	Course of Actions								
Step no			Description	Expected value	OK/NOK	Comments			
1	In the M	MEL_CIV_pH set the pH set point to 6							
2	With th	ne APS set 2.9±0.5	5 V to CIV_N	/IV_pH (AI 05)					
3	Check i	in the MEL_CIV_pH display pH value 6.65±0.1							
4	Wait 15	minutes							
5	Check a	after 15 minutes, t	fter 15 minutes, the pH alarm has been notified to Supervision.						

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5.7 MEL-CIV-TP-07: Initial Values

5.7.1 Purpose

When PLC is restarted, default initial values are loaded into program parameters. It shall be verified that these default values are properly defined, since the PLC will use this parameters immediately after is restarted.

5.7.2 Features to be tested

Verify default values loaded into the PLC used when it is restarted.

5.7.3 Procedure Steps

- 1. Stop the PLC
- 2. Load last program version into the PLC
- 3. Start the PLC
- 4. With the Concept tool Reference Data Editor, check that initial values are as in the following table:

TC Identifier	IEL-CIV-TP-07	Purpose	Check that	correct initial values are used at PLC restart		
Tester:		Date:				
Variable name	Туре	Address	Init. Value	Description	OK	
CIV_CNS_AcKp	REAL	400544	100.0	Acid pump regulator proportional constant.		
CIV_CNS_BsKp REAL		400546	100.0	Base pump regulator proportional constant.		
CIV_CNS_CO2_Kd	REAL	400552	0.01	CO2 flow regulator derivate constant for PID		
CIV CNS CO2 KI	RFΔI	100550	100.0	CO2 flow regulator integration constant for PID		
CIV_CNS_CO2_Kp	REAL	400548	5.0	CO2 flow regulator proportional constant for PID		
CIV CNS ConvV	RFΔI	400518	10	Density factor to translate Ko. to liters		
CIV CNS DW	RFAI	400542	10	Constant to calculate hiomass dry weight		
CIV_CNS_Li1FrA	REAL	400512	18.315	Parameter A for liquid input pump 1 set point calc		
CIV_CNS_Li1FrB	REAL	400514	14 11.0989 Parameter B for liquid input pump 1 set point calc			
CIV_CNS_Li2FrA REAL 400538			16.103	Parameter A for liquid input pump 2 set point calc		
CIV_CNS_Li2FrB REAL		400540	0.8534	Parameter B for liquid input pump 2 set point calc		
CIV_CNS_LoFrA REAL		400510	15.0	Parameter A for liquid output pump set point calc		
CIV_CNS_LoFrB	REAL	400516	1.0	Parameter B for liquid output pump set point calc		
CIV_CNS_MaxPress	REAL	400524	0.02	Maximum allowed pressure in the reactor		
CIV_CNS_MinV	RFAI	400500	10.0	Minimum volume to switch liquid input tank		
CIV CNS OffsetCO2	RFAI	400536	0.0	Offset to provided a constant flux of CO2 to the		
CIV_CNS_OpModeB	P Integer	400566	0	Biomass Production control mode (0=Off, 1=Auto,		
CIV CNS OpMode	as Integer	400568	0	Gas control mode (0=Off, 1=Auto, 2=Manual)		
CIV CNS OpModep	H Integer	400567	0	pH control mode ((0=Off, 1=Auto, 2=Manual)		
CIV_CNS_pHMode	Integer	400565	1	pH regulation mode parameter (1=CO2 only, 2=CO2+Base, 3=Base+Acid)		
CIV SSP I 1RP	RFAI	400554	0 0	Level 1 Riomass production set-point		
CIV_SSP_Fgex	REAL	400532	0.0	Gas flow external input supervision set point		
CIV_SSP_Fgi	REAL	400526	26 0.0 Gas flow at input regulation supervision set po			
CIV_SSP_Fgo REAL 400528 0.0 Ga		Gas flow at output regulation supervision set point				
CIV_SSP_L1LiFr	REAL	400508	0.0	Level 1 Liquid input flow rate set-point		
CIV_SSP_Light REAL		400520	0.0	Light Supervision set point.		
CIV SSP NomPress	RFAI	400522	0.01	Nominal pressure in the reactor		

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TC Identifier	MEL-CIV-TP-07	Purpose	Check that correct initial values are used at PLC restart		
Tester:		Date:			
Variable name	Туре	Address	Init. Value	Description	OK
CIV SSP T	RFAI	400562	36.0	Temperature set-point fixed by the supervision	
CIV_SSP_pH	REAL	400534	9.5	pH set-point fixed by the supervision	

5. If one or more initial values differ from those in the table then follow the procedure defined in the Operations Manual [R9], section 9.2 to update.



5.8 MEL-CIV-TP-08: Check Sensor / Actuator Link Errors

5.8.1 Purpose

When a current (4-20 mA) analogue input / output is disconnected (link error) the status shall be notified to the supervision.

5.8.2 Features to be tested

Verify link errors are notified to the supervision as specified. Verify safety values are set to measured variables when a link error occurs.

5.8.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIV-TC-0801	Check link errors on analogue inputs
MEL-CIV-TC-0802	Check link errors on analogue outputs

5.8.4 Procedure Steps

Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.



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5.8.5 MEL-TC-CIV-0801: Check Link Errors on Analogue Inputs

TC Ider	ntifier	ier MEL-TC-CIV-0801 Purpose: Verify that when a current analogue input connection is broken is notified to supervision								
Functions	s Tested	CIV_PLCSW_pH, MEL	CIV_pH		111.1					
Descrip	ption	All current inputs shall h	e displayed in the s	supervision as alarms and safety values are displ	ayed blinking in the super	rvision screens.				
Special Ke	er.	An current inputs shan t	be disconnected	Date						
Itst				Course of A	Actions					
Step no				Description		Expected value	OK/NOK	Comments		
1	In the I	MEL_CIV_BP su	pervision dis	play check Biomass Concentration	on value	1.0 (Blinking)				
2	In the M	MEL_CIV_BP su	pervision dis	play check Tank 1 volume value	e	0.0 (Blinking)				
3	In the MEL_CIV_BP supervision display check Tank 2 volume value									
4	In the M	MEL_CIV_Gas su	upervision di	splay set pressure set point to 1.	C					
5	In the M	MEL_CIV_Gas su	upervision di	splay check Pressure (P) value		1.0 (Blinking)				
6	In the M	MEL_CIV_Gas su	upervision di	splay check O2 value		0.0 (Blinking)				
8	In the MEL_CIV_Gas supervision display check CO2 value									
9	In the MEL_CIV_Gas supervision display check DO value									
10	In the MEL_CIV_Temp supervision display set Temperature set-point to 27 °C									
11	In the M	MEL_CIV_Temp	supervision	display check Temperature value	e	27.0 (Blinking	g)			
13	In the M	MEL_CIV_pH su	pervision dis	play set pH set-point to 6.5						
14	In the M	MEL_CIV_pH suj	pervision dis	play check pH value		6.5 (Blinking)				
15	In the I	MEL_CIV_Main	supervision c	display check Biomass Concentr	ation value	1.0 (Blinking)				
16	In the M	MEL_CIV_Main	supervision d	lisplay check Pressure value		1.0 (Blinking)				
17	In the M	MEL_CIV_Main	supervision c	display check O2 value		0.0 (Blinking)				
18	In the M	MEL_CIV_Main	supervision d	lisplay check CO2 value		0.0 (Blinking)				
19	In the M	MEL_CIV_Main	supervision d	lisplay check DO value		0.0 (Blinking)				
20	In the I	MEL_CIV_Main	supervision c	display Temperature value		27.0 (Blinking	g)			
21	In the M	MEL_CIV_Main	supervision d	lisplay pH value		6.5 (Blinking)				
22	Check	following alarms	are fired:							
	- Ala	rm to notify O2 s	ensor link er	ror						
	- Ala	rm to notify biom	nass sensor li	nk error						
	- Alarm to notify DO sensor link error									
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TC Identifier	MEL-TC-CIV-0801 Purpose:	Verify that when a current analogue input connection	is broken is notified to supe	ervision					
Functions Tested	CIV_PLCSW_pH, MEL_CIV_pH								
Description	Errors on sensor links are displayed in the s	upervision as alarms and safety values are displayed blinking in the supervision screens.							
Special Requisites:	All current inputs shall be disconnected								
- Ala	- Alarm to notify CO2 sensor link error								
- Ala	arm to notify pressure sensor li	nk error							
- Ala	arm to notify pH sensor link er	ror							
- Ala	- Alarm to notify Temperature sensor link error								
- Alarm to notify scale1 sensor link error									
- Ala	arm to notify scale2 sensor link	error							

5.8.6 MEL-TC-CIV-0802: Check Link Errors on Analogue Outputs

TC Ider	ntifier	MEL-TC-CIV-0802	Purpose:		Verify that	when a current analogue output connection	n is broken is notified to sur	pervision				
Functions	s Tested	CIV_PLCSW_pH, MEL_C	IV_pH									
Descrip	ption	Errors on actuator links are	displayed in the	supervision as alarms								
Special Re	equisites:	All current outputs shall be	disconnected									
Test	Tester: Date:											
	Course of Actions											
Step no				Expected value	OK/NOK	Comments						
									<u> </u>			
1	Check t	following alarms are	e fired:									
	$-\Delta 1a$	rm to notify acid pu	ımn link er	ror								
	- Ala	ini to notify actu pu	imp mix ci	101					1			
	- Alarm to notify base pump link error											
	- Ala	Alarm to notify light supply link error										

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5.9 MEL-CIV-TP-09: Check operational modes

5.9.1 Purpose

Each loop (Biomass, pH, Gas) allows the selection of the operational mode: OFF: Outputs are set to 0

AUTO: Outputs are set with the value resulting of the control action.

MAN: Outputs are set to manual values (provided by the Supervision from each loop Supervision displays).

5.9.2 Features to be tested

Verify changing operational modes outputs are set as specified.

5.9.3 Test Cases

Following Test Cases are executed in this Test Procedure:

Identifier	Name
MEL-CIV-TC-0901	Check Biomass Production loop operational modes.
MEL-CIV-TC-0902	Check Gas loop operational modes
MEL-CIV-TC-0903	Check pH loop operational modes

5.9.4 Special Requirements

Table of Outputs that participates in the regulation loops: Ty (Type) = RL: Relay, AO: Analogue Output

Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIV_RL_Li1	RL	01	Relay to activate liquid	CIV_CP	170	+	24V
			Input pump 1		174	-	1
CIV_RL_Li2	RL	02	Relay to activate liquid	CIV_CP	178	+	24V
			input pump 2		182	-	
CIV_RL_Cx	RL	03	Relay output to activate	CIV_AC_OUT	01	AC L	220 VAC
			aeration of biomass		03	AC N	
			sensor for cleaning		05	GND	
CIV_RL_Fg	RL	04	Pressure safety valve	CIV_AC_OUT	07	AC L	220 VAC
			activation		09	AC N	
					11	GND	
CIV SP ErCO2	40	01	CO2 Flow rate set-point		129	+	0 – 5 V
010_01_11002	70	01			133	-	
CIV SP Eqi	AO	02	Gas input Flow rate set-		137	+	0 – 5 V
	//0	02	point		141	-	
	۸0	02	Gas output Flow rate		145	+	0 – 5 V
CIV_SF_Fg0	AU	03	set-point		149	-	
	40	04	Gas external input Flow		153	+	0 – 5 V
		04	rate set-point		157	-	
	2210	DI (1 T		D	54 6140

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Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIV_SP_Li1	AO	05	Liquid input tank 1 Flow rate set-point		161 165	+ -	0 – 5 V
CIV_SP_Li2	AO	06	Liquid input tank 2 Flow rate set-point		169 173	+ -	0 – 5 V
CIV_SP_LO	AO	07	Liquid output Flow rate Control set-point		177 181	+ -	0 – 5 V
CIV_SP_Bs	AO	09	Base Flow rate set-point		193 197	+ -	4 – 20 mA
CIV_SP_Ls	AO	10	Light supply Radiation set-point		201 205	+ -	4 – 20 mA
CIV_SP_Ac	AO	11	Acid Flow rate set-point		209 213	+	4 – 20 mA

Devices needed in this test procedure:

- 1 Multimeter to measure analogue current / voltage outputs
- 2 Pilot lights 220 VAC

5.9.5 Procedure Steps

Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.



5.9.6 MEL-TC-CIV-0901: Check Biomass Production Loop Operational Modes

TC Ide	ntifier	fier MEL-TC-CIV-0901 Purpose: Verify when operational mode is changed in the Biomass Production Loop, outputs are set as specified									
Function	s Tested	CIV_PLCSW_Biomass, CIV_PLCSW_Light, CIV_PLCSW_Liquid, MEL_CIV_BP									
Descri	ption	From the Biomass Production supervision screen it is possible to change the operational mode and set the manual values.									
Special Re	equisites:	Use a Multimeter to measure expected outputs Use MEL_CIV_BP supervision screen to change operational modes and manual values.									
Test	ter:	Date:									
		Course of Actions	1								
Step no	To the N	Description	Expected value	OK/NOK	Comments						
	In the r	AEL_CIV_BP supervision screen set operational mode to OFF									
2	Apply	a 1 KOnm resistor to CIV_SP_Ls output (AO 10)									
	Connec	t a pilot light to CIV_RL_Cx									
3	Check	Pilot light	OFF								
4	Check	CIV_SP_Li1 voltage output	0±0.1 V								
5	Check	CIV_SP_Li2 voltage output	0±0.1 V								
6	Check	CIV_SP_LO voltage output	0±0.1 V								
8	Check	CIV_RL_Li1 voltage output	OPEN								
9	Check	CIV_RL_Li2 voltage output	OPEN								
10	Check	CIV_SP_Ls voltage output	4±0.1 V								
11	In the I	AEL_CIV_BP edit the manual values and set:									
	Activat	e valve to clean biomass sensor: checked									
	Enable	liquid input pump 1: checked									
	Liquid	input pump 1 set-point (0-100%): 10									
	Enable	liquid input pump 2: checked									
	Liquid	input pump 2 set-point (0-100%): 20									
	Liquid	output pump set-point (0-100%): 30									
	Light s	upply set-point (0-100%): 50									
13	In the M	AEL_CIV_BP supervision screen set operational mode to MAN									
14	Check	Pilot light	ON								
15	Check	CIV_SP_Li1 voltage output	0.5±0.1 V								
16	Check	CIV_SP_Li2 voltage output	1.0±0.1 V								

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TC Ider	ntifier	MEL-TC-CIV-0901	Purpose:	Verify when operational mode is changed in the Biomass Pro	oduction Loop, outputs are	set as specified	1		
Functions	s Tested	CIV_PLCSW_Biomass,	CIV_PLCSW_Lig	ht, CIV_PLCSW_Liquid, MEL_CIV_BP					
Descrip	otion	From the Biomass Produ	uction supervision s	creen it is possible to change the operational mode and set the manual values.					
Special Re	quisites:	Use a Multimeter to me	meter to measure expected outputs						
	Use MEL_CIV_BP supervision screen to change operational modes and manual values.								
17	Check	CIV_SP_LO voltage output 1.5±0.1 V							
18	Check	CIV_RL_Li1 vol	tage output		CLOSED				
19	Check CIV_RL_Li2 voltage output				CLOSED				
20	Check CIV_SP_Ls voltage output 12±0.1 V								

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5.9.7 MEL-TC-CIV-0902: Check Gas Loop Operational Modes

TC Ide	ntifier	MEL-TC-CIV-0902	Purpose:	Verify v	when operational mode is changed in the	Gas Loop, outputs are set as s	specified				
Function	s Tested	CIV_PLCSW_Gas, MEL_C	CIV_Gas								
Descri	ption	From the Gas regulation sup	pervision screen	it is possible to change the operational mode a	and set the manual values.						
Special Re	equisites:	Use a Multimeter to measur	re expected outp	uts							
		Use MEL_CIV_Gas superv	rision screen to c	hange operational modes and manual values.							
Test	er:			Date:							
	Course of Actions										
Step no				Description	Expected value	OK/NOK	Comments				
1	In the M	In the MEL_CIV_BP supervision screen set operational mode to OFF									
	Connec	nect a Pilot light to CIV_RL_Fg									
2	Check	Pilot light				OFF					
3	Check	CIV_SP_Fgi voltage	output			0±0.1 V					
4	Check	CIV_SP_Fgo voltage	e output			0±0.1 V					
5	Check	CIV_SP_Fgex voltag	ge output			0±0.1 V					
6	In the M	MEL_CIV_Gas edit	l values and set:								
	Enable	le Pressure safety valve: checked									
8	In the M	MEL_CIV_Gas supe	ervision sci	reen set operational mode to M	AN						
9	Check	Pilot light				ON					

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5.9.8 MEL-TC-CIV-0903: Check pH Loop Operational Modes

TC Identifier		MEL-TC-CIV-0903 Purpose: Verify when operational mode is changed in the pH Loop, outputs are set as specified										
Functions Tested		CIV_PLCSW_pH, MEL_CIV_pH										
Description		From the pH regulation supervision screen it is possible to change the operational mode and set the manual values.										
Special Requisites:		Use a Multimeter to measure expected outputs										
		Use MEL_CIV_pH super	Use MEL_CIV_pH supervision screen to change operational modes and manual values.									
Test	ter:				Date:							
					Course of A	Actions						
Step no				Description				Expected value	OK/NOK	Comments		
1	In the M	MEL_CIV_pH sup	pervision scr	een set operational mo	ode to OFF	7						
2	Apply	1 Kohm registor	to CIV SD	P_{α} (AO 00) and CIV	SD Ag(A	0 11)						
	Apply	a 1 Komm resistor to CIV_SP_DS (AO 09) and CIV_SP_AC (AO 11)										
3	<u>C</u> 11.							4+0.1 V				
C	Спеск	CIV_SP_Bs voltage			12011							
4								4+0.1 V				
	Check	CIV_SP_Ac voltage	e output			120.1						
5	5 61 1 011/ 07 5 000 1/						0+0.1 V					
	Спеск	CIV_SP_FrCO2 voltage output						0_011 +				
6	In the M	MEL_CIV_pH edit the manual values and set:										
	Acid n	imp set-point (0-1	00%) · 10									
	Docom	p_{1} set point (0 100%): 10										
	Dase p	pump set-point $(0-100\%)$: 20										
	CO2 Fl	Tow Rate set-point (0-5 nLm): 2.5										
8	In the M	e MEL_CIV_pH supervision screen set operational mode to MAN										
9	Check	Check CIV SP Ac voltage output						5.6±0.1 V				
	Check CIV SP. Be voltage output							7.2±0.1 V				
	Check CIV SP FrCO2 voltage output							2.5±0.1 V				
	CINCOR	00 1002 10	nuge suipui									

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6 COMPARTMENT III SYSTEM TEST PROCEDURES

These Test Procedures are implemented to verify the system from a functional approach. Therefore, each Test Procedure (TP) verifies a high level function (as for example biomass regulation for a compartment). Test Procedures include one or more Test Cases that shall be executed as part of the procedure.

Identifier Name Description MEL-CIII-TP-01 Test point to point connectivity for the Point to point connectivity test electrical interfaces. Test electrical isolation MEL-CIII-TP-02 **Electrical Isolation** MEL-CIII-TP-03 Check Interfaces End Test value ranges, communication with the to End supervision, supervision displays MEL-CIII-TP-04 pH Regulation Test pH regulation Test liquids flow rates regulation MEL-CIII-TP-05 Liquid flows regulation MEL-CIII-TP-06 Gas flows regulation Test gas flow rates regulation MEL-CIII-TP-07 Temperature Test temperature regulation regulation MEL-CIII-TP-08 Initial values Test parameters initial values when PLC is restarted MEL-CIII-TP-09 Sensor/Actuator Link Test errors on sensors / actuators links are handled as specified. Errors MEL-CIII-TP-10 Operational modes Test changes in outputs caused by changing the operational mode (OFF, AUTO, MAN)

The following Test Procedures are specified in the following sections:

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6.1 MEL-CIII-TP-01: Point to point connectivity test procedure

6.1.1 Purpose

- Identify all components are deployed as specified in the HDD.
- Verify electrical connections are implemented as defined in the HDD.

6.1.2 Description

CAUTION This test procedure must be executed without powering the rack.

This test procedure is performed using a device that checks the electrical connectivity between two points (e.g. a multi-meter). Connections to check for Compartment III are specified in ANNEX B. This ANNEX define a template that shall be included as part of the Test Report.

6.1.3 Expected outcome

All connections specified in the template are checked OK.

6.1.4 Procedure steps

1. Check all connections specified in the template and mark if there is conductivity or not.



6.2 MEL-CIII-TP-02: Electrical isolation

6.2.1 Purpose

Check that electrical isolation between AC L and GND and AG N and GND is performed according to applicable regulations.

6.2.2 Description

CAUTION This test procedure must be executed without powering the rack.

This test procedure is performed using a device that insulates 1500 V between AC L and GND and AC N and GND during a fixed period of time (60 seconds) to check that isolation in cabling, connectors and 220 VAC powered devices, is properly dimensioned.

6.2.3 Special requirements

A Dielectric Withstanding Electrical Test device is needed to execute this test procedure. The device outputs 1500 V during a limited time and controls current is not over a defined value.

6.2.4 Expected outcome

Device response indicates test passed OK.

6.2.5 Procedure steps

- 1. Program device to output 1500 V during 60 seconds and limited current to 30 mA.
- 2. Connect device output to CIII_AC_IN pin 01 (AC L) and CIII_AC_IN pin 03 (GND).
- 3. Activate device to perform the verification.
- 4. Connect device output to CIII_AC_IN pin 02(AC N and CIII_AC_IN pin 03 (GND).
- 5. Activate device to perform the verification.
- 6. Annotate verification results.



6.3 MEL-CIII-TP-03 Check Interfaces end-to-end

6.3.1 Purpose

Check that signals applied on inputs are transmitted to Supervision and values fixed by the Supervision are transmitted to outputs adequately, with the correct ranges.

6.3.2 Features to be tested

Verify integration and functionality of the following items:

- PLC Rack I/O Interface (CIV_CP)
- Supervision PLC Interface (Software interface)

6.3.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIII-TC-0301	Check analogue inputs
MEL-CIII-TC-0302	Check analogue outputs
MEL-CIII-TC-0303	Check digital inputs
MEL-CIII-TC-0304	Check digital outputs

6.3.4 Special Requirements

To execute this procedure following devices will be necessary:

- Multimeter (to measure analogue outputs)
- Adjustable Power Supply (to generate known values)
- Resistances 500 ohm (to allow measuring 4-20 mA outputs)

The values can be monitored from the Supervision Real Time Database display (iFix Database Manager application).

<u>Table of inputs / outputs</u>	

Variable Name	Тр.	N.	Description	Connector	Pin	Signal	Range
CIII MV Dob	ΔΙ	01	DO at bottom	CIII_CP	001	+	4 – 20 mA
		01			005	-	
	A1	02	DO at top		009	+	4 – 20 mA
		02			013	-	
	A 1	02	Ammonium		017	+	4 – 20 mA
		03	concentration		021	-	
	Δ1	04	Nitrate concentration		025	+	4 – 20 mA
		04			029	-	
	A 1	05	Pressure at top of the		033	+	4 – 20 mA
	AI	05	gas phase		037	-	

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Variable Name	Tp.	N.	Description	Connector	Pin	Signal	Range
CIII_MV_PHb	AI	06	pH at bottom		041 045	+	4 – 20 mA
CIII_MV_PHt	AI	07	pH at Top		049	+	4 – 20 mA
CIII MV Psl	AI	08	Pressure sensor for the		053	+	4 – 20 mA
		00	sampling line Temperature at bottom		061 065	- +	4 – 20 mA
	AI	09			069	-	0 51/
CIII_MV_Tt	AI	10	Temperature at top		073 077	+ -	0 – 5 V
CIII_SP_CO2	AO	01	CO2 input flow regulation		129 133	+ -	0 – 5 V
CIII_SP_N2	AO	02	N2 flow regulation		137 141	+ -	0 – 5 V
CIII_SP_O2	AO	03	O2 flow regulation		145 149	+	0 – 5 V
CIII SP Ac	AO	05	Acid pump flow		143	+	4 – 20 mA
	/.0	00	regulation		165	-	
CIII_SP_Bs	AO	06	Base pump flow		169	+	4 – 20 mA
			regulation		175	-	
CIII_SP_Lin	AO	07	Liquid input pump flow		177 181	+ -	4 – 20 mA
			regulation		405	_	1 00 m A
CIII_SP_LO	AO	08	Liquid output pump flow regulation		185	-	4 – 20 MA
CIII_IND_CaINH 4	DI	01	NH4 Analyser calibration indicator		193 197	+ -	0 – 24 V
CIII_IND_CaINO 3	DI	02	Nitrate analyser calibration indicator		002 006	+ -	0 – 24 V
CIII_MV_Llow	DI	03	Level measurement low		010	+	0 – 24 V
CIII_MV_Lhigh	DI	04	Level measurement high		018	+	0 – 24 V
		05	Indiantar of may layer		022	-+	0 – 24 V
		05	reached for a buffer tank		028	-	
CIII_RL_Lbt	DO	01	Activation of the pump for the buffer tank		122 126	+ -	0 – 24 V
CIII_AC_AC	DO	02	Relay acid pump	CIII_AC_OUT	001 003	AC L AC N	220 VEF
	D		Dalar		005 007	GND AC I	220 VEF
CIII_AC_BS	סט	03	Relay base pump		009	AC N	
		04	Compressor activation		013	AC L	220 VEF
		04			015	AC N	
	00	05	Open/close the cooling		019	AC L	220 VEF
			valve		021 023	AC N GND	

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Variable Name	Тр.	N.	Description	Connector	Pin	Signal	Range
CIII_AC_Heat	DO	06	Activate Heater		025 027 029	AC L AC N GND	220 VEF
CIII_RL_Lp	DO	07	Relay to have a pulse in the level sensor lecture	CIII_CP	11 19	+ +	24 V
CIII_AC_Safe	DO	08	Activation of Pressure Safety Valve	CIII_AC_OUT	31 33 35	AC L AC N GND	220 VEF

6.3.5 Procedure Steps

Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.

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6.3.6 MEL-TC-CIII-0301: Check analogue inputs

TC Idei	ntifier	MEL-TC-CIII-0301	Purpose:	V	erify that analogue inpu	its are connecte	d, acquired, supervised	d and ranged as specified	
Functions	s Tested	Interface between CIII_	CP – CIII_PLC –	Supervision					
Descrip	ption	Known values applied to	o analogue inputs	shall be displayed in the S	Supervision ranged as s	pecified.			
Special Re	equisites:	Values to apply / check	must be between t	he indicated range		1			
Test	er:			~	Date:				
	1				rse of Actions				OKNOK
Step no	A 1	1 1 0 1/4 41 01		Description	4 1 1 1	1 DOI	. 0/1	Expected value	OK/NOK
1	Apply	$1 - 1.2 \vee \text{to AI 0}$		DOD) and check	the displayed va	alue DObo	t % in the	0 - 5	
	Superv	ision screen MEI	CIII_GAS	•					
2	Apply 4	4.8 - 5 V to AI 02	l (CIII_MV_	Dob) and check	the displayed v	alue DObo	ot % in the	95 - 100	
	Superv	ision screen MEI	_CIII_GAS						
3	Apply	1 - 1.2 V to AI 02	2 (CIII_MV_	Dot) and check	the displayed va	lue DOtop	% in the	0 - 5	
	Superv	ision screen MEI	CIII_GAS	•	1.0	1			
4	Apply 4	4.8 - 5 V to AI 02	2 (CIII MV	Dot) and check	the displayed va	lue DOtor	% in the	95 - 100	
	Superv	ision screen MEI	L_CIII_GAS	- ,	1 2	1			
5	Apply	1 - 1.2 V to AI 03	3 (CIII MV	NH4) and check	the displayed v	alue NH4	in the	0 - 10	
	Superv	ision screen MEI	CIII_Liqu	id.					
6	Apply 4	4.8 - 5 V to AI 03	3 (CIII_MV_	NH4) and check	the displayed v	alue NH4	in the	190 - 200	
	Superv	ision screen MEI	L_CIII_BP.						
7	Apply	$1 - 1.2$ V to AI 0^{4}	4 (CIII_MV_	NO3) and check	the displayed v	value NO3	in the	0-50	
	Superv	ision screen MEI	CIII_Liqu	id.					
8	Apply 4	4.8 - 5 V to AI 04	(CIII_MV_	NO3) and check	the displayed v	alue NO3	in the	950 - 1000	
	Superv	ision screen MEI	CIII_Liqu	id.	1				
9	Apply	1 - 1.2 V to AI 05	5 (CIII_MV_	P) and check the	e displayed valu	e P in the	Supervision	0-50	
	screen	MEL_CIII_Gas.					-		
10	Apply 4	4.8 - 5 V to AI 05	5 (CIII_MV_	P) and check the	e displayed valu	e P in the	Supervision	950 - 1000	
	screen	MEL_CIII_Gas.							
11	Apply	1 - 1.2 V to AI 00	5 (CIII_MV_	PHb) and check	the displayed v	alue pHbc	ot in the	3-3.5	
	Superv	ision screen MEL	_CIII_pH.						
12	Apply 4	4.8 - 5 V to AI 06	5 (CIII_MV_	PHb) and check	the displayed v	alue pHbo	t in the	12.5 – 13	

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TC Ide	entifier	MEL-TC-CIII-0301 Purpose: Verify that analogue inputs are connected, acquired, supervised	and ranged as specified	
Function	s Tested	Interface between CIII_CP – CIII_PLC – Supervision		
Descri	ption	Known values applied to analogue inputs shall be displayed in the Supervision ranged as specified.		
Special R	equisites:	Values to apply / check must be between the indicated range		
Test	ter:	Date:		
		Course of Actions		
Step no		Description	Expected value	OK/NOK
	Superv	ision screen MEL_CIII_pH.		
13	Apply	1 – 1.2 V to AI 07 (CIII_MV_PHt) and check the displayed value pHtop in the	1.5 - 2	
	Superv	ision screen MEL_CIII_pH.		
14	Apply	4.8 - 5 V to AI 07 (CIII_MV_PHt) and check the displayed value pHtop in the	11 – 11.5	
	Superv	ision screen MEL_CIII_pH.		
15	Apply	1 – 1.2 V to AI 09 (CIII_MV_Tb) and check the displayed value Temperature in the	0.2 - 7.54	
	Superv	ision screen MEL_CIII_Temp.		
16	Apply	4.8 - 5 V to AI 09 (CIII_MV_Tb) and check the displayed value Temperature in the	139.66 - 147	
	Superv	ision screen MEL_CIII_Temp.		
17	Apply	1 – 1.2 V to AI 10 (CIII_MV_Tt) and check the displayed value Temperature in the	0.2 - 7.54	
	Superv	ision screen MEL_CIII_Temp.		
18	Apply	4.8 - 5 V to AI 10 (CIII_MV_Tt) and check the displayed value Temperature in the	139.66 - 147	
	Superv	ision screen MEL_CIII_Temp.		

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6.3.7 MEL-TC-CIII-0302: Check analogue outputs

TC	ldentifier	MEL-TC-CIII-0302	Purpose:	V	verify that analogue	inputs are connected, acquired and super	vised as specified	
Funct	ions Tested	Interface between CIII_0	CP – CIII_PLC – S	upervision				
Des	cription	Known values applied to will be checked by other	o Supervision varia TC.	bles shall be translated to th	e analogue outputs v	within the ranges specified. Only outputs	with direct set-points are ch	ecked, the rest
Special	Requisites:	Use a Multimeter to mea	asure voltage outpu	its				
Т	ester:				Date:			
<u></u>	1			Course	e of Actions		E	OKNOK
Step no	Set regul	ation mode to MA	N to all loor	Description			Expected value	OK/NOK
2	In the sur	attoit mode to MF	IT to all loop	Jadit manual valu	as and sat the	value 0 to "CO2 Flow set	$0 V \pm 0 1$	
2	noint" on	d maagura AO 01	net_ent_pi	i cuit manual valu	es and set me	value 0 to CO2 Flow set	$0 \neq \pm 0.1$	
2	In the out	u illeasule AO 01	I CIII m	Ladit manual yalu	ag and gat the	value 100 to "CO2 Flow	5 V 10 1	
3	In the sup	and massure AC	value 100 to CO2 Flow	$5 V \pm 0.1$				
4		and measure AC			1 / 1		0.11.10.1	
4	In the sup	pervision screen N	AEL_CIII_G	as edit manual vali	ues and set the	e value 0 to "N2 Flow set	$0 \vee \pm 0.1$	
	point" an	d measure AO 02	output volts	•				
5	5 In the supervision screen MEL_CIII_Gas edit manual values and set the value 150 to "N2 Flow							
	set point"	and measure AC	02 output v	olts.				
6	In the sup	pervision screen N	AEL_CIII_G	as edit manual valu	ues and set the	e value 0 to "O2 Flow set	0 V ±0.1	
	point" an	d measure AO 03	output volts					
7	In the sup	pervision screen N	AEL_CIII_G	as edit manual valu	ues and set the	e value 100 to "O2 Flow	5 V ±0.1	
	set point"	and measure AC	03 output v	olts.				
8	Apply a 5	500 ohm resistor t	to AO 05					
9	In the sup	pervision screen N	/IEL_CIII_pl	H edit manual valu	es and set the	value 0 to "Acid pump set	2 V ±0.2	
	point" an	d check "Enable A	Acid pump".	Measure AO 05 of	utput volts.			
10	In the sup	pervision screen N	/IEL_CIII_pl	H edit manual valu	es and set the	value 100 to "Acid pump	10 V ±0.2	
	set point"	and measure AC	05 output v	olts.				
11	Apply a 5	500 ohm resistor t	o AO 06					
12	In the sup	pervision screen N	value 0 to "Base pump set	2 V ±0.2				
	point" an	d check "Enable l	base pump".	Measure AO 06 ou	utput volts.			
13	In the sup	pervision screen N	/IEL_CIII_pl	Hedit manual valu	es and set the	value 100 to "Base pump	10 V ±0.2	

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TC	ldentifier	MEL-TC-CIII-0302	Purpose:	Verif	y that analogue	inputs are connected, acquired and supe	rvised as specified		
Functi	ions Tested	Interface between CIII_	CP – CIII_PLC – S	ipervision					
Des	cription	Known values applied to	nown values applied to Supervision variables shall be translated to the analogue outputs within the ranges specified. Only outputs with direct set-points are checked, the rest						
	D	Will be checked by other	f IC.	4					
Special	Requisites:	Use a Multimeter to me	asure voltage outpu	ts					
Т	ester:				Date:				
				Course of	Actions				
Step no				Description			Expected value	OK/NOK	
	set point'	' and measure AC	06 output v	olts.					
14	Apply a 5	500 ohm resistor (
15	In the supervision screen MEL CIII Liquid edit manual values and set the value 0 to "Liquid								
	input pur	np set point" and	measure AO	07 output volts.		1			
16	In the sur	pervision screen N	AEL CIII Li	ouid edit manual valu	ies and set	the value 100% to "Liquid	10+0.2 V		
_	input pur	np set point" and	measure AO	07 output volts.		1	10_0.2		
17	Apply a 5	500 ohm resistor (to AO 08	•					
18	In the sup	pervision screen N	AEL CIII Li	quid edit manual valu	ues and set	the value 0 to "Liquid	2 ±0.2 V		
	output pu	mp set point" and	1						
19	In the supervision screen MEL CIII Liquid edit manual values and set the value 100 to "Liquid								
	output pu	mp set point" and	d measure A	08 output volts.		1			

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6.3.8 MEL-TC-CIII-0303: Check digital inputs

TC Ide	ntifier	MEL-TC-CIV-0303	Purpose:	Verify that digital i	nputs are connected, acquired and supervise	sed as specified	
Function	s Tested	Interface between CIII_0	CP - CIII_PLC - S	apervision			
Descri	ption	Status set to digital input	s shall be translate	to the supervision as specified.			
Special Re	equisites:				T		
Test	ter:			Date:			
				Course of Actions			_
Step no				Expected value	OK/NOK		
1	Set DI	01 in open circuit	Liquid, indicator	Disabled			
	"Calibr	rating" in NH4		-	-		
2	Set DI	01 in closed circu	it and check	in supervision screen MEL CI	II Liquid, indicator	Enabled	
	"Calibr	rating" in NH4		1 –			
3	Set DI	02 in open circuit	and check in	n supervision screen MEL_CIII	Liquid, indicator	Disabled	
	"Calib	rating" in NO3		· _ ·			
4	Set DI	02 in closed circu	it and check	in supervision screen MEL_CI	II_Liquid, indicator	Enabled	
	"Calibi	rating" in NO3					
5	Set DI	03 in open circuit	and check in	n supervision screen MEL_CIII	Liquid, indicator "Level	Enabled	
	Low" i	n Level sensor		-	— 1 /		
6	Set DI	03 in closed circu	it and check	in supervision screen MEL CI	II Liquid, indicator "Level	Disabled	
	Low" i	n Level sensor		1 –	— 1 /		
7	Set DI	04 in open circuit	Liquid, indicator "Level	Disabled			
	High"	in Level sensor					
8	Set DI	04 in closed circu	it and check	in supervision screen MEL_CI	II_Liquid, indicator "Level	Enabled	
	High"	in Level sensor					

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6.3.9 MEL-TC-CIII-0304: Check digital outputs

TC Ide	entifier	MEL-TC-CIV-0304 Purpose: Verify that digital outputs are connected, acquired and supervi	sed as specified							
Function	ns Tested	Interface between CIII_CP – CIII_PLC – Supervision								
Descri	iption	Manual values applied to Supervision shall be translated to the digital outputs within the ranges specified. Only outputs with manual check the rest	values are checked, function	onal TC will						
Special R	equisites:	Connect lights to 220 VEF relay outputs to check status								
Test	ter:	Date:								
		Course of Actions								
Step no		Description	Expected value	OK/NOK						
1	Set reg	ulation mode to MAN to all loops.								
2	In the s	supervision screen MEL_CIII_Liquid edit manual values and enable "Output buffer tank	Closed							
	pump A	Activation" and check DO 01 connectivity.								
3	In the s	supervision screen MEL_CIII_Liquid edit manual values and disable "Output buffer tank	Open							
	pump A	Activation" and check DO 01 connectivity.	_							
4	In the s	supervision screen MEL_CIII_pH edit manual values and enable "Acid pump activation"	On							
	and che	eck DO 02 light status.								
5	In the s	supervision screen MEL_CIII_pH edit manual values and disable "Acid pump activation"	Off							
	and me	asure DO 02 light status.								
6	In the s	supervision screen MEL_CIII_pH edit manual values and enable "Base pump activation"	On							
	and me	asure DO 03 light status.								
7	In the s	supervision screen MEL_CIII_pH edit manual values and disable "Base pump activation"	Off							
	and me	asure DO 03 light status.								
8	In the s	supervision screen MEL_CIII_Temp edit manual values and enable "Cooling value	On							
	activati	on" and check DO 05 light status.								
9	In the s	supervision screen MEL_CIII_Temp edit manual values and disable "Cooling value	Off							
	activati	on" and check DO 05 light status.								
10	In the s	supervision screen MEL_CIII_Temp edit manual values and enable "Heater activation"	On							
	and che	eck DO 06 light status.								
11	In the supervision screen MEL CIII Temp edit manual values and disable "Heater activation" Off									
	and che	eck DO 06 light status.								
12	In the s	n the supervision screen MEL CIII Gas edit manual values and enable "Enable Pressure safety On								
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TC Ide	entifier	MEL-TC-CIV-0304	Purpose:	Verif	y that digital ou	utputs are connected, acquired and supe	ervised as specified	
Function	s Tested	Interface between CIII_	CP – CIII_PLC – S	apervision				
Descri	ption	Manual values applied t check the rest.	o Supervision shall	be translated to the digital outpu	ts within the ra	nges specified. Only outputs with manu	al values are checked, function	onal TC will
Special Re	ecial Requisites: Connect lights to 220 VEF relay outputs to check status							
Test	Tester: Date:							
				Course of A	Actions			
Step no				Description			Expected value	OK/NOK
	valve"	and check DO 08	B light status.					
13	3 In the supervision screen MEL_CIII_Gas edit manual values and disable "Enable Pressure						Off	
	safety valve" and check DO 08 light status.							

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6.4 MEL-CIII-TP-04 pH Regulation

6.4.1 Purpose

pH regulation controls the pH in the compartment. Two pH probes measure pH and in case of deviation, several actions can be taken depending on the current operation mode:

- Only CO2: When the pH is over the set point, additional CO2 is added. A PI controls CO2 addition.
- CO2 and basic medium: When pH is over the set point, CO2 is added, when is under basic medium is added. A PI controls basic medium/CO2 addition.
- Acid and basic media. When pH is over the set point, acid media is added, when is under, basic media is added. A PI controls both, basic and acid, media addition.

6.4.2 Features to be tested

Verify integration and functionality of the following items:

- Supervision displays:
 - MEL_CIII_Main: Display of the most important values of the CIII compartment.
 - MEL_CIII_pH: pH regulation display.
- Local Control (PLC) program sections:
- CIII_PLCSW_pH: pH regulation.
- PLC Rack I/O Interface
- Supervision PLC Interface

6.4.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIII-TC-0601	pH Regulation with CO2
MEL-CIII-TC-0602	pH Regulation with CO2 and additional
	base medium
MEL-CIII-TC-0603	pH Regulation with Base and Acid
	additional media
MEL-CIII-TC-0604	pH alarms

6.4.4 Special Requirements

Table of I/O that participates in the pH loop:

Ty (Type) = DI: Digital Input, DO: Digital Output, AI: Analogue Input, AO: Analogue Output

Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
	ΔΙ	01	DO at bottom	CIII_CP	001	+	4 – 20 mA
		01			005	-	
CIII MV Dot	A 1	02	DO at top		009	+	4 – 20 mA
		02			013	-	

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Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIII MV PHb	AI	06	pH at bottom	CIII_CP	041	+	4 – 20 mA
	/ ()	00			045	-	
CIII MV PHt	AI	07	pH at Top		049	+	4 – 20 mA
	7.0	01			053	-	
CIII SP Ac	AO	05	Acid nump flow		161	+	4 – 20 mA
	/.0	00	regulation		165	-	
	40	06	Base nump flow		169	+	4 – 20 mA
		00	regulation		173	-	
	۸0	01	CO2 input flow		129	+	0 – 5 V
011_3F_002		01	regulation		133	-	
		02	Relay acid pump	CIII_AC_OUT	001	AC L	220 VEF
		02			003	AC N	
					005	GND	
		03	Relay base pump		007	AC L	220 VEF
		03			009	AC N	
					011	GND	

Devices needed in this test procedure:

- 2 Adjustable Power Supply (APS) to provide current / voltage to analogue inputs
- 1 Multimeter to measure analogue current / voltage outputs
- Lights to check 220 VEF relay outputs.
- 1 Function Generator

6.4.5 Procedure Steps

- Set pH loop operation mode to AUTO.
- Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.



6.4.6 MEL-TC-CIII-0401: pH Regulation with CO2

Immer Tested CIII.PICSW_pH.MEL_CIII.pH.MEL_CIII.Main Description When in control mode, 1i, pH goes vorte has epionit, the PI shall open CO2 valve according to parameters provided from the supervision. Special Requisite: 2 APS are used to simulate the pI sensors. Check supervision values in MEL_CIII.Main displays Tester: Date: Course of Actions Step pio Expected value 0 Set pH control mode to 1 – CO2 only 2 Using APS 1 set 2.90 – 3.10 V to AI 06 (CIII_MV_pHb) Course of Actions 3 In the MEL_CIII_pH Supervision screen check pH bottom value 8.0±0.1 pH 4 Using APS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pHt) Expected value 8.0±0.1 pH 5 In the MEL_CIII_pH Supervision screen check pH value 8.0±0.1 pH Expected value 8.0±0.1 pH 6 In the MEL_CIII_pH Heark Stepse to point 0 ±0.1 9K Description Expected value 8.0±0.1 pH 7 In the MEL_CIII_pH Heark Stepse to point 0 ±0.1 9K Description Description 8 In the MEL_CIII_pH expervision screen check pH value 8.0±0.1 pH Description Description Description Description <th>TC Id</th> <th>rding to provided pa</th> <th>rameters.</th>	TC Id	rding to provided pa	rameters.										
Description When in control mode 1. if pl goes over the set point, the Pl shall open CO2 valve according to parameters provided from the supervision. Special Requisite: 2 APB are used to simulate the pH sensor. Second Requisite: Date: Course of Actions Step no Date: Course of Actions Step no Description 1 Set pH control mode to 1 – CO2 only 2 Using APS 1 set 2.90 – 3.10 V to AI 06 (CIII_MV_pHb) 3 In the MEL_CIII_pH Supervision screen check pH bottom value 8.0±0.1 pH 4 Using APS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pHt) 5 In the MEL_CIII_pH Supervision screen check pH value 8.0±0.1 pH 6 In the MEL_CIII_pH Supervision screen check pH value 8.0±0.1 pH 7 In the MEL_CIII_pH edit the PI parameters (click over Acid pump to open dialog). 9 In the MEL_CIII_pH edit the proportional constant for CO2 valve (click over CO2 valve to open dialog). 10 In the MEL_CIII_pH edit the proportional constant for CO2 valve (click over CO2 valve to open dialog).	Items	Tested	CIII_PLCSW_pH, MEL_CIII_pH, MEL_CIII_Main										
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19 In the MEL_CIII_pH Supervision screen set pH set point to 8.0 and wait until CO2 valve control 45±3.75 % TEN 72 4 MEL 2210 PL 024 NEE	18	Check th	hat in 3 minutes CO2 valve control action approaches to 0 (ramp effect)	0±5 %									
	19	In the MEL_CIII_pH Supervision screen set pH set point to 8.0 and wait until CO2 valve control 45±3.75 %											
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TC Io	dentifier	MEL-TC-CIII-0401 Purpose: Verify that when in pH control mode 1, if pH goes over the set point, C	CO2 valve is opened accor	ding to provided	parameters.							
Items	s Tested	CIII_PLCSW_pH, MEL_CIII_pH, MEL_CIII_Main										
Desc	ription	When in control mode 1, if pH goes over the set point, the PI shall open CO2 valve according to parameters provided from the super	vision.									
Special	Requisites:	APS are used to simulate the pH sensors.										
		eck supervision values in MEL_CIII_pH and MEL_CIII_Main displays										
Те	ester:	Date:										
	Course of Actions											
Step no		Description	Expected value	OK/NOK	Comments							
	action va	alue is restored.										
20	Using A	Jsing APS 1 set 2.90 – 3.10 V to AI 06 (CIII_MV_pHb)										
21	Using A	PS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pHt)										
22	In the M	EL_CIII_pH edit the PI parameters (click over Acid pump to open dialog).										
	Set prop	ortional = 1, Integration = 30										
23	Using A	PS 1 set 4.10 – 4.20 V to AI 06 (CIII_MV_pHb)										
24	Using A	Jsing APS 2 set 4.70 – 4.90 V to AI 07 (CIII_MV_pHt)										
24	In the M Calculat	EL_CIII_pH annotate CO2 valve control action value at 10 seconds and at 40 seconds. e the gradient (CO2 at $20 - CO2$ at $10) / 30$	0.5±0.05 %									

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6.4.7 MEL-TC-CIII-0402: pH Regulation with CO2 and additional Base medium

TC Identifier MEL-TC-CIII-0402 Purpose: Verify that when in pH control mode 2, if pH goes under the set point, Base pump is activated according to provided paramete								
Items	s Tested	CIII_PLCSW_pH, MEL_CIII_pH						
Desc	ription	When in pH control mode 2, if pH goes under the set point, the PI shall activate the base pump according to parameters provided f	rom the supervision.					
Special	Requisites:	2 APS are used to simulate the pH sensors. Check supervision values in MEL_CIII_pH display						
Te	ster:	Date:						
		Course of Actions						
Step no		Description	Expected value	OK/NOK	Comments			
1	Set pH c	control mode to $2 - CO2 + Base$						
2	Using A	PS 1 set 2.90 – 3.10 V to AI 06 (CIII_MV_pHb)						
3	Using A	PS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pHt)						
4	Check in	n MEL_CIII_pH Supervision display the value of pH	8 ±0.25 pH					
5	Check D	O 03 light	Off					
6	Check C	CO2 valve and Base pump control action values	0±0.1 %					
7	In the M	EL_CIII_pH edit the PI parameters (click over base pump to open dialog).						
	Set prop	ortional = 3, Integration = 3000						
8	Using A	PS 1 set 1.70 – 1.90 V to AI 06 (CIII_MV_pHb)						
9	Using A	PS 2 set 2.30 – 2.50 V to AI 07 (CIII_MV_pHt)						
10	Check in	n MEL_CIII_pH Supervision display the value of pH	5 ±0.25 pH					
11	In the M	EL_CIII_pH edit the PI parameters (click over Acid pump to open dialog).						
	Set prop	ortional = 3, Integration = 0						
12	Check B	ase pump control action value during 10 seconds every 30 seconds	9±0.75 %					
13	Check D	O 03 light during 10 seconds every 30 seconds	On					
14	Apply a	500 ohm resistor to AO 06						
15	Check A	O 06 voltage output	2.72±0.1 V					
16	In the M	EL_CIII_pH edit the PI parameters (click over Acid pump to open dialog).						
	Set prop	ortional = 1, Integration = 30						
17	In the M	EL_CIII_pH annotate max. Base pump control action value within the 10 seconds is	0.1±0.01 %					
	active. C	Calculate gradient $(Base_{t=10} - Base_{t=0}) / 10$						
18	Using A	PS 1 set 2.90 – 3.10 V to AI 06 (CIII_MV_pHb)						
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TC Id	lentifier	MEL-TC-CIII-0402 P	urpose:	Verify that whe	en in pH control m	ode 2, if pH goes under	the set point, Base pump is activated acc	cording to provided p	parameters.			
Items	s Tested	CIII_PLCSW_pH, MEL_CIII_	pH									
Desc	ription	When in pH control mode 2, if	pH goes und	er the set point, the PI shall acti	vate the base pum	p according to paramete	ers provided from the supervision.					
Special	Requisites:	2 APS are used to simulate the Check supervision values in M	pH sensors.	tienlav								
Те	ster:	Check supervision values in W	LL_CIII_pII	uispiay	Date:							
	Course of Actions											
Step no				Description			Expected value	OK/NOK	Comments			
19	Using A	PS 2 set 3.50 – 3.70 V	V to AI 0	7 (CIII_MV_pHt)								
20	Check in	n MEL_CIII_pH Supe	rvision d	isplay the value of pl		8 ±0.25 pH						
21	Check C	O2 valve and Base pu	ump cont	rol action values (wa	s)	0±0.1 %						
22	Check D	OO 03 light (wait 30 se	econds)				Off					
23	Using A	PS 1 set 4.10 – 4.30 V	/ to AI 0	5 (CIII_MV_pHb)								
24	Using A	PS 2 set 4.70 – 4.90 V	V to AI 0	7 (CIII_MV_pHt)								
25	Check in	n MEL_CIII_pH Supe	rvision d	isplay the value of pl	H		11 ±0.25 pH					
26	Check C	O2 valve control action	on value				>0 %					
27	Using A	PS 1 set 2.90 – 3.10 V	/ to AI 0	6 (CIII_MV_pHb)								
28	Using A	g APS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pHt)										
29	Check in	n MEL_CIII_pH Supe	rvision d	isplay the value of pl		8 ±0.25 pH						
30	Check C	O2 valve and Base pu	ump cont	ol action values			0±0.1 %					

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6.4.8 MEL-TC-CIII-0403: pH Regulation with Base and Acid additional media

TC Identifier MEL-TC-CIII-0403 Purpose: Verify that when in pH control mode 2, if pH goes under the set point, Base pump is activated according to provided parameters.								arameters.				
Items	s Tested	CIII_PLCSW_pH, MEL_	CIII_pH	· · · · ·								
Desc	ription	When in pH control mode	e 3, if pH goes und	ler/over the set point, the	e PI shall activate the ba	ase/acid pump respectively a	according to pa	arameters provided from	the supervision.			
Special	Requisites:	2 APS are used to simulat Check supervision values	in MEL_CIII_pH	display								
Те	ster:				Date:							
					Course of	Actions						
Step no				Description				Expected value	OK/NOK	Comments		
1	Set pH control mode to 3 – Acid + Base											
2	Using A	PS 1 set $2.90 - 3.1$	10 V to AI (6 (CIII_MV_pH	(b)							
3	Using A	PS 2 set 3.50 – 3.7	70 V to AI (7 (CIII_MV_pH	[t)							
4	Check in	n MEL_CIII_pH S	upervision of	lisplay the value	of pH			8 ±0.25 pH				
5	Check D	O 02, DO 03 ligh	ts (wait 30 s	econds)				Off				
6	Check A	cid and Base pum	p control ac	tion values (wait	t 30 seconds)			0±0.1 %				
7	In the M	EL_CIII_pH edit	the PI paran	neters (click over	r Acid pump to	open dialog).						
	Set prop	ortional = 3, Integ	ration = 0									
8	Using A	PS 1 set 4.10 – 4.2	20 V to AI (6 (CIII_MV_pH	b)							
9	Using A	PS 2 set 4.70 – 4.9	90 V to AI (7 (CIII_MV_pH	lt)							
25	Check in	n MEL_CIII_pH S	upervision of	lisplay the value	of pH			11 ±0.25 pH				
12	Check a	cid pump control a	action value	during 10 second	ds every 30 sec	onds		9±0.75 %				
13	Check D	O 02 light during	10 seconds	every 30 second	S			On				
16	In the M	EL_CIII_pH edit	the PI paran	neters (click over	r Acid pump to	open dialog).						
	Set prop	ortional = 1, Integ	ration $= 30$									
17	In the M	EL_CIII_pH anno	otate max. A	cid pump contro	l action value w	vithin the 10 second	ds is	0.1±0.1 %				
	active. C	Calculate gradient	$(\operatorname{Acid}_{t=10} - A)$	$(d_{t=0}) / 10$								
18	Using A	PS 1 set 2.90 – 3.1	10 V to AI (6 (CIII_MV_pH	(b)							
19	Using A	PS 2 set 3.50 – 3.7	70 V to AI (7 (CIII_MV_pH	lt)							
20	Check in	ck in MEL_CIII_pH Supervision display the value of pH 8 ±0.25 pH										
21	Check A	cid and Base pum	p control ac	tion values (wait	t 30 seconds)			0±0.1 %				
22	Check D	O 02, DO 03 ligh	ts (wait 30 s	econds)				Off				
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TC Id	lentifier	MEL-TC-CIII-0403	Purpose:	Verify that whether the the test of te	hen in pH control	mode 2, if pH goes under	the set point, Base p	pump is activated acco	ording to provided	parameters.		
Items	5 Tested	CIII_PLCSW_pH, MEL	_CIII_pH									
Description When in pH control mode 3, if pH goes under/over the set point, the PI shall activate the base/acid pump respectively according to parameters provided from the superv								he supervision.				
Special	Requisites:	2 APS are used to simula	APS are used to simulate the pH sensors.									
		Check supervision value	eck supervision values in MEL_CIII_pH display									
Те	ster:				Date:							
	Course of Actions											
Step no					Expected value	OK/NOK	Comments					
23	Using APS 1 set 1.70 – 1.90 V to AI 06 (CIII_MV_pHb)											
24	Using A	PS 2 set 2.30 – 2.	.50 V to AI 0	7 (CIII_MV_pHt)								
25	Check in	MEL_CIII_pH S	Supervision d	isplay the value of p	ρH		5	±0.25 pH				
26	Check B	ase pump control	action value	during 10 seconds e	every 30 sec	onds	>	0 %				
27	Using A	PS 1 set 2.90 – 3.	10 V to AI 0	6 (CIII_MV_pHb)								
28	Using A	sing APS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pHt)										
29	Check in	eck in MEL_CIII_pH Supervision display the value of pH 8 ±0.25 pH										
30	Check A	cid and Base pun	np control act	tion values (wait 30	seconds)		0:	±0.1 %				

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6.4.9 MEL-TC-CIII-0404: pH alarms

TC Id	lentifier	MEL-TC-CIII-0404	Purpose:		Verify that	at when pH value is over the set point durin	ng 15 minutes an alarm is	generated	
Items	5 Tested	CIII_PLCSW_pH, MEL	_CIII						
Desc	ription	When pH is out of the se	t point for more that	an 15 minutes, a high priority a	alarm shall be ge	enerated.			
Special Requisites: 2 APS are used to simulate the pH sensors. Check supervision values in MEL_CIII_pH and MEL_CIII_Main displays									
Tester: Date:									
	Course of Actions								
Step no		Description				Expected value	OK/NOK	Comments	
1	Using A	PS 1 set 4.10 – 4.	20 V to AI 0	6 (CIII_MV_pHb)					
2	Using A	PS 2 set 4.70 – 4.	90 V to AI 0	7 (CIII_MV_pHt)					
3	3 Check in MEL_CIII_pH Supervision display the value of pH				11 ±0.25 pH				
27	27 Wait 15 minutes								
28	Check in	n alarm area pH de	eviation alarr	n status			Alarm		

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6.5 MEL-CIII-TP-05 Liquid Flows Regulation

6.5.1 Purpose

Liquid flows regulation controls the liquid input/output flows of the compartment. Level is measured by to contact sensors (on/off) that indicate Low or High level. Output pump flow rate is decreased/increased depending on the level status. In addition, liquid input flow rate is controlled by the Nitrite estimator. This estimator is implemented as a algorithm running in the Supervision Server fired every 10 minutes.

6.5.2 Features to be tested

Verify integration and functionality of the following items:

- Supervision displays:
 - MEL_CIII_Main: Display of the most important values of the CIII compartment.
 - MEL_CIII_Liquid: Liquid flows regulation display.
- Local Control (PLC) program sections:
 - CIII_PLCSW_Liquid: Liquid flows regulation.
 - CIII_PLCSW_N: Nitrates regulation
- PLC Rack I/O Interface
- Supervision PLC Interface

6.5.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIII-TC-0501	Liquid level control
MEL-CIII-TC-0502	Nitrite estimator
MEL-CIII-TC-0503	Output buffer tank pump activation
MEL-CIII-TC-0504	Liquid level alarms

6.5.4 Special Requirements

Table of I/O that participates in the Liquid flows loop:

Ty (Type) = DI: Digital Input, DO: Digital Output, AI: Analogue Input, AO: Analogue Output

Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIII MV Dob	ΔΙ	01	DO at bottom	CIII_CP	001	+	4 – 20 mA
	/\	01			005	-	
CIII MV Dot	Δι	02	DO at top		009	+	4 – 20 mA
		02			013	-	
	Δι	03	Ammonium		017	+	4 – 20 mA
		03	concentration		021	-	
	A 1	04	Nitrate concentration		025	+	4 – 20 mA
		04			029	-	

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Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIII_SP_Lin	AO	07	Liquid input pump flow regulation		177 181	+ -	4 – 20 mA
CIII_SP_LO	AO	08	Liquid output pump flow regulation		185 189	+ -	4 – 20 mA
CIII_MV_Llow	DI	03	Level measurement low		010 014	+ -	0 – 24 V
CIII_MV_Lhigh	DI	04	Level measurement high		018 022	+ -	0 – 24 V
CIII_MVO_Lbt	DI	05	Indicator of max level reached for a buffer tank		026 030	+ -	0 – 24 V
CIII_RL_Lbt	DO	01	Activation of the pump for the buffer tank		122 126	+ -	open/clos ed

Devices needed in this test procedure:

- 3 Adjustable Power Supply (APS) to provide current / voltage to analogue inputs
- 1 Multimeter to measure analogue current / voltage outputs

6.5.5 Procedure Steps

- Set Liquid loop operation mode to AUTO.
- Execute the Test Cases and record the successful or unsuccessful execution of tests in the Test Report.



6.5.6 MEL-TC-CIII-0501: Liquid level control

TC	Image: Click Identifier MEL-TC-CIII-0501 Purpose: Verify that when liquid level is high output pump flow rate is increased, when is low, output pump flow rate is decreased							
Iten	ns Tested	CIII_PLCSW_Liquid, MEL_CIII_Liquid, MEL_CIII_Main	1 1 1 1 1		1 050/			
Des	cription Doquisitos:	Initially output flow = input flow. When liquid level reaches high status, output pump flow is increased a 25%, when liquid level Check supervision values in MEL CIII. Liquid display.	el reaches low level, output pu	mp flow is decreas	sed a 25%.			
- Special T	ester:	Check supervision values in WEB_CHI_Eliquid display						
-	cotti i	Course of Actions						
Step no		Description	Expected value	OK/NOK	Comments			
1	In the MI	EL_CIII_Liquid set control mode to AUTO						
2	In the MI	EL_CIII_Liquid set input pump calibration parameters to:						
	Paramete	r A = 73.5294						
	Paramete	r B = 0.1765						
3	Using Co	ncept tool modify liquid input safety set point to 0,4 (default)						
4	Check in	MEL_CIII_Liquid supervision display "Liquid input flow rate"	0,4 (blinking)					
5	Check in	put pump actuation	29.59±0.1 %					
6	Check Le	vel High indicator	Off					
7	Check Le	evel Low indicator	On					
8	Check ou	tput pump actuation	22.19±0.1 %					
9	Set close	d circuit to DI 03 (CIII_MV_Llow)						
10	Check Le	vel High and Level Low indicators	Off					
11	Check ou	tput pump actuation	29.59±0.1 %					
12	Set open	circuit to DI 03 (CIII_MV_Llow)						
13	Check Le	evel Low indicator	On					
14	Check ou	tput pump actuation	22.19±0.1 %					
15	Set close	d circuit to DI03 and DI 04 (CIII_MV_Llow, CIII_MV_Lhigh)						
16	Check Le	vel High indicator	On					
17	Check ou	tput pump actuation	36.98±0.1 %					
18	Set open	circuit to DI 04 (CIII_MV_Lhigh)						
19	Check Le	vel High and Level Low indicators	Off					
20	Check ou	tput pump actuation	29.59±0.1 %					

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6.5.7 MEL-TC-CIII-0502: Nitrite estimator

TC Id	lentifier	MEL-TC-CIII-0502 Purpose: Verify integration of the Nitrite en	stimator algorithm.		
Items	Tested	CIII_PLCSW_Liquid, MEL_PLCSW_N, MEL_CIII_pH, MEL_CIII_pH			
Desc	ription	Firing manually the Nitrite Estimator control law, will set the Liquid input flow rate set point and NO2 estimation.			
Special To	stor.	Check supervision values in MEL_Em_Elquid and MEL_Em_Main displays			
	5101.	Course of Actions			
Step no		Description	Expected value	OK/NOK	Comments
1	In the M	EL_CIII_Liquid Supervision display set control mode to AUTO			
2	In the M	EL_CIII_Liquid Supervision display set input pump calibration parameters to:			
	Paramete	er A = 73.5294			
	Paramete	er B = 0.1765			
3	In the M	EL_CIII_Liquid Supervision display set Level 2 liquid level set point to 0.4			
4	Using C	oncept tool modify safety values for NO3, NH4, DO and the liquid input set point. Set:			
	NO3 = 3	29 ppm			
	NH4 = 4	l.2 ppm			
	DO = 80	0% (default value)			
	LIN = 0	.4 l/h			
	Using iF	ix tool Database Manager, set CIII_SSP_L1IN to 0,4			
7	In the M	EL_CIII_Liquid Supervision display, open Nitrite estimator parameters dialog.			
10	In the N	itrite estimator parameters dialog, check O2 at liquid output	0,0002 mol/l		
11	In the N	itrite estimator parameters dialog, check Required & Measured Liquid input flow rate	0.4 l/h		
	In the N	itrite estimator parameters dialog, update values using the table below (MEL-TC-CIII-			
	0502.Ta	ble1)			
12	Using iF	ix Scheduler, set scheduler properties to "Run in Foreground"			
13	Fire CIII	[_CTRLLAW_NIT event			
14	In the M	EL_CIII_Liquid Supervision display check Estimated NO2 concentration	1.59 ppm		
15	In the M	EL_CIII_Liquid Supervision display check Level 1 Liquid Input Flow	0.4 l/h		
16	In the M	EL_CIII_Liquid Supervision display check Liquid Input Flow	0.4 l/h		
17	In the M	EL_CIII_Main Supervision display check Liquid Input Flow	0.4 l/h		
18	In the M	EL_CIII_Main Supervision display check NO2 estimation	1.59 ppm		

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Nitrite Estimator parameters table

Index	Description	Values	Unit
0	Measured liquid flow rate or setpoint of the FRC of the liquid pump	0.4000	l/h
1	O ₂ concentration in the gas input stream	0.0066	mol/l
2	CO ₂ concentration in the gas input stream	0.0019	mol/l
3	NH ₃ concentration in the gas input stream	0.0000	mol/l
4	O ₂ concentration in the liquid input stream	0.0004	mol/l
5	total CO ₂ concentration in the liquid input stream	0.0159	mol/l
6	total NH ₃ concentration in the liquid input stream	0.0250	mol/l
7	unused (room for NO ₂ concentration if not null)	0.0000	mol/l
8	NO ₃ concentration in the liquid input stream	0.0000	mol/l
9	PO ₄ concentration in the liquid input stream	0.0016	mol/l
10	SO ₄ concentration in the liquid input stream	0.0040	mol/l
11	O ₂ concentration in the liquid output stream	0.0002	mol/l
12	total CO ₂ concentration in the liquid output stream	0.0564	mol/l
13	total NH ₃ concentration in the liquid output stream	0.0003	mol/l
14	NO ₃ concentration in the liquid output stream	0.0235	mol/l
15	PO ₄ concentration in the liquid output stream	0.0016	mol/l
16	SO ₄ concentration in the liquid output stream	0.0039	mol/l
17	Measured gas flow rate or set point of the FRC of the gas pump	60.0000	l/h
18	'Required' liquid flow rate	0.4000	l/h
19	Maximum constraint of NO ₂	0.0003	mol/l
20	Compensation term for estimator	0.0000	mol/l

MEL-TC-CIII-0502.Table1

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6.5.8 MEL-TC-CIII-0503: Output buffer tank pump activation

TC Id	lentifier	MEL-TC-CIII-0503	Purpose:			Verify buffer tank output pump is activ	ated when level is high			
Items	Tested	CIII_PLCSW_Liquid, M	EL_CIII_Liquid							
Desci	ription	When output buffer liqui	d reaches high leve	l, the output pump is activated	1.					
Special Requisites:		Check supervision values Use a Multimeter to chec	s in MEL_CIII_Liq k output voltage va	uid lues.						
Te	ster:				Date:					
	Course of Actions									
Step no		Description				Expected value	OK/NOK	Comments		
1 Check in MEL_CIII_Liquid the Buffer tank Level High indicator				Off						
2	Check in	n MEL_CIII_Liqu	id the Buffer	tank output pump s	tatus		Off			
3	Close cir	cuit in DI 05								
4	4 Check in MEL_CIII_Liquid the Buffer tank Level High indicator					On				
5	Check in MEL_CIII_Liquid the Buffer tank output pump status			On						
6	Check D	O 01 relay status					Closed			

6.5.9 MEL-TC-CIII-0504: Liquid level alarms

TC Id	lentifier	MEL-TC-CIII-0504	Purpose:				Verify high liquid level	alarm			
Items	Items Tested CIII_PLCSW_Liquid, MEL_CIII_Liquid										
Desci	ription	High level alarm shall be	activated when lev	el is high during 15 minutes.							
Special 1	Requisites:	Check supervision values	s in MEL_CIII_Lic	uid display							
Te	Fester:				Date:						
	Course of Actions										
Step no			Description				Expected value	OK/NOK	Comments		
1	In the M	/IEL_CIII_Liquid set Liquid input set point to 0.4 1/h									
2	Close cir	rcuit in DI 04									
3	Check L	ck Level High indicator						On			
4	Wait 15	Wait 15 minutes					Alarm				
5	Check in	n Alarm area, the l	level high ala	arm has been indicate	ed.			On			
6	Check L	iquid input flow r	ate					0 l/h			

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6.6 MEL-CIII-TP-06 Gas Flows Regulation

6.6.1 Purpose

Gas flows regulation controls gas input/output flows of the compartment. O2 and N2 are inserted to the compartment to regulate DO concentration. In addition CO2 is added to regulate pH (see MEL-CIII-TP-04 pH Regulation). A safety pressure valve controls overpressure status.

6.6.2 Features to be tested

Verify integration and functionality of the following items:

- Supervision displays:
 - MEL_CIII_Main: Display of the most important values of the CIII compartment.
 - MEL_CIII_Gas: Liquid flows regulation display.
- Local Control (PLC) program sections:
 - CIII_PLCSW_DO: DO Regulation.
 - CIII_PLCSW_P: Pressure Regulation.
- PLC Rack I/O Interface
- Supervision PLC Interface

6.6.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIII-TC-0601	DO regulation
MEL-CIII-TC-0602	Pressure valve activation
MEL-CIII-TC-0603	DO and Pressure alarms

6.6.4 Special Requirements

Table of I/O that participates in the Gas flow loop:

Ty (Type) = DI: Digital Input, DO: Digital Output, AI: Analogue Input, AO: Analogue Output

Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range		
CIII MV Dob	AI	01	DO at bottom	CIII_CP	001	+	4 – 20 mA		
	7.1	01			005	-			
CIII MV Dot	ΔΙ	02	DO at top		009	+	4 – 20 mA		
		02			013	-			
	ΔΙ	05	Pressure at top of the		033	+	4 – 20 mA		
			gas phase		037	-			
CIII AC Safe		08	Activation of Prossure	CIII_AC_OUT	31	AC L	220 VEF		
		00	Safety Valve		33	AC N			
			Salety valve		35	GND			
	40	02	N2 flow regulation		137	+	0 – 5 V		
	70	02	NZ NEW regulation		141	-			
	40	03	O2 flow regulation		145	+	0 – 5 V		
011_01_02	70	05	Oz new regulation		149	-			
TN 72 4 MEL	2210	DI (24 NTE Vargion	1 Icouo	. 1	Dogo	22 of 140		
11N / 2.4 MEL	IN /2.4 MEL-3310-PL-024-NTE Version: I Issue: I Page 88 of 149								
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Devices needed in this test procedure:

- 2 Adjustable Power Supply (APS) to provide current / voltage to analogue inputs
- 1 Multimeter to measure analogue current / voltage outputs

6.6.5 Procedure Steps

- Set Gas loop operation mode to AUTO.
- Execute the Test Cases and record the successful or unsuccessful execution of tests in the Test Report.



6.6.6 MEL-TC-CIII-0601: DO regulation

Items Tested CIII_PLCSW_DO, MEL_CIII_Gas, MEL_CIII_Main Description When DO grows, O2 valve is closed. If O2 valve is completely closed and O2 is still over the set point, the N2 valve opens. Special Requisites: 1 APS and a FG are used to simulate DO sensor. Check supervision values in MEL_CIII_Gas and MEL_CIII_Main displays Tester: Date: Step no Expected value OK/NOK Course of Actions Step no Description Expected value OK/NOK Course of Actions 1 In the MEL_CIII_Gas, set DO control action mode to AUTO In the MEL_CIII_Gas, set DO ramp parameter to 0.0167 80% 3 In the MEL_CIII_Gas, check DO set point (initial value) 80% 4 In the MEL_CIII Gas Supervision screen click over the O2 valve to edit PID parameters. Set: In the	Comments								
Description When DO grows, 02 valve is closed. If 02 valve is completely closed and 02 is still over the set point, the N2 valve opens. Special Requisites: 1 APS and a FG are used to simulate DO sensor. Check supervision values in MEL_CIII_Gas and MEL_CIII_Main displays Tester: Date: Step no Expected value OK/NOK Completely closed and 02 is still over the set point, the N2 valve opens. Step no Description Expected value OK/NOK Completely closed and 02 is still over the set point, the N2 valve opens. In the MEL_CIII_Gas set DO control action mode to AUTO In the MEL_CIII_Gas, set DO ramp parameter to 0.0167 80% 3 In the MEL_CIII_Gas, check DO set point (initial value) 80% In the MEL CIII Gas Supervision screen click over the O2 valve to edit PID parameters. Set: In the MEL	Comments								
Special Kequisites: TATS and a FO actions minute DO sensor. Check supervision values in MEL_CIII_Gas and MEL_CIII_Main displays Tester: Date: Course of Actions Step no Expected value OK/NOK Course of Actions Step no Description Expected value OK/NOK Course of Actions 1 In the MEL_CIII_Gas set DO control action mode to AUTO In the MEL_CIII_Gas, set DO ramp parameter to 0.0167 2 In the MEL_CIII_Gas, check DO set point (initial value) 80% In the MEL_CIII_Gas Supervision screen click over the O2 value to edit PID parameters. Set: In the MEL_CIII_Gas Supervision screen click over the O2 value to edit PID parameters.	Comments								
Tester: Date: Course of Actions Step no Expected value OK/NOK Course of Actions Step no Description Expected value OK/NOK Course of Actions 1 In the MEL_CIII_Gas set DO control action mode to AUTO Expected value OK/NOK Course of Actions 2 In the MEL_CIII_Gas, set DO control action mode to 0.0167 Image: Course of Actions Image: Course of Actions Image: Course of Actions 3 In the MEL_CIII_Gas, check DO set point (initial value) 80% Image: Course of Actions Image: Course of Actions 4 In the MEL CIII Gas Supervision screen click over the O2 valve to edit PID parameters. Set: Image: Course of Actions Image: Course of Actions	Comments								
Course of Actions Step no Expected value OK/NOK Course of Actions 1 In the MEL_CIII_Gas set DO control action mode to AUTO 6 6 2 In the MEL_CIII_Gas, set DO ramp parameter to 0.0167 6 6 3 In the MEL_CIII_Gas, check DO set point (initial value) 80% 6 4 In the MEL_CIII Gas Supervision screen click over the O2 valve to edit PID parameters. Set: 6	Comments								
Step noDescriptionExpected valueOK/NOKCultication1In the MEL_CIII_Gas set DO control action mode to AUTO </td <td>Comments</td>	Comments								
1 In the MEL_CIII_Gas set DO control action mode to AUTO									
2 In the MEL_CIII_Gas, set DO ramp parameter to 0.0167 3 In the MEL_CIII_Gas, check DO set point (initial value) 4 In the MEL CIII Gas Supervision screen click over the O2 valve to edit PID parameters. Set:									
3 In the MEL_CIII_Gas, check DO set point (initial value) 80% 4 In the MEL_CIII_Gas Supervision screen click over the O2 valve to edit PID parameters. Set: 80%									
4 In the MEL CIII Gas Supervision screen click over the O2 value to edit PID parameters. Set:									
Proportional = 12									
Integrative $= 30$									
Derivative $= 0.033$									
Bias = 0									
5 In the MEL_CIII_Gas Supervision screen click over the N2 valve to set Proportional constant to									
0.5									
6 With Concept open CIII_PLCSW_DO and disable EN_I, EN_D (only proportional part is									
enabled).									
7 With APS set 4.15 – 4.25 to AI 01 (DO bottom)									
8 In the MEL_CIII_Gas check DO concentration bottom 80±1.25%									
9 With APS set 4.15 – 4.25 to AI 02 (DO top)									
10In the MEL_CIII_Gas check DO concentration top80±1.25%									
11 With APS set 4.15 – 4.25 V to AI 01 and AI 02 (DO bottom/top)									
12In the MEL_CIII_Main check DO concentration640±1.25 ppm									
13In the MEL_CIII_Liquid check DO (ppm) concentration640±1.25 ppm									
13In the MEL_CIII_Gas check DO concentration80±1.25%									
14 In the MEL_CIII_Gas, modify DO set point to 78%									
15Check that in 2 minutes O2 Set Point moved to expected value (effect of ramp parameter applied24±1.25%									

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TC	ldentifier	MEL-TC-CIII-0601 Purpose: Verify DO regulation p	performed	by a PID actuating over the N2 and O2 ga	s input flow regulators a	ccording to provided	d parameters.		
Iten	ns Tested	CIII_PLCSW_DO, MEL_CIII_Gas, MEL_CIII_Main							
Des	cription Description	When DO grows, O2 valve is closed. If O2 valve is completely closed and O2 is s	still over t	he set point, the N2 valve opens.					
Special	Requisites:	Check supervision values in MEL_CIII_Gas and MEL_CIII_Main displays							
Т	ester:		ate:						
	Course of Actions								
Step no		Description			Expected value	OK/NOK	Comments		
	to DO set	point):							
16	In the ME	EL_CIII_Gas, modify DO set point to 80%							
17	Check that in 2 minutes O2 Set Point moved to expected value (effect of ramp parameter applied				0±1.5%				
	to DO set	point):							
18	With APS	set $3.95 - 4.05$ V to AI 01 and AI 02 (DO bottom/top)							
19	In the MI	EL_CIII_Gas check DO concentration	75±1.25%						
20	In the ME	EL_CIII_Gas check O2 flow controller set point (SP)	60%						
21	With APS	5 set $4.35 - 4.45$ V to AI 01 and AI 02 (DO bottom/top)							
22	In the MI	In the MEL_CIII_Gas check DO concentration							
23	In the MI	EL_CIII_Gas check N2 flow controller set point (SP)			30±1.25 %				
24	With APS	5 set $4.15 - 4.25$ V to AI 01 and AI 02 (DO bottom/top))						
25	In the MI	EL_CIII_Gas check DO concentration			80±1.25%				
26	In the ME	EL_CIII_Gas check N2, O2 flow controllers set point			0±1.25%				
27	With Con	cept open CIII_PLCSW_DO and disable EN_P, EN_D	and er	nable EN_I (only					
	integrativ	e part is enabled).							
28	With APS	S set 3.95 – 4.05 V to AI 01 and AI 02 (DO bottom/top))						
29	In the MB	EL_CIII_Gas annotate O2 valve control action value with	thin the	e 10 seconds is active.	2±0.15%				
	Calculate	gradient $(O2_{t=10} - O2_{t=0}) / 10$							
30	With Con	cept open CIII_PLCSW_DO and disable EN_P, EN_I a	and en	able EN_D (only derivative					
	part is en	abled).							
31	With a FC	G apply a triangular wave Freq=0.1 Hz, A=0.8 V, Offset	<u>et=3.8</u> V	V (3.8 – 4.6 V / 70 – 80%)					
32	In the ME	EL_CIII_Gas check O2 flow controller set point (SP) M	IAX		4±0.5%				

6.6.7 MEL-TC-CIII-0602: Pressure valve activation

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TC	ldentifier	MEL-TC-CIII-0602 Purpose: Verify that safety valve is opened when pressure goes over the set point								
Iten	ns Tested	CIII_PLCSW_P, MEL_CIII_Gas, MEL_CIII_Main								
Des	cription	When pressure goes over the set point, the safety pressure valve shall be opened until the	pressure returns under the set point.							
Special	Requisites:	APS is used to simulate Pressure sensor.								
T	~ ~ 4 ~ ~ ~ ~	Check supervision values in MEL_CIII_Gas and MEL_CIII_Main displays								
	ester:									
C 4	Course of Actions									
Step no	In the MI	EL CIII Cos set control mode to AUTO		Expected value	UK/NUK	Comments				
1		EL_CIII_Gas set control mode to AUTO	1							
2	In the MI	EL_CIII_Gas Supervision screen set Pressure Set point to 100	mb							
3	Apply 1.3	30 – 1.40 V to AI 05 (CIII_MV_P)								
4	In the MI	EL_CIII_Main Supervision screen check Pressure value	87.5±12.5 mb							
5	In the MI	EL_CIII_Gas Supervision screen check Pressure value	87.5±12.5 mb							
6	In the MI	EL_CIII_Gas Supervision screen check safety valve status	Closed							
7	Apply a l	ight to DO 08 (CIII_AC_Safe in CIII_AC_OUT)								
8	Check lig	ght status		Off						
9	Apply 1.9	95 – 2.05 V to AI 05								
10	In the MI	EL_CIII_Gas Supervision screen check Pressure value		250±12.5 mb						
11	In the MI	EL_CIII_Gas Supervision screen check safety valve status		Open						
12	Check lig	tht status		On						
13	Apply 1.3	30 – 1.40 V to AI 05 (CIII_MV_P)								
14	In the MI	EL_CIII_Gas Supervision screen check Pressure value		87.5±12.5 mb						
15	In the MI	EL_CIII_Gas Supervision screen check safety valve status		Closed						
16	Check lig	tht status		Off						

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6.6.8 MEL-TC-CIII-0603: DO and Pressure alarms

TC	ldentifier	MEL-TC-CIII-0603	Purpose:		Verify that DO and pressure alarms are notified					
Iten	ns Tested	CIII_PLCSW_P, MEL_C	CIII_Gas, MEL_Cl	II_Main						
Des	cription	When pressure goes over	When pressure goes over the set point, the safety pressure valve shall be opened until the pressure returns under the set point.							
Special	Requisites:	APS is used to simulate Pressure sensor.								
		Check supervision values	s in MEL_CIII_Ga	s and MEL_CIII_Main displays						
T	ester:			Date:						
C.	Course of Actions									
Step no	X 1 X (7			Description		Expected value	OK/NOK	Comments		
1	In the MI	EL_CIII_Gas Supe	ervision scre	en set Pressure Set point to 100 i	mb					
2	Apply 1.95 – 2.05 V to AI 05 (CIII_MV_P)									
3	In the MEL_CIII_Gas Supervision screen check Pressure value					250±12.5 mb				
4	Wait 15 r	Wait 15 minutes.								
5	Check in	ck in the Alarm Area the pressure alarm status				Alarm				
6	In the MI	EL_CIII_Gas Supe	ervision scre	en set DO set point to 80%						
7	Apply 4.6	65 – 4.75 V to AI	01 and AI 02	2 (CIII_MV_DO top/bottom)						
8	In the MI	EL_CIII_Gas Supe	ervision scre	en check DO value		92.5±1.25 %				
9	Check in	the Alarm Area th	ne DO alarm	status		Alarm				
10	Apply 4.1	5-4.25 V to AI	01 and AI 02	2 (CIII_MV_DO top/bottom)						
11	In the MI	EL_CIII_Gas Supe	ervision scre	en check DO value		80±1.25 %				
12	Check in	the Alarm Area th	ne DO alarm	status		OK				
13	Apply 3.6	oly 3.65 – 3.75 V to AI 01 and AI 02 (CIII_MV_DO top/bottom)								
14	Check in	the Alarm Area th	ne DO alarm	status		Alarm				

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6.7 MEL-CIII-TP-07 Temperature regulation

6.7.1 Purpose

Temperature regulation maintains the temperature of the compartment in the set point. In case of over temperature the cooling valve is opened, and in case of under temperature the heater resistance is activated using a pulse action.

6.7.2 Features to be tested

Verify integration and functionality of the following items:

- Supervision displays:
 - MEL_CIII_Main: Display of the most important values of the CIII compartment.
 - MEL_CIII_Temp: Temperature regulation display.
- Local Control (PLC) program sections:
- CIII_PLCSW_Temp: Temperature Regulation.
- PLC Rack I/O Interface
- Supervision PLC Interface

6.7.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIII-TC-0701	Temperature regulation
MEL-CIII-TC-0702	Temperature alarms

6.7.4 Special Requirements

Table of I/O that participates in the Gas flow loop:

Ty (Type) = DI: Digital Input, DO: Digital Output, AI: Analogue Input, AO: Analogue Output

Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIII MV Th	Δι	00	Temperature at bottom	CIII_CP	065	+	4 – 20 mA
		03			069	-	
CIII MV Tt	ΔΙ	10	Temperature at top		073	+	0 – 5 V
		10			077	-	
		06	Activate Heater	CIII_AC_OUT	025	AC L	220 VEF
	00	00	Activate Tieater		027	AC N	
					029	GND	
		05	Open/clase the cooling		019	AC L	220 VEF
	00	00	valve		021	AC N	
			valve		023	GND	
CIII SP Lin		07	Liquid input pump flow		177	+	4 – 20 mA
	70	01	regulation		181	-	

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Devices needed in this test procedure:

- 2 Adjustable Power Supply (APS) to provide current / voltage to analogue inputs
- 1 Multimeter to measure analogue current / voltage outputs

6.7.5 Procedure Steps

- Set Temperature loop operation mode to AUTO.
- Execute the Test Cases and record the successful or unsuccessful execution of tests in the Test Report.



6.7.6 MEL-TC-CIII-0701: Temperature regulation

TC	Identifier	MEL-TC-CIII-0701 Purpose: Verify that when temperature goes under the set point the heater is activated with	a pulse action and when is ov	ver the set point the	cooling valve is opened				
Iten	Items Tested CIII_PLCSW_Temp, MEL_CIII_Temp, MEL_CIII_Main								
Des	scription	When temperature goes under the set point, the heater is activated with a pulse action and cooling valve is opened.							
Special Requisites: 1 APS is used to simulate reinperature sensors. Check supervision values in MEL_CIII_Temp and MEL_CIII_Main displays									
Т	Tester: Date:								
		Course of Actions							
Step no		Description	Expected value	OK/NOK	Comments				
1	In the M	EL_CIII_Temp set control mode to AUTO							
2	Apply a l	ight to DO 06 and DO 05 (CIII_AC_Heat, CIII_AC_CV in the CIII_AC_CP)							
3	In the M	EL_CIII_Temp, set Temp ramp parameter to 30 seconds.							
4	In the M	EL_CIII_Temp, check Temp set point (initial value)	28° C						
5	Apply 1.	70 – 1.80 V to AI 09 (Temperature bottom)							
6	In the M	EL_CIII_Temp, check Temperature bottom value	27.725±1.8° C						
7	Apply 1.7	70 – 1.80 V to AI 10 (Temperature top)							
8	In the MEL_CIII_Temp, check Temperature top value 27.725±1.8° C								
9	Apply 1.	70 – 1.80 V to AI 09, AI 10 (Temperature bottom/top)							
10	In the M	MEL_CIII_Temp, check Temperature value 27.725±1.8° C							
11	Apply 1.	Apply 1.80 – 1.90 V to AI 09, AI 10 (Temperature bottom/top)							
12	In the M	In the MEL_CIII_Temp, check Temperature value 31.935±1.8° C							
13	Check DO 05 light (CIII_AC_CV) On								
14	In the MEL_CIII_Temp check cooling valve status Open								
15	Apply 1.	60 – 1.70 V to AI 09, AI 10 (Temperature bottom/top)							
16	In the M	EL_CIII_Temp, check Temperature value	24.04±1.8° C						
17	Check DO 05 light (CIII_AC_CV) Off								
18	Check DO 06 light (CIII_AC_Heater) status every 5 seconds (shall be 5 seconds blinking, 5 On								
	seconds off)								
19	Apply 1.70 – 1.80 V to AI 09 (Temperature bottom)								
20	In the M	In the MEL_CIII_Temp, check Temperature bottom value 27.725±1.8° C							
21	Check D	Check DO 05, DO 06 lights (CIII_AC_CV, CIII_AC_Heater) Off							
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6.7.7 MEL-TC-CIII-0702: Temperature alarms

TC	Identifier	MEL-TC-CIII-0702 Purpose: Verify that when temperature goes under the set point the heater is activated with a pulse action and when is over the set point the cooling valve is opened							
Iten	ns Tested	CIII_PLCSW_Temp, MEL_CIII_Temp, MEL_CIII_Main							
Des	cription	When temperature goes under the set point, the heater is activated with a pulse action and cooling valve is opened.							
Special	al Requisites: 1 APS is used to simulate Temperature sensors.								
		Check supervision values in MEL_CIII_	Temp, CIII_MEL_Liquid and MEL_CIII_Main displa	ays					
T	ester:		Date:						
	Course of Actions								
Step no			Description		Expected value	OK/NOK	Comments		
1	In the MI	EL_CIII_Temp set control r	node to AUTO						
2	In the MI	EL_CIII_Temp, check Temp	set point (initial value)		28° C				
	In the MI	EL_CIII_Liquid, set Liquid	input flow rate set point to 0.4 l/h						
3	Apply 1.4	45 – 1.55 V to AI 09 (Tempo	erature bottom)						
4	In the MI	EL_CIII_Temp, check Temp		18.55±1.8° C					
5	In the MI	EL_CIII_Temp, check Temp		20.44±1.8° C					
6	Check in	the Alarm Area the Temper		Alarm					
7	Check in	the MEL_CIII_Liquid, the		0±0.1 l/h					
8	Apply 1.70 – 1.80 V to AI 09 (Temperature bottom)								
9	In the MEL_CIII_Temp, check Temperature value				27.725±1.8° C				
10	Check in the Alarm Area the Temperature deviation alarm status				OK				
11	Apply 2.45 – 2.55 V to AI 10 (Temperature top)								
12	In the MEL_CIII_Temp, check Temperature top value				55.25±1.8° C				
13	In the MEL_CIII_Temp, check Temperature value				33.45±1.8° C				
14	Check in	eck in the Alarm Area the Temperature deviation alarm status Alarm							
15	Apply 1.7	y 1.70 – 1.80 V to AI 10 (Temperature top)							
16	In the MI	1 the MEL_CIII_Temp, check Temperature value 27.725±1.8° C							
17	Check in	the Alarm Area the Temper	ature deviation alarm status		OK				

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6.8.1 Purpose

When PLC is restarted, default initial values are loaded into program parameters. It shall be verified that these default values are properly defined, since the PLC will use this parameters immediately after is restarted.

6.8.2 Features to be tested

Verify default values loaded into the PLC used when it is restarted.

6.8.3 Procedure Steps

- 1. Stop the PLC
- 2. Load last program version into the PLC
- 3. Start the PLC
- 4. With the Concept tool Reference Data Editor, check that initial values are as in the following table:

TC Identifier M	EL-CIII-TP-08	Purpose	Check that correct initial values are used at PLC restart				
Tester:		Date:					
Variable name	Туре	Address	Init. Value	Description	OK		
CIII_CNS_CO2Kp	real	400522	5	Additional proportional constant for CO2			
CIII_CNS_DOBias	real	400518	0	Disturbance variable (Feed_fw) for DO PID			
CIII_CNS_DOKd	real	400516	0.0033	Derivative constant for DO PID			
CIII_CNS_DOKi	real	400514	3000	Integrative constant for DO PID			
CIII_CNS_DOKp	real	400512	12	Proportional constant for DO PID			
CIII_CNS_Doramp	real	400588	0.016	DO supervision set point ramp coefficient			
CIII_CNS_LinA	real	400584	73.5294	Input pump calibration constant parameter A			
CIII_CNS_LinB	real	400586	0.1765	Input pump calibration constant parameter B			
CIII_CNS_LoA	real	400598	0	Output pump calibration constant parameter A			
CIII_CNS_LoB	real	400600	0	Output pump calibration constant parameter B			
CIII_CNS_N2Kp	real	400614	0.5	Proportional constant for N2 regulation			
CIII_CNS_OpModeD	0 int	400568	0	DO control operational mode (0=Off, 1=Auto, 2=Manual)			
CIII_CNS_OpModeGa	as int	400566	0	Gas control operational mode (0=Off, 1=Auto, 2=Manual)			
CIII_CNS_OpModeL	int	400565	0	Liquid control operational mode (0=Off, 1=Auto,			
CIII_CNS_OpModepH	l int	400612	0	pH control operational mode (0=Off, 1=Auto,			
CIII_CNS_OpModeT	int	400567	0	Temperature control operational mode (0=Off,			
CIII_CNS_pHKi	real	400510	3000	Integration constant for Acid/Base PI			
CIII_CNS_pHKp	real	400508	3	Proportional constant for Acid/Base PI			
CIII_CNS_pHMode	int	400554	1	pH regulation mode variable (1=CO2 only, 2=CO2+Base, 3=Base+Acid)			
CIII_CNS_pHramp real		400560	0.005	pH supervision set point ramp coefficient			
CIII_CNS_Tramp	real	400556	0.0083	Temperature supervision set point ramp coefficient			
CIII_MAN_Ac	real	400570	0	Manual acid pump set point			
CIII_MAN_Bs	real	400572	0	Manual base pump set point			

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TC Identifier	MEL-CIII-TP-08	Purpose	Check that correct initial values are used at PLC restart			
Tester:		Date:				
Variable name	Туре	Address	Init. Value	Description	OK	
CIII_MAN_CO2	real	400574	0	Manual CO2 flow controller set point		
CIII_MAN_EnAc	Bool	000190	0	Manual enable of acid pump		
CIII_MAN_EnBs	Bool	000191	0	Manual enable of base pump		
CIII_MAN_EnCV	Bool	000192	0	Manual enable of the cooling valve		
CIII_MAN_EnHT	Bool	000193	0	Manual enable of the heater		
CIII_MAN_EnLOBT	F Bool	000195	0	Manual enable of buffer output pump		
CIII_MAN_EnP	Bool	000194	0	Manual enable of pressure safety valve		
CIII_MAN_Lin	real	400576	0	Manual liquid input pump set point		
CIII_MAN_LO	real	400578	0	Manual liquid output pump set point		
CIII_MAN_N2	real	400580	0	Manual N2 flow controller set point		
CIII_MAN_O2	real	400582	0	Manual O2 flow controller set point		
CIII_SSP_DO	real	400520	80	DO Supervision set point		
CIII_SSP_L1Lin	real	400524	0	Level 1 liquid input supervision set point		
CIII_SSP_L2Lin	real	400542	0	Level 2 liquid Input supervision set point		
CIII_SSP_P	real	400526	80	Pressure supervision set point		
CIII_SSP_pH	real	400504	8	pH supervision set point		
CIII_SSP_T	real	400500	28	Temperature supervision set point		

5. If one or more initial values differ from those in the table then follow the procedure defined in the Operations Manual [R9], section 9.2 to update.



6.9 MEL-CIII-TP-09: Check Sensor / Actuator Link Errors

6.9.1 Purpose

When a current (4-20 mA) analogue input / output is disconnected (link error) the status shall be notified to the supervision.

6.9.2 Features to be tested

Verify link errors are notified to the supervision as specified. Verify safety values are set to measured variables when a link error occurs.

6.9.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-CIII-TC-0901	Check link errors on analogue inputs
MEL-CIII-TC-0902	Check link errors on analogue outputs

6.9.4 Procedure Steps

Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.


6.9.5 MEL-TC-CIII-0901: Check Link Errors on Analogue Inputs

TC Ide	ntifier	MEL-TC-CIII-0901 Purpose: Verify that when a current analogue input connection	n is broken is notified to su	pervision					
Function	s Tested	CIII_PLCSW							
Descri	ption	Errors on sensor links are displayed in the supervision as alarms and safety values are displayed blinking in the supervision screens.							
Special Ke	equisites:	All current inputs shall be disconnected							
Test	er:	Date:							
Step no	1	Description	Expected value	OK/NOK	Comments				
	In the M	MEL_CIII_Temp supervision display set Temperature set point to 28							
1	In the M	MEL_CIII_Temp supervision display check Temperature bottom value	28 (Blinking)						
2	In the I	MEL_CIII_Temp supervision display check Temperature top value	28 (Blinking)						
	In the M	MEL_CIII_Gas supervision display set DO(%) set point to 80							
3	In the M	MEL_CIII_Gas supervision display check DO(%) bottom value	80 (Blinking)						
4	In the M	MEL_CIII_Gas supervision display check DO(%) top value	80 (Blinking)						
8	In the M	MEL_CIII_Gas supervision display check Pressure value	80 (Blinking)						
5	In the M	MEL_CIII_Liquid supervision display check NH4 value	0.0 (Blinking)						
6	In the M	MEL_CIII_Liquid supervision display check NO3 value	0.0 (Blinking)						
9	In the M	MEL_CIII_pH supervision display check pH bottom value	8.0 (Blinking)						
10	In the M	MEL_CIII_pH supervision display check pH top value	8.0 (Blinking)						
11	In the M	MEL_CIII_Main supervision display check Pressure value	80 (Blinking)						
13	In the M	MEL_CIV_Main supervision display check DO value	640 (Blinking)						
14	In the M	MEL_CIV_Main supervision display check NH4 value	0.0 (Blinking)						
15	In the M	MEL_CIV_Main supervision display check NO3 value	0.0 (Blinking)						
16	In the I	MEL_CIV_Main supervision display Temperature value	28.0 (Blinking)						
17	In the M	MEL_CIV_Main supervision display pH value	8.0 (Blinking)						
22	Check	following alarms are fired:							
	- Ala	rm to notify Temperature sensor link error							
	- Ala	rm to notify DO sensor link error							
	- Ala	Alarm to notify NO3 sensor link error							
	- Ala	rm to notify NH4 sensor link error							
	- Ala	rm to notify pressure sensor link error							

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TC Identifier	MEL-TC-CIII-0901 Purpose:	/IEL-TC-CIII-0901 Purpose: Verify that when a current analogue input connection is broken is notified to supervision								
Functions Tested	ZIII_PLCSW									
Description	Errors on sensor links are displayed in the supervision as alarms and safety values are displayed blinking in the supervision screens.									
Special Requisites:	All current inputs shall be disconnected									
- Ala										

6.9.6 MEL-TC-CIII-0902: Check Link Errors on Analogue Outputs

TC Ider	ntifier	MEL-TC-CIII-0902	Purpose:		Verify that	when a current analogue output connection	n is broken is notified to sup	pervision			
Functions	s Tested	CIII_PLCSW									
Descrip	otion	Errors on actuator links a	are displayed in the	supervision as alarms							
Special Re	Requisites: All current outputs shall be disconnected										
Test	er:				Date:						
	Course of Actions										
Step no	Description						Expected value	OK/NOK	Comments		
1	Check	following alarms	are fired:								
	- Ala	rm to notify acid	pump link er	ror							
	- Ala	rm to notify base	numn link ei	ror							
	1110										
	- Ala	- Alarm to notify liquid input link error									
	- Ala	larm to notify liquid output link error									

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6.10MEL-CIII-TP-10: Check operational modes

6.10.1Purpose

Each loop (Temperature, Liquid, pH, Gas) allows the selection of the operational mode: OFF: Outputs are set to 0

AUTO: Outputs are set with the value resulting of the control action.

MAN: Outputs are set to manual values (provided by the Supervision from each loop Supervision displays).

6.10.2Features to be tested

Verify changing operational modes outputs are set as specified.

6.10.3Test Cases

Following Test Cases are executed in this Test Procedure:

Identifier	Name
MEL-CIII-TC-1001	Check Temperature loop operational modes.
MEL-CIII-TC-1002	Check Liquid loop operational modes.
MEL-CIII-TC-1003	Check pH loop operational modes Check
MEL-CIII-TC-1004	Check Gas loop operational modes

6.10.4Special Requirements

Table of Outputs that participates in the regulation loops: Ty (Type) = RL: Relay, AO: Analogue Output

Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIII_SP_CO2	AO	01	CO2 input flow regulation		129 133	+ -	0 – 5 V
CIII_SP_N2	AO	02	N2 flow regulation		137 141	+ -	0 – 5 V
CIII_SP_O2	AO	03	O2 flow regulation		145 149	+ -	0 – 5 V
CIII_SP_Ac	AO	05	Acid pump flow regulation		161 165	+ -	4 – 20 mA
CIII_SP_Bs	AO	06	Base pump flow regulation		169 173	+ -	4 – 20 mA
CIII_SP_Lin AO 07 Liquid input pump regulation		Liquid input pump flow regulation		177 181	+ -	4 – 20 mA	
CIII_SP_LO	CIII_SP_LO AO 08 Liquid output pump flow regulation			185 189	+ -	4 – 20 mA	
CIII_RL_Lbt DO 01 Activation for the		Activation of the pump for the buffer tank		122 126	+	0 – 24 V	

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Variable Name	Ту	N.	Description	Connector	Pin	Signal	Range
CIII AC AC	DO	02	Relay acid pump	CIII_AC_OUT	001	AC L	220 VEF
					003	AC N	
				005	GND		
CIII AC BS	DO	03	Relay base pump		007	AC L	220 VEF
•···_· •• •			·····		009	AC N	
					011	GND	
		04	Compressor activation		013	AC L	220 VEF
		04	Compressor activation		015	AC N	
					017	GND	
		05	Open/close the cooling		019	AC L	220 VEF
	00	05	Open/close the cooling		021	AC N	
			valve		023	GND	
		06	Activate Heater		025	AC L	220 VEF
	00	00	Activate Tleater		027	AC N	
					029	GND	
		07	Bolov to hove a pulse in	CIII CP	11	+	24 V
CIII_KL_LP	00	07	the level concer lecture	_	19	+	
		00	Activation of Prossure	CIII_AC_OUT	31	AC L	220 VEF
		00	Safaty Valva		33	AC N	
			Salety Valve		35	GND	

Devices needed in this test procedure:

- 1 Multimeter to measure analogue current / voltage outputs
- 6 Pilot lights 220 VAC

6.10.5Procedure Steps

Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.



6.10.6MEL-TC-CIII-1001: Check Temperature Loop Operational Modes

TC Ide	ntifier	MEL-TC-CIII-1001	Purpose:		Verify when o	perational mode is changed in the	Temperature Loop, outputs are se	et as specified	
Function	s Tested	CIII_PLCSW_Temp, MI	EL_CIII_Temp						
Descri	ption	From the MEL_CIII_Ter	mp supervision scr	en it is possible to change the o	operational mode	e and set the manual values.			
Special Re	equisites:	Use a Multimeter to mea	sure expected outp	uts					
		Use MEL_CIV_BP supe	rvision screen to cl	ange operational modes and m	anual values.				
Test	ter:				Date:				
					Course of A	Actions			
Step no				Description			Expected value	OK/NOK	Comments
1	In the M	MEL_CIII_Temp	screen set operational	OFF					
2	Connec	t a pilot light to A	AC outputs C	III_AC_CV, CIII_A	C_Heat				
3	Check	Pilot lights					OFF		
11	In the M	MEL_CIII_Temp	edit the man	ual values and set:					
	Cooling	g valve activation:	checked						
	Heater	eater activation: checked							
13	In the MEL_CIII_Temp supervision screen set operational mode to MAN								
14	Check	Pilot lights					ON		

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6.10.7MEL-TC-CIII-1002: Check Liquid loop operational modes.

TC Ide	entifier	MEL-TC-CIII-1002 Purpose:	Verify when	n operational mode is changed in the Liqu	id Loop, outputs are set as	specified		
Function	s Tested	CIII_PLCSW_Liquid, MEL_CIII_Liquid						
Descri	ption	From the MEL_CIII_Liquid supervision screen in	t is possible to change the operational mod	e and set the manual values.				
Special R	equisites:	Use a Multimeter to measure expected outputs						
		Use MEL_CIII_Liquid supervision screen to cha	nge operational modes and manual values.					
Tes	ter:		Date:					
	-		Course of A	Actions	1			
Step no			Description		Expected value	OK/NOK	Comments	
1	In the I	MEL_CIII_Liquid supervision scr	een set operational mode to	OFF				
2	Apply	a 500 ohm resistor to AO 07						
3	Check	AO 07 (CIII_SP_Lin) voltage output		2.0±0.1 V				
4	Apply	a 500 ohm resistor to AO 07						
5	Check	AO 08 (CIII_SP_LO) voltage output	t		2.0±0.1 V			
6	In the I	MEL_CIII_Liquid edit the manual	values and set:					
	Liquid	input set point: 30						
	Liquid	d output set point: 20						
7	In the l	he MEL_CIII_Liquid supervision screen set operational mode to MAN						
8	Check	AO 07 (CIII_SP_Lin) voltage output	t		4.4±0.1 V			
9	Check	AO 08 (CIII_SP_LO) voltage outpu	t		3.6±0.1 V			

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6.10.8MEL-TC-CIII-1003: Check pH loop operational modes

TC Ide	ntifier	MEL-TC-CIII-1003 Purpose: Verify when operational mode is changed in the pH Loop, outputs are set as specified								
Function	s Tested	CIII_PLCSW_pH, MEL	_CIII_pH							
Descri	ption	From the MEL_CIII_pH	supervision screet	n it is possible to change the operational mode a	nd set the manual values.					
Special R	equisites:	Use a Multimeter to mea	sure expected out	puts						
		Use MEL_CIII_pH supe	ervision screen to c	change operational modes and manual values.						
Test	er:			Date:						
~				Course of A	Actions	1		~		
Step no				Description		Expected value	OK/NOK	Comments		
1	In the M	MEL_CIII_pH sup	pervision scr	reen set operational mode to OFI	Ľ					
2	Connec	t a pilot light to A	AC outputs C	CIII_AC_AC, CIII_AC_BS						
3	Place a	500 ohm resistor	to AO 05, A	AO 06						
4	Check .	AO 05 (CIII_SP_	AC)			2.0±0.1 V				
5	Check .	AO 06 (CIII_SP_	BS)			2.0±0.1 V				
	Check .	AO 01 (CIII_SP_	CO2)			0.0±0.1 V				
6	Check	pilot lights				Off				
7	In the N	MEL_CIII_pH edi	it the manua	l values and set:						
	Acid pu	mp set point: 10								
	Acid pu	ump activation: cl	necked							
	Base pu	mp set point: 20								
	Base pu	ump activation: ch	necked							
	CO2 flo	ow rate set point:	30							
8	In the M	MEL_CIII_pH su	pervision scr	reen set operational mode to MA	N					
9	Check	AO 05 (CIII_SP_	AC)			2.8±0.1 V				
10	Check .	eck AO 06 (CIII_SP_BS) 3.6±0.1 V								
11	Check .	AO 01 (CIII_SP_	CO2)			1.5±0.1 V				
12	Check	pilot lights				On				

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6.10.9MEL-TC-CIII-1004: Check Gas loop operational modes

TC Ide	TC Identifier MEL-TC-CIII-1004 Purpose: Verify when operational mode is changed in the Gas Loop, outputs are set as specified								
Function	s Tested	CIII_PLCSW_Gas, MEL	_CIII_Gas						
Descri	ption	From the MEL_CIII_Gas	s supervision scree	n it is possible to change the operational mode	and set the manual values.				
Special Re	equisites:	Use a Multimeter to meas	sure expected out _l	buts					
		Use MEL_CIII_Gas supe	ervision screen to c	hange operational modes and manual values.					
Test	Tester: Date:								
	1			Course of	Actions				
Step no				Description		Expected value	OK/NOK	Comments	
1	In the M	MEL_CIII_Gas su	pervision sc	reen set operational mode to O	FF				
2	Connec	nect a pilot light to AC outputs CIII_AC_Safe							
3	Check .	Check AO 02 (CIII_SP_N2)							
4	Check .	Check AO 03 (CIII_SP_O2)							
5	Check	pilot light				Off			
6	In the M	MEL_CIII_Gas ed	lit the manua	al values and set:					
	N2 Flo	w Set point: 10							
	O2 Flo	w set point: 20							
	Pressur	e safety valve acti	ivation: chec	ked					
7	In the M	MEL_CIII_Gas su	pervision sc	reen set operational mode to M	AN				
8	Check .	AO 02 (CIII_SP_I	N2)			0.33±0.1 V			
9	Check	AO 03 (CIII_SP_0		1.00±0.1 V					
10	Check	pilot light				On			

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7 HMI TEST PROCEDURES

The following Test Procedures are specified in the following sections:

Identifier	Name	Description		
MEL- HMI -TP-01 Check CIII HMI		Test values of Compartment CIII are displayed		
	Displays	according to specifications.		
MEL-HMI-TP-02	Check CIV HMI	Test analogue output values of Compartment		
	Displays	CIII are displayed according to specifications.		

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7.1 MEL-HMI-TP-01 Check CIII HMI Displays

7.1.1 Purpose

Check that CIII PLC values are displayed in the HMI displays according to specifications.

7.1.2 Features to be tested

Verify integration and functionality of the following items:

- HMI – CIII PLC Interface (Software interface)

7.1.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-HMI-TC-0101	Check CIII_HMI_Temp
MEL-HMI-TC-0102	Check CIII_HMI_pH
MEL-HMI-TC-0103	Check CIII_HMI_Liquid
MEL-HMI-TC-0104	Check CIII_HMI_Gas

7.1.4 Special Requirements

Values of displayed variables can be modified using following procedures: Analogue input variables: Apply a voltage to rack connection panel using an APS. Analogue output variables: Modify manual values in Supervision displays. Supervision set points: Modify using Supervision screens. Digital input variables: Close circuit using a resistance. Digital output variables: Modify manual values in Supervision displays.

Table of inputs

Variable Name	Tp.	N.	Description	Connector	Pin	Signal	Range
	Δι	01	DO at bottom	CIII_CP	001	+	4 – 20 mA
		01			005	-	
CIII MV Dot	Δι	02	DO at top		009	+	4 – 20 mA
		02			013	-	
CIII MV NH4	ΔI	03	Ammonium		017	+	4 – 20 mA
		00	concentration		021	-	
	Δι	04	Nitrate concentration		025	+	4 – 20 mA
		04			029	-	
	Δι	05	Pressure at top of the		033	+	4 – 20 mA
		05	gas phase		037	-	
	ΔΙ	06	pH at bottom		041	+	4 – 20 mA
		00			045	-	
		07	pH at Top		049	+	4 – 20 mA
		07			053	-	
	Δι	08	Pressure sensor for the		057	+	4 – 20 mA
		00	sampling line		061	-	

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Variable Name	Tp.	N.	Description	Connector	Pin	Signal	Range
CIII MV Th	ΔI	09	Temperature at bottom		065	+	4 – 20 mA
	7.1	00			069	-	
CIII MV Tt	ΔI	10	Temperature at top		073	+	0 – 5 V
	7.1	10			077	-	
	וח	01	NH4 Analyser calibration		193	+	0 – 24 V
		01	indicator		197	-	
4			Indicator				
CIII IND CaINO	וס	02	Nitrate analyser		002	+	0 – 24 V
3		02	calibration indicator		006	-	
CIII MV Llow	וס	03	Level measurement low		010	+	0 – 24 V
		00			014	-	
CIII MV Lhigh	וח	04	Level measurement high		018	+	0 – 24 V
		04	Level measurement night		022	-	
CIII MVO Lht	וח	05	Indicator of max loval		026	+	0 – 24 V
		00	reached for a buffer tank		030	-	
			reached for a buller tark				

7.1.5 Procedure Steps

Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.

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7.1.6 MEL-TC-HMI-0101: Check CIII_HMI_Temp

TC Ide	TC Identifier MEL-TC-HMI-0101 Purpose: Verify that values in CIII_HMI_Te,mp are displayed according to specifications.							
Function	s Tested	Interface between HMI – CIII_PLC, CIII_HMI_Main, CIII_HMI_Temp						
Descri	ption	Known values applied to PLC variables shall be displayed in the display as specified.						
Special Re	equisites:	Use an APS to generate voltages.						
Test	er:	Date:						
		Course of Actions	-					
Step no		Description	Expected value	OK/NOK	Comments			
1	Apply 2	2.9 – 3.1 V to AI 09 (CIII_MV_Tb) and check the displayed value Temperature in the	73.6±4.3 mbar					
	Superv	ision screen CIII_HMI_Temp.						
2	Apply (2.9 - 3.1 V to AI 10 (CIII MV Tt) and check the displayed value Temperature in the	73.6+4.3 mbar					
-	Superv	ision screen CIII HMI Temp	75.0±4.5 mou					
2	Superv	$\frac{1}{1} = \frac{1}{1} = \frac{1}$	50 (140 1					
3	Apply 2	$2.9 - 3.1$ V to AI 09, AI 10 (CIII_MV_ID, CIII_MV_ID) and check the displayed value	73.6 ± 4.3 mbar					
	Temper	rature in the Supervision screen CIII_HMI_Temp.						
4	Check	temperature value in the CIII_HMI_Main display.	73.6±4.3 mbar					
5	In the M	MEL_CIII_Temp Supervision display change the temperature set point to 27 ° C						
6	Check	the Temperature set point in the CIII_HMI_Temp display (note ramp action)	down to 27° C					
7	In the I	MEL_CIII_Temp Supervision display change the control mode to AUTO						
8	Check	the operational mode changed accordingly in the CIII_HMI_Temp display	AUTO					
9	In the M	MEL_CIII_Temp Supervision display change the control mode to MAN						
10	Check	the operational mode changed accordingly in the CIII_HMI_Temp display	MAN					
11	In the I	MEL_CIII_Temp Supervision display edit manual values and set:						
	- Hea	ater enabled.						
	- Coo	oling valve enabled.						
12	Check	in the CIII_HMI_Temp display status of Heater and the Cooling Valve.	Enabled					

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7.1.7 MEL-TC-HMI-0102: Check CIII_HMI_pH display

TC Ide	TC Identifier MEL-TC-HMI-0102 Purpose: Verify that values in CIII_HMI_pH are displayed according to specifications.									
Functions	s Tested	Interface between HMI -	- CIII_PLC, CIII_H	IMI_Main, CIII_HMI_pH, CI	II_HMI_Gas					
Descri	otion	Known values applied to	PLC variables sha	Il be displayed in the display a	as specified.					
Special Re	equisites:	Use all APS to generate v	voltage values.		Deter					
1051	ei.				Course of	Actions				
Step no	p no Description Expected value OK/NOK Ct									
1	Apply 2	2.9 - 3.1 V to AI (06 (CIII MV	PHb) and check th	ne displayed	l value pHbot i	n the	8 0+0 25 pH		
-	Supervision screen CIII_HMI_pH.							0.020.20 pm		
2	Apply 2.9 – 3.1 V to AI 07 (CIII_MV_PHt) and check the displayed value pHtop in the					the	6.5±0.25 pH			
	Supervision screen CIII_HMI_pH.									
3	Apply 2.9 – 3.1 V to AI 06 and AI 07 (CIII_MV_PHb, CIII_MV_PHt) and check the displayed						he displayed	7.85±0.25 pH		
	value pH in the HMI screen CIII_HMI_pH.									
4	Check pH value in the HMI screen CIII_HMI_Main							7.85±0.25 pH		
5	In the MEL_CIII_pH Supervision display change the pH set point to 9									
6	Check	eck the pH set point in the CIII_HMI_pH display (note ramp action) in 3 minutes					S	up to 9 pH		
7	In the M	MEL_CIII_pH Su	pervision dis	play change the con	trol mode to	o AUTO				
8	Check	the operational me	ode changed	accordingly in the G	CIII_HMI_1	pH display		AUTO		
9	In the N	MEL_CIII_pH Su	pervision dis	play change the pH	operation n	node to 2=CO2	+Base			
10	Check	the pH operation	mode change	ed accordingly in the	e CIII_HMI	[_pH display		2		
11	In the N	MEL_CIII_pH Su	pervision dis	play change the pH	operation n	node to 3=Acid	l+Base			
12	Check	the pH operation	mode change	ed accordingly in the	e CIII_HMI	[_pH display		3		
13	In the N	MEL_CIII_pH Su	pervision dis	play change the con	trol mode to	o MAN				
14	Check	the operational me	ode changed	accordingly in the G	CIII_HMI_j	pH display		MAN		
15	In the M	MEL_CIII_pH Su	pervision dis	play edit manual va	lues and set	t:				
	- Aci	d pump enabled								
	- Aci	d pump control ac	ction 10%.							
	- Bas	e pump enabled								
	- Bas	e pump control ac	ction 20%.							
	- CO	2 valve at 30%								

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TC Ide	ntifier	MEL-TC-HMI-0102 Purpose:	Verif	y that values in CIII_HMI_pH are displa	yed according to specification	ons.						
Function	s Tested	Interface between HMI - CIII_PLC, CIII_HMI_Main, CIII_HMI_pH, C	CIII_HMI_Gas									
Descri	ption	Known values applied to PLC variables shall be displayed in the display	v as specified.									
Special Re	tal Requisites: Use an APS to generate voltage values.											
Test	er:		Date:									
	Course of Actions											
Step no		Description			Expected value	OK/NOK	Comments					
16	Check	in CIII_HMI_pH acid pump control action		10%								
17	Check	in CIII_HMI_pH base pump control action		20%								
18	Check	in CIII_HMI_pH CO2 valve control action		30%								
19	Check	in CIII_HMI_Gas CO2 valve control action			30%							
20	Check	acid and base pump status		Enabled								
21	In the M	MEL_CIII_pH Supervision display change the co										
22	Check the operational mode changed accordingly in the CIII_HMI_pH display				OFF							
23	Check	acid, base, CO2 control actions	0.0									
24	Check	acid, base pumps status			Disabled							

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7.1.8 MEL-TC-HMI-0103: Check CIII_HMI_Liquid display

Functions Tested Interface between HMI - CIII, PLC, CIII, HMI_Main, CIII, HMI_Liquid, MEL, HMI_Main Description Known values applied to PLC variables shall be displayed in the display as specified. Special Requisites: Use an APS to generate voltage values. Tester: Date: Course of Actions Step no Expected value OK/NOK Comments In the MEL_CIII_Liquid Supervision display change the Level 2 Liquid Input set point to 0,4 Course of Actions Step no Description Expected value OK/NOK Comments In the MEL_CIII_Liquid Supervision display change the Level 2 Liquid Input set point to 0,4 Image: Course of Actions Course of Actions Step no Description Expected value OK/NOK Comments 1 Check Level 2 Liquid input set point value in the HMI screen CIII_HMI_Liquid 0,4 Image: Check in the CIII_HMI_Liquid display the Liquid Level I Liquid Input set point to 0,4 Image: Check in the CIII_HMI_Liquid display the Liquid Level I Liquid Input set point to 0,4 Image: Check in the CIII_HMI_Liquid display the Liquid Level High indicator status Enabled Image: Check in the CIII_HMI_Liquid display the Liquid Level High indicator status Enabled Image: Check In the CIII_HMI_Liquid display the control mode to AUTO
Description Known values applied to PLC variables shall be display as specified. Special Requisities: Use an APS to generate voltage values. Tester: Date: Course of Actions Step no Expected value OK/NOK Comments In the MEL_CIII_Liquid Supervision display change the Level 2 Liquid Input set point to 0,4 Expected value OK/NOK Comments 2 Using iFix Database Manager change the Level 1 Liquid Input set point to 0,4 0,4 1 3 Check Level 1 Liquid input set point value in the HMI screen CIII_HMI_Liquid 0,4 1 4 Check in the CIII_HMI_Liquid display the Liquid Level Low indicator status Enabled 1 5 Apply a resistance to DI 04 (Level High) 1 1 In the MEL_CIII_Liquid display the Liquid Level High indicator status Enabled 1 6 Check in the CIII_HMI_Liquid display the control mode to AUTO 1 1 1 1 9 Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid 0,4 1 1
Special Requisitie: Use an APS to generate voltage values. Tester: Date: Course of Actions Step no Expected value OK/NOK Comments Step no Expected value OK/NOK Comments 1 Check Level 2 Liquid input set point value in the HMI screen CIII_HMI_Liquid 0,4 Image: Colspan="2">Image: Colspan="2">Course of Actions 2 Using iFix Database Manager change the Level 1 Liquid Input set point to 0,4 Image: Colspan="2">Image: Colspan="2">Image: Colspan="2">Course of Actions 3 Check Level 1 Liquid input set point value in the HMI screen CIII_HMI_Liquid 0,4 Image: Colspan="2">Image: Colspan="2">Course of Actions 4 Check In the CIII_HMI_Liquid display the Liquid Level Low indicator status Enabled Image: Colspan="2">Image: Colspan="2">Course of Actions 5 Apply a resistance to DI 04 (Level High) Image: Colspan="2">Image: Colspan="2">Image: Colspan="2">Course of Actions 6 Check in the CIII_HMI_Liquid display the Liquid Level Low indicator status Enabled Image: Colspan="2">Image: Colspan="2">Colspan="2">Course of Actions 5 Apply a resistance to DI 04 (Level High) Image: Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2"
Totate: 1 Course of Actions Course of Actions Step no Expected value OK/NOK Comments 1 In the MEL_CIII_Liquid Supervision display change the Level 2 Liquid Input set point to 0,4 0,4 1 2 Using iFix Database Manager change the Level 1 Liquid Input set point to 0,4 0,4 1 3 Check Level 1 Liquid input set point value in the HMI screen CIII_HMI_Liquid 0,4 1 4 Check in the CIII_HMI_Liquid display the Liquid Level Low indicator status Enabled 1 5 Apply a resistance to DI 04 (Level High) 1 1 6 Check in the CIII_HMI_Liquid display the Liquid Level High indicator status Enabled 1 7 In the MEL_CIII_Liquid display the control mode to AUTO 1 1 8 Check in the CIII_HMI_Liquid display the control mode value AUTO 1 9 Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid 0,4 1 10 Check Liquid input flow rate value in the HMI screen CIII HMI Main 0,4 1
Course of Actions Step no Description Expected value OK/NOK Comments 1 In the MEL_CIII_Liquid Supervision display change the Level 2 Liquid Input set point to 0,4 0,4 1 2 Using iFix Database Manager change the Level 1 Liquid Input set point to 0,4 0,4 1 3 Check Level 1 Liquid input set point value in the HMI screen CIII_HMI_Liquid 0,4 1 4 Check in the CIII_HMI_Liquid display the Liquid Level Low indicator status Enabled 1 5 Apply a resistance to DI 04 (Level High) 1 1 1 6 Check in the CIII_HMI_Liquid display the Liquid Level High indicator status Enabled 1 7 In the MEL_CIII_Liquid display the Liquid Level High indicator status Enabled 1 8 Check in the CIII_HMI_Liquid display the control mode value AUTO 1 9 Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid 0,4 1
In the MEL_CIII_Liquid Supervision display change the Level 2 Liquid Input set point to 0,4Data takeData
1 Check Level 2 Liquid input set point value in the HMI screen CIII_HMI_Liquid 0,4 2 Using iFix Database Manager change the Level 1 Liquid Input set point to 0,4 0,4 3 Check Level 1 Liquid input set point value in the HMI screen CIII_HMI_Liquid 0,4 4 Check in the CIII_HMI_Liquid display the Liquid Level Low indicator status Enabled 5 Apply a resistance to DI 04 (Level High) 0 6 Check in the CIII_HMI_Liquid display the Liquid Level High indicator status Enabled 7 In the MEL_CIII_Liquid Supervision display change the control mode to AUTO 4UTO 8 Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid 0,4 9 Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid 0,4
2 Using iFix Database Manager change the Level 1 Liquid Input set point to 0,4
3Check Level 1 Liquid input set point value in the HMI screen CIII_HMI_Liquid0,44Check in the CIII_HMI_Liquid display the Liquid Level Low indicator statusEnabled5Apply a resistance to DI 04 (Level High)6Check in the CIII_HMI_Liquid display the Liquid Level High indicator statusEnabled7In the MEL_CIII_Liquid Supervision display change the control mode to AUTO8Check in the CIII_HMI_Liquid display the control mode valueAUTO9Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid0,410Check Liquid input flow rate value in the HMI screen CIII HMI Main0,4
4Check in the CIII_HMI_Liquid display the Liquid Level Low indicator statusEnabled5Apply a resistance to DI 04 (Level High)6Check in the CIII_HMI_Liquid display the Liquid Level High indicator statusEnabled7In the MEL_CIII_Liquid Supervision display change the control mode to AUTO8Check in the CIII_HMI_Liquid display the control mode valueAUTO9Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid0,410Check Liquid input flow rate value in the HMI screen CIII HMI Main0,4
5Apply a resistance to DI 04 (Level High)Image: Check in the CIII_HMI_Liquid display the Liquid Level High indicator statusEnabled6Check in the CIII_HMI_Liquid display the Liquid Level High indicator statusEnabled7In the MEL_CIII_Liquid Supervision display change the control mode to AUTOImage: Check in the CIII_HMI_Liquid display the control mode value8Check in the CIII_HMI_Liquid display the control mode valueAUTO9Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid0,410Check Liquid input flow rate value in the HMI screen CIII HMI Main0,4
6 Check in the CIII_HMI_Liquid display the Liquid Level High indicator status Enabled 7 In the MEL_CIII_Liquid Supervision display change the control mode to AUTO 8 Check in the CIII_HMI_Liquid display the control mode value AUTO 9 Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid 0,4 10 Check Liquid input flow rate value in the HMI screen CIII HMI Main 0,4
7 In the MEL_CIII_Liquid Supervision display change the control mode to AUTO 4000 8 Check in the CIII_HMI_Liquid display the control mode value AUTO 9 Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid 0,4 10 Check Liquid input flow rate value in the HMI screen CIII HMI Main 0,4
8 Check in the CIII_HMI_Liquid display the control mode value AUTO 9 Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid 0,4 10 Check Liquid input flow rate value in the HMI screen CIII HMI Main 0,4
9 Check Liquid input flow rate value in the HMI screen CIII_HMI_Liquid 0,4 10 Check Liquid input flow rate value in the HMI screen CIII HMI Main 0,4
10 Check Liquid input flow rate value in the HMI screen CIII HMI Main 0.4
11 Check Liquid input flow rate value in the HMI screen MEL_HMI_Main 0,4
12 Check Liquid input pump control action in the HMI screen CIII_HMI_Liquid 29.59%
13 Check Liquid output pump control action in the HMI screen CIII_HMI_Liquid 36.99%
14 Apply a resistance to DI 05 (CIII_MVO_Lbt)
15 Check in the CIII_HMI_Liquid display the Buffer tank level high indicator Enabled
16 Check in the CIII_HMI_Liquid display the Buffer tank output pump status ON
17 In the MEL_CIII_Liquid Supervision display change the control mode to MAN
18 Check in the CIII_HMI_Liquid display the control mode value MAN
19 In the MEL_CIII_Liquid Supervision display edit manual values and set:
- Liquid input pump control action 10%
- Liquid output pump control action 20%.
- Buffer output pump enabled
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TC Ide	ntifier	MEL-TC-HMI-0103 Purpose:		Verify	that values in CIII_HMI_Liquid	are displayed according	ng to specifica	tions.		
Function	s Tested	Interface between HMI – CIII_PLC, CIII_HMI_M	Main, CIII_HMI_Liquid, M	IEL_HMI_Mai	n					
Descri	ption	Known values applied to PLC variables shall be o	displayed in the display as a	specified.						
Special R	Special Requisites: Use an APS to generate voltage values.									
Test	Tester: Date:									
	Course of Actions									
Step no			Description			Expe	cted value	OK/NOK	Comments	
20	Check	n the CIII_HMI_Liquid display th	he Liquid input pu	imp contro	ol action	10%				
21	Check	n the CIII_HMI_Liquid display th	he Liquid output p	oump cont	rol action	20%				
22	Check	n the CIII_HMI_Liquid display th	ne Buffer tank pun	np status		ON				
23	Apply 2	2.9 – 3.1 V to AI 03 (CIII_MV_N	H4) and check NH	H4 value in	n the HMI display	100±5	ppm			
	CIII_H	MI_Liquid								
24	Check	Check NH4 value in the HMI screen CIII_HMI_Main					ppm			
25	Apply 2	2.9 – 3.1 V to AI 04 (CIII_MV_N	O3) and check NO	D3 value in	n the HMI display	500±25	5 ppm			
	CIII_H	MI_Liquid								
26	Check	NO3 value in the HMI screen CIII	I_HMI_Main			500±25	5 ppm			
27	Using i	Fix Data Manager set 5 to CIII_S	MV_NO2			30%				
28	Check	n the CIII_HMI_Liquid display th	ne NO2 value			5				
29	Check	n the MEL_HMI_Main display th	e NO2 value			5				
30	Check NO2 value in the HMI screen CIII_HMI_Main					5				
31	In the MEL_CIII_Liquid Supervision display change the control mode to OFF									
32	Check	he operational mode changed acc	ordingly in the CI	II_HMI_I	Liquid display	OFF				
33	Check	nput and output pump control act	ion values			0.0				
34	Check	ouffer pump status				Disable	ed			

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7.1.9 MEL-TC-HMI-0104: Check CIII_HMI_Gas display

TC Ide	ntifier	MEL-TC-HMI-0104 Purpose: Verify that values in CIII_HMI_Gas are displ	layed according to specificat	ions.							
Function	s Tested	Interface between HMI – CIII_PLC, CIII_HMI_Main, CIII_HMI_Gas									
Descri	ption	Known values applied to PLC variables shall be displayed in the display as specified.									
Special R	equisites:	Use an APS to generate voltage values.									
Test	Tester: Date: Course of Actions										
Step no	1	Course of Actions Description	Expected value	OK/NOK	Comments						
1	In the 1	MEL CIII Gas Supervision display change the DO set point to 85%	Expected value		Comments						
2	Check	in the CIII_HMI_Gas display the DO set point value (note ramp action) in 5 minutes	up to 85%								
3	Apply	2.9 – 3.1 V to AI 01 (CIII_MV_Dob) and check DO bottom value in CIII_HMI_Gas	50±2.5%								
4	Apply	2.9 – 3.1 V to AI 02 (CIII MV Dot) and check DO top value in CIII HMI Gas display.	50±2.5%								
5	Apply CIII_H	2.9 – 3.1 V to AI 01 and AI 02 (CIII_MV_Dob, CIII_MV_Dot) and check DO value in MI_Gas display.	50±2.5%								
6	Check	Check in the CIII_HMI_Main display the DO value 50±2.5%									
7	Check in the MEL_HMI_Main display the DO value 50±2.5%										
9	In the	In the MEL_CIII_Gas Supervision display change the DO control mode to AUTO									
10	Check	in the CIII_HMI_Gas display the DO control mode value	AUTO								
11	In the l	MEL_CIII_Gas Supervision display change the DO control mode to MAN									
12	Check	in the CIII_HMI_Gas display the DO control mode value	MAN								
13	In the	MEL_CIII_Gas Supervision display edit manual values and set:									
	- 02	control action to 10%									
	- N2	Liquid output pump control action 20%.									
14	Check	O2 valve control action in the HMI screen CIII_HMI_Gas	10%								
15	Check	N2 valve control action in the HMI screen CIII_HMI_Gas	20%								
16	Apply 2.9 - 3.1 V to AI 05 (CIII_MV_P) and check P value in CIII_HMI_Gas display.500±2.5 mbar										
17	Check	in the CIII_HMI_Main display the P value									
18	In the l	MEL_CIII_Gas Supervision display change the Gas control mode to MAN									
19	Check	in the CIII_HMI_Gas display the Gas control mode value	MAN								
20	In the	MEL_CIII_Gas Supervision display change the Gas control mode to AUTO									
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21	Check in the CIII_HMI_Gas display the Gas control mode value	AUTO	
22	In the MEL_CIII_Gas Supervision display change the P set point to 200 mbar		
23	Check in the CIII_HMI_Gas display the Pressure set point	200 mbar	
24	Check in the CIII_HMI_Gas display the Safety Pressure Valve status	OPEN (green)	
25	In the MEL_CIII_Gas Supervision display change the P set point to 500 mbar		
26	Check in the CIII_HMI_Gas display the Safety Pressure Valve status	CLOSED (red)	

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7.2 MEL-HMI-TP-02 Check CIV_HMI_Displays

7.2.1 Purpose

Check that CIV PLC values are displayed in the HMI displays according to specifications.

7.2.2 Features to be tested

Verify integration and functionality of the following items:

- HMI – CIV PLC Interface (Software interface)

7.2.3 Test Cases

Following Test Cases are executed in this Test Procedure

Identifier	Name
MEL-HMI-TC-0201	Check CIV_HMI_pH
MEL-HMI-TC-0202	Check CIV_HMI_BP
MEL-HMI-TC-0203	Check CIII_HMI_Gas

7.2.4 Special Requirements

Values of displayed variables can be modified using following procedures: Analogue input variables: Apply a voltage to rack connection panel using an APS. Analogue output variables: Modify manual values in Supervision displays. Supervision set points: Modify using Supervision screens. Digital input variables: Close circuit using a resistance. Digital output variables: Modify manual values in Supervision displays.

Table of inputs

Variable Name	Tp.	N.	Description	Connector	Pin	Signal	Range
CIV_MV_CxAbs	AI	01	Analogue input for biomass concentration measurement in light absorbance units	CIV_CP	001 005	+ -	4 – 20 mA
CIV_MV_M1	AI	02	Scale 1		009 013	+ -	4 – 20 mA
CIV_MV_M2	AI	03	Scale 2		017 021	+ -	4 – 20 mA
CIV_MV_P	AI	04	Pressure measurement		025 029	+ -	4 – 20 mA
CIV_MV_pH	AI	05	pH measurement		033 037	+ -	4 – 20 mA
CIV_MV_T	AI	06	Temperature measurement		041 045	+ -	4 – 20 mA
CIV_MGO_O2	AI	07	O2 measurement at gas output		049 053	+ -	4 – 20 mA
CIV_MGO_CO2	AI	08	CO2 measurement at gas output		057 061	+ -	4 – 20 mA

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Variable Name	Tp.	N.	Description	Connector	Pin	Signal	Range
CIV MV DO	AI	09	Percent of DO saturation		065	+	4 – 20 mA
••••_•••			in the reactor		069	-	
CIV MV FrGas	ΔI	13	Gas flow at		097	+	0 – 5 V
	, , ,	10	compartment input		101	-	
CIV MGO ErGa	ΔΙ	14	Gas flow at output		105	+	0 – 5 V
		14			109	-	
5							
CIV MV FrCO2	ΔΙ	15	CO2 flow measurement		113	+	0 – 5 V
010_1010_11002		10			117	-	
CIV MGL ErGas	ΔΙ	16	Gas flow at external		121	+	0 – 5 V
		10	input		125	-	
		01	Collibration indicator		42	+	0 – 24 V
	וט	01	Calibration indicator		46	-	
2							
	ום	02	Error indicator		50	+	0 – 24 V
		02			54	-	
02							
CIV SCI 1 CO2	וח	03	Lising scale 1 indicator		58	+	0 – 24 V
02		00	Using Sould 1 Indicator		62	-	
<u> </u>							
CIV SCI 2 CO2	וס	04	Using scale 2 indicator		66	+	0 – 24 V
02		07			70	-	
32							

7.2.5 Procedure Steps

Execute the Test Cases and record the successful or unsuccessful execution of the test in the Test Report.



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7.2.6 MEL-TC-HMI-0201: Check CIV_HMI_pH display

TC Ide	ntifier	MEL-TC-HMI-0201 Purpose: Verify that values in CIV_HMI_pH are display	ed according to specificati	ons.							
Functions	s Tested	Interface between HMI – CIV_PLC, CIV_HMI_Main, CIV_HMI_pH, CIV_HMI_Gas									
Descri	ption	Known values applied to PLC variables shall be displayed in the display as specified.									
Special Re	equisites:	Ose an APS to generate voltage values.									
Test	Course of Actions										
Step no		Description	Expected value	OK/NOK	Comments						
1	Apply 2	2.9 – 3.1 V to AI 05 (CIV MV pH) and check the displayed value pH in the HMI screen	7.0±0.35 pH								
	CIV_H	MI_pH.	r in the r								
2	Check	pH value in the HMI screen CIV_HMI_Main	7.0±0.35 pH								
3	In the I	MEL_CIV_pH Supervision display change the pH set point to 9									
4	Check	the pH set point in the CIV_HMI_pH display	9								
5	In the I	MEL_CIV_pH Supervision display change the control mode to AUTO									
6	Check	the operational mode changed accordingly in the CIV_HMI_pH display	AUTO								
7	In the I	MEL_CIV_pH Supervision display change the control mode to MAN									
8	Check	the operational mode changed accordingly in the CIV_HMI_pH display	MAN								
9	In the I	MEL_CIV_pH Supervision display edit manual values and set:									
	- Aci	id pump control action 10%									
	- Bas	se pump control action 20%.									
	- CO	2 valve control action 2,5 nLm									
10	Check	in CIV_HMI_pH acid pump control action	10 %								
11	Check	in CIV_HMI_pH base pump control action	20 %								
12	Check	in CIV_HMI_pH CO2 valve control action	2,5 nLm								
13	Check	in CIV_HMI_Gas CO2 valve control action	2,5 nLm								
14	In the I	MEL_CIV_pH Supervision set CO2 offset to 1,5 nLm									
15	Check	the CO2 offset changed accordingly in the CIV_HMI_pH display	1,5								
16	In the I	MEL_CIV_pH Supervision set pH control mode to 2=CO2 + Base									
17	Check	the pH control mode changed accordingly in the CIV_HMI_pH display	2								
18	In the I	MEL_CIV_pH Supervision set pH control mode to 3=Acid + Base									
19	Check	the pH control mode changed accordingly in the CIV_HMI_pH display	3								
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TC Ide	ntifier	MEL-TC-HMI-0201	EL-TC-HMI-0201 Purpose: Verify that values in CIV_HMI_pH are displayed according to specifications.						
Function	s Tested	Interface between HMI – CIV_PLC, CIV_HMI_Main, CIV_HMI_pH, CIV_HMI_Gas							
Descri	ription Known values applied to PLC variables shall be displayed in the display as specified.								
Special Re	equisites:	quisites: Use an APS to generate voltage values.							
Test	er: Date:								
	Course of Actions								
Step no				Description		Expected value	OK/NOK	Comments	
20	In the M	In the MEL_CIV_pH Supervision display change the operation mode to OFF							
21	Check the operational mode changed accordingly in the CIV_HMI_pH display OFF								
22	Check	acid, base and CC	02 control act	ions		0.0			

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7.2.7 MEL-TC-HMI-0202: Check CIV_HMI_BP display

TC Ide	ntifier	MEL-TC-HMI-0202	Purpose:		Veri	fy that v	dues in CIV_HMI_BP are disp	layed according to specificat	ions.	
Functions	s Tested	Interface between HMI -	CIV_PLC, CIV_I	HMI_Main, CIV_HMI_BP, N	MEL_HMI_Main					
Descri	ption	Known values applied to	PLC variables sha	all be displayed in the display	as specified.					
Special Re	equisites:	Use an APS to generate v	oltage values.			1				
Test	er:				Date:					
	1				Course of	Action	S			
Step no				Description				Expected value	OK/NOK	Comments
1	Apply 2	2.9 - 3.1 V to AI ()2 (CIV_M\	/_M1) and check the	ne displayed	level	for input Tank 1 in	75±3.751		
	the HM	II screen CIV_HM	II_BP.							
2	Apply 2	2.9 – 3.1 V to AI ()3 (CIV_M\	/M2) and check the	75±3.751					
	the HN	II screen CIV HN	II BP.				•			
3	Apply '	$29 - 31$ V to ΔI	1 (CIV M)	/ CxAbs) and chec	k the displa	ved v	alue for Biomass	$2.0\pm0.5.\alpha/1$		
5	Apply .	2.7 = 5.1 V to AI (in the displa	yeu v	and for Diomass	5.0±0.5 g/1		
	concen	tration in the HMI	screen CIV	_HMI_BP.						
4	In the I	MEL_CIV_BP Su	pervision dis	splay change the Le	evel 2 Bioma	ass Pro	oduction Set point to			
	1,2									
5	Check	the Level 2 Bioma	ass production	on set point changed	d accordingly	v in th	e CIV HMI BP	1.2		
	display		1	1 0	0.			,		
6	Using i	Fix Data Manager	r change the	(CIV SSP L1BP)	Level 1 Bio	mass	Production Set point			
Ũ	to 1.1	I IN Duiu Mulugo	enunge uie		Level i blo	mass	roduction set point			
7	C^{1}	1 I 11D'	1	1	1 1' 1	•		1 1		
7	Check	the Level I Bioma	ass production	on set point changed	d accordingly	y in th	e CIV_HMI_BP	1,1		
	display									
8	In the I	MEL_CIV_BP Sup	pervision dis	splay change the Le	evel 2 Liquid	l inpu	flow rate Set point	0		
	0.7									
9	Check	the Level 2 Liquid	l input flow	rate set point chang	ed according	glv in	the CIV HMI BP	0.7		
-	dienlau				,	B-J		.,,		
10			1 (1		T 111.	• 1 •				
10	Using 1	Fix Data Manager	change the	(CIV_SSP_LILIFr) Level I Li	quid i	nput flow rate Set			
	point to	0,6								
11	Check	the Level 1 Liquid	l input flow	rate set point chang	ged according	gly in	the CIV_HMI_BP	0,6		
	display	1		· · · ·	-	- •				
12	Check	the Biomass produ	uction rate in	n the CIV_HMI_BI	P display			0,66		

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TC Ide	ntifier	MEL-TC-HMI-0202 Purpose: Verify that values in CIV_HMI_BP are dis	played according to specificati	ons.	
Function	s Tested	Interface between HMI – CIV_PLC, CIV_HMI_Main, CIV_HMI_BP, MEL_HMI_Main			
Descri Special Re	puon equisites:	Use an APS to generate voltage values.			
Test	ter:	Date:			
		Course of Actions			
Step no		Description	Expected value	OK/NOK	Comments
13	Check	the Biomass production rate in the CIV_HMI_Main display	0,66		
14	Check	the Biomass production rate in the MEL_HMI_Main display	0,66		
15	Check	the Liquid input flow rate in the CIV_HMI_BP display	0,6		
16	Check	the Liquid input flow rate in the CIV_HMI_Main display	0,6		
17	Check	the Liquid input flow rate in the MEL_HMI_Main display	0,6		
18	Using i	iFix Data Manager change the (CIV_SSP_LightWm) Light intensity to 150			
19	Check	the Light intensity set point in the CIV_HMI_BP display	150 W/m2		
20	Check	the Light intensity set point in the CIV_HMI_Main display	150 W/m2		
21	In the I	MEL_CIV_BP Supervision display change the operational mode to AUTO			
22	Check	the operational mode in the CIV_HMI_BP display	AUTO		
23	In the I	MEL_CIV_BP Supervision display change the operational mode to MAN			
24	In the l	MEL_CIV_BP Supervision display edit manual values and set:			
	- Ena	able Biomass sensor aeration valve			
	- Ena	able Liquid input pump 1			
	- Ena	able Liquid input pump 2			
	- Ena	able Liquid output pump			
	- Set	liquid input pump 1 set point to 10%			
	- Set	liquid input pump 2 set point to 20%			
	- Set	liquid output pump set point to 30%			
	- Set	light supply regulator set point to 40%			
25	Check	in CIV_HMI_BP liquid input pump 1 control action	10 %		
26	Check	in CIV_HMI_BP liquid input pump 2 control action	20 %		
27	Check	in CIV_HMI_BP liquid output pump control action	30 %		
28	Check	in CIV_HMI_BP light supply control action	40 %		
29	Check	in CIV_HMI_BP liquid output flow rate	2,6 l/h		

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TC Ide	ntifier	MEL-TC-HMI-0202	Purpose:		Verify	that values in CIV_	HMI_BP are display	ed according to specification	ns.		
Function	s Tested	Interface between HMI – C	CIV_PLC, CIV_H	MI_Main, CIV_HMI_BP, MEI	L_HMI_Main						
Descri	ption	Known values applied to P	LC variables sha	l be displayed in the display as	specified.						
Special Re	equisites:	Use an APS to generate vol	ltage values.								
Test	ter:				Date:						
Course of Actions											
Step no				Description				Expected value	OK/NOK	Comments	
30	Check	Check in CIV_HMI_Main liquid output flow rate									
31	Check	Check in CIV_HMI_Main liquid input pump 1 status						Enabled (green)			
32	Check	in CIV_HMI_Main	ı liquid inpu	t pump 2 status				Enabled (green)			
33	Check	in CIV_HMI_Main	n liquid outp	ut pump status				Enabled (green)			
34	Check	Check in CIV_HMI_Main Biomass sensor aeration valve						Open (green)			
35	In the M	In the MEL_CIV_BP Supervision display change the operational mode to OFF									
36	Check	Check the operational mode in the CIV_HMI_BP display									
37	Check	liquid input/output,	and light s	upply control actions				0,0			

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7.2.8 MEL-TC-HMI-0203: Check CIV_HMI_Gas display

TC Ide	ntifier	MEL-TC-HMI-0203 Purpose: Verify that values in CIV_HMI_Gas are display	ved according to specification	ons.	
Function	s Tested	Interface between HMI – CIV_PLC, CIV_HMI_Main, CIV_HMI_Gas, MEL_HMI_Main			
Descri	ption	Known values applied to PLC variables shall be displayed in the display as specified.			
Special Re	equisites:	Use an APS to generate voltage values.			
Test	ter:				
64	1	Course of Actions	Farry of a dama have	OV NOV	0
Step no	A	$\frac{\text{Description}}{20 - 2.1 \text{ M} + 2.1 \text$	Expected value	OK/NOK	Comments
1	Apply	$2.9 - 3.1$ v to AI 04 (CIV_IVIV_P) and check the displayed pressure value in the HMI	0.75 ± 0.375 bar		
	screen	CIV_HMI_Gas.			
2	Check	in CIV_HMI_Main the pressure value	0.75±0.375 bar		
3	Apply	2.9 – 3.1 V to AI 07 (CIV_MGO_O2) and check the displayed O2 flow rate value in the	12.5±0.7 nLm		
	HMI so	creen CIV HMI Gas.			
4	Check	in CIV_HMI_Main the O2 value	12.5±0.7 nLm		
5	Check	in MEL_HMI_Main the O2 value	12.5±0.7 nLm		
6	Apply	2.9 – 3.1 V to AI 08 (CIV_MGO_CO2) and check the displayed CO2 at gas output	250±15 ppm		
	value				
7	Check	in CIV_HMI_Main the CO2 at output value	250±15 ppm		
8	Apply	2.9 – 3.1 V to AI 09 (CIV_MV_DO) and check the displayed DO concentration in the	50±2.5 %		
	HMI so	creen CIV_HMI_Gas.			
9	Apply	2.9 – 3.1 V to AI 13 (CIV_MV_FrGas) and check the displayed gas flow at	18±0.6 nLm		
	compar	rtment input (FG-CI) in the HMI screen CIV_HMI_Gas.			
10	Check	in CIV_HMI_Main the Gas at compartment input flow rate	18±0.6 nLm		
11	Apply	2.9 – 3.1 V to AI 14 (CIV_MGO_FrGas) and check the displayed gas flow at	18±0.6 nLm		
	compa	rtment output (FG-CO) in the HMI screen CIV_HMI_Gas.			
12	Apply	2.9 – 3.1 V to AI 15 (CIV_MV_FrCO2) and check the displayed CO2 flow at	3±0.1 nLm		
	compa	rtment input in the HMI screen CIV_HMI_Gas.			
13	Check	in CIV_HMI_Main the CO2 input flow rate	3±0.1 nLm		
14	Apply	2.9 – 3.1 V to AI 16 (CIV_MGI_FrGas) and check the displayed Air flow at	18±0.6 nLm		
	compar	rtment input in the HMI screen CIV_HMI_Gas.			
15	Apply	2.9 – 3.1 V to AI 06 (CIV_MV_T) and check the Temperature value in the HMI screen	75±3.75 ° C		
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TC Ide	dentifier MEL-TC-HMI-0203 Purpose: Verify that values in CIV_HMI_Gas are displayed according to specifications.									
Function	s Tested	Interface between HMI – CIV_PLC, CIV_HMI_Main, CIV_HMI_Gas, MEL_HMI_Main								
Descri	ption	Known values applied to PLC variables shall be displayed in the display as specified.								
Special R	equisites:	Use an APS to generate voltage values.								
Test	ter:									
Stop no.		Course of Actions	E-mosted value	OK/NOK	Commonto					
Step no	CIV H	IMI Main.	Expected value	UK/NUK	Comments					
16	In the l	MEL CIV Gas Supervision display change the Pressure set point to 0,8								
17	Check	in CIV_HMI_Gas the pressure set point	0,8 bar							
18	In the l	MEL_CIV_Gas Supervision display change the Air input set point to 10								
19	Check	in CIV_HMI_Gas the Air input set point	10 nLm							
20	In the l	MEL_CIV_Gas Supervision display change the Gas at compartment input set point to 20								
21	Check	in CIV_HMI_Gas the Gas at compartment input set point	20 nLm							
22	In the l	MEL_CIV_Gas Supervision display change the Gas at output set point to 15								
23	Check	in CIV_HMI_Gas the Gas at compartment input set point	15 nLm							
24	In the 1	MEL_CIV_Gas Supervision display change the operational mode to AUTO								
25	Check	in CIV_HMI_Gas the operational mode	AUTO							
26	In the l	MEL_CIV_Gas Supervision display change the operational mode to MAN								
27	Check	in CIV_HMI_Gas the operational mode	MAN							
28	In the l	MEL_CIV_Gas Supervision display edit manual values and set:								
	- Ena	able Safety Pressure valve								
29	Check	in CIV_HMI_Gas the Safety pressure valve status	Open (green)							
30	In the l	MEL_CIV_Gas Supervision display change the operational mode to OFF								
31	Check	in CIV_HMI_Gas the operational mode	OFF							
32	Check	in CIV_HMI_Gas the Air input, CO2 input, Gas at compartment input, Gas at output set	0,0							
	points	value								
33	Check	in CIV_HMI_Gas the safety pressure valve status	Closed (red)							

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8 APPENDIX A: Comp. CIV Connection Tables

		(CIV_TB_ACI				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV_AI_01+	CIV_TB_ACI	1	CIV_CP	4	24	WH	
CIV_AI_01-	1	2	_	8		WH/YL	
CIV_AI_02+	1	5		12		BR/GN	
CIV_AI_02-		6		16		WH/GN	
CIV_AI_03+		11		20		PR	
CIV_AI_03-		12		24		RD	
CIV_AI_04+		15		28		BL	
CIV_AI_04-		16		32		PK	
CIV_AI_05+		21		36		YL	
CIV_AI_05-		22		40		YL/BR	
CIV_AI_06+		25		44		BR	
CIV_AI_06-		26		48		GN	
CIV_AI_07+		31		52		GY/PK	
CIV_AI_07-		32		56		GY	
CIV_AI_08+		35		60		RD/BL	
CIV_AI_08-		36		64		BK	
SENSE 1		3	CIV_TB_ACI	1			
SENSE 2		7		5			
SENSE 3		13		11			
SENSE 4		17		15			
SENSE 5		23		21			
SENSE 6	4	27		25			
SENSE /	-	33		31			
SENSE 8		37		35			
N.C.		4					
		8					
		9					
		10					
		14					
		10					
		20					
		20					
		28					
		29					
		30					
		34					1
		38					
		39					
		40					

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		(CIV_TB_AVI				
Tested by:		Date:					1
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV_AI_09+	CIV_TB_AVI	3	CIV_CP	68	24	WH	1
CIV_AI_09-	1	2		72		WH/YL	1
CIV_AI_10+		5		76		BR/GN	
CIV_AI_10-	1	6		80		WH/GN	1
CIV_AI_11+		11		84		PR	
CIV_AI_11-	1	12		88		RD	1
CIV_AI_12+	1	15		92		BL	
CIV_AI_12-	1	16		96		PK	1
CIV_AI_13+		21		100		YL	
CIV_AI_13-		22		104		YL/BR	
CIV_AI_14+		25		108		BR	
CIV_AI_14-		26		112		GN	
CIV_AI_15+		31		116		GY/PK	
CIV_AI_15-		32		120		GY	
CIV_AI_16+		35		124		RD/BL	
CIV_AI_16-		36		128		BK	
SENSE 1		3	CIV_TB_AVI	1			
N.C.		4					
		7					
		8					
		9					
		10					
		13					
		14					
		1/					
		18					
		19					
		20					
		23					
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		С	IV_TB_AVO1				
Tested by:		Date:					1
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV_AO_01+	CIV_TB_AVO1	1	CIV_CP	132	24	PK	
CIV_AO_01-		2		136		YL	
CIV_AO_02+		11		140		GY	
CIV_AO_02-		12		144		GN	
CIV_AO_03+		21		148		PR	
CIV_AO_03-		22		152		WH	
CIV_AO_04+		31		156		BK	
CIV_AO_04-		32		160		RD	
R1		3	CIV_TB_AVO1	1			
COMMON 1		4		8			
CONTROL 1		5		3			
MASTER OVER		8		4			
R2		13		11			
COMMON 2		14		18			
CONTROL 2		15		13			
MASTER OVER		18		14			
R3		23		21			
COMMON 3		24		28			
CONTROL 3		25		23			
MASTER OVER		28		24			
R4		33		31			
COMMON 4		34		38			
CONTROL 4		35		33			
MASTER OVER		38		34			
N.C.		6					
REFERENCE 1		7					
N.C.		9					
N.C.		10					
N.C.		16		1			
REFERENCE 1		17		1			
N.C.		19					
N.C.		20					
N.C.		26					
REFERENCE 1		27		1			
N.C.		29					
N.C.		30		1			
N.C.		36					
REFERENCE 1		37					
N.C.		39					
N.C.		40					



		С	IV_TB_AVO2				
Tested by:		Date:					Γ
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV AO 05+	CIV TB AVO2	1	CIV CP	164	24	YL	
CIV_AO_05-		2	_	168		PK	
CIV_AO_06+		11		172		GY	
CIV_AO_06-		12		176		GN	
CIV_AO_07+		21		180		PR	
CIV_AO_07-		22		184		WH	
CIV_AO_08+		31		188		BK	
CIV_AO_08-		32		192		RD	
R1		3	CIV_TB_AVO2	1			
COMMON 1		4		8			
CONTROL 1		5		3			
MASTER OVER		8		4			
R2		13		11			
COMMON 2		14		18			
CONTROL 2		15		13			
MASTER OVER		18		14			
R3		23		21			
COMMON 3		24		28			
CONTROL 3		25		23			
MASTER OVER		28		24			
R4		33		31			
COMMON 4		34		38			
CONTROL 4		35		33			
MASTER OVER		38		34			
N.C.		6					
REFERENCE 1		7					
N.C.		9					
N.C.		10					
N.C.		16					
REFERENCE 1		17					
N.C.		19					
N.C.		20					
N.C.		26					
REFERENCE 1		27					
N.C.		29					
N.C.		30					
N.C.		36					
REFERENCE 1		37					
N.C.		39					
N.C.		40					

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CIV_TB_ACO							
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV_AO_09-	CIV_TB_ACO	4	CIV_CP	200	24	PK	
CIV_AO_10-		8	_	208		YL	
CIV_AO_11-		14		216		GY	
CIV_AO_12-	1	18	1	7		GN	
CIV_AO_13-		24		15		PR	
CIV_AO_14-		28		23		WH	
CIV_AO_15-	1	34	1	31		BK	
CIV_AO_16-	1	38	1	39		RD	
24V-	1	2	CIV_VC_24_CP	18	20	BK	
MONITOR 1		1					
N.C.		3					
MONITOR 2		5					
RETURN	1	6					
N.C.		7					
N.C.		9					
N.C.		10					
MONITOR 3		11					
RETURN		12					
N.C.		13					
N.C.		19					
N.C.		20					
MONITOR 4		15					
RETURN		16					
N.C.		17					
MONITOR 5		21					
RETURN		22					
N.C.		23					
MONITOR 6		25					
RETURN		26					
N.C.		27					
N.C.		29					
N.C.		30					
MONITOR 7		31					
RETURN		32					
N.C.		33					
MONITOR 8]	35					
RETURN]	36					
N.C.]	37					
N.C.]	39					
N.C.		40					

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CIV_TB_DIO								
Tested by:		Date:			1		Ι	
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
CIV_DO_01	CIV_TB_DIO	1	CIV_RELAY_01	A1	24	PR		
CIV_DO_02		3	CIV_RELAY_02	A1	1	BK		
CIV_DO_03		5	CIV_RELAY_03	A1	1	RD		
CIV_DO_04		7	CIV_RELAY_04	A1	1	BR		
CIV_DO_05		11	CIV_RELAY_05	A1	1	WH		
CIV_DO_06		13	CIV_RELAY_06	A1	1	BL		
CIV_DO_07		15	CIV_CP	203	1	WH/BK		
CIV_DO_08		17		211		BR		
CIV_DI_01		21		47	1	RD/BL		
CIV_DI_02		22		55		BK		
CIV_DI_03		23		63		WH/RD		
CIV_DI_04		24		71		PR		
CIV_DI_05		25		79		BR		
CIV_DI_06		26		87		RD		
CIV_DI_07		27		95		GN		
CIV_DI_08		28		103		BL		
CIV_DI_09		31		111		WH/BL		
CIV_DI_10		32		119		PK/BR		
CIV_DI_11		33		127		BR/BL		
CIV_DI_12		34		135		PK/GY		
CIV_DI_13		35		143		WH		
CIV_DI_14		36		151		PK		
CIV_DI_15		37		159		WH/GN		
CIV_DI_16		38		167		BR/GN		
24V-		9	CIV_PS_CP	20	20	BK		
24V+		10		06		RD		
24V-		19		22		BK		
24V+		20		08		RD		
24V-		29		16		BK		
24V-		39		30		BK		
N.C.		2						
N.C.		2						
N.C.		4						
N.C.		6						
N.C.		8					ļ	
N.C.		12					ļ	
N.C.	4	14						
N.C.	4	16						
N.C.	4	18						
N.C.	4	30						
N.C.		40					I	

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CIV_PS_SRC								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
GND	CIV_PS_SRC	1	CIV_AC_GND	3	20	YL/GN		
AC N		2	CIV_AC_CP	8		BL		
AC L		3		2		BR		
24V+		4	CIV_PS_CP	1		RD		
24V-		5		15		BK		
24V+		7		1		RD		
24V-		8		11		BK		


			CIV_PS_CP				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
24V+	CIV_PS_CP	1	CIV_PS_SRC	4	20	RD	_
24V+		13		/		RD	_
24V-		15		5		BK	_
24V-		29		8		BK	_
24V+		3	CIV_PS_CP	1		RD	
24V+		5		3		RD	
24V+	-	/		5		RD	
24V+	-	9		/		RD	
24V+	4	10		9		RD	
24V+	-	13		15		RD	
24V-	-	1/		15		BK	
24V-	-	19		10		BK	
24V-		21		21		BK	+
240-	-	25		21		DK DV	
241/-	-	23		25		BK	+
24V-		16	CIV ΤΒ ΔΟΟ	23		BK	+
24V+	1	6		 10		RD	+
2411	4	8		20		RD	
24V-		18		9		RK	
24V-		20		19		BK	
24V-		20		29		BK	
24V-		24		39		BK	
24V+		10	CIV CP	003		RD	<u> </u>
24V+				011		RD	<u> </u>
24V+				019		RD	
24V+				027		RD	
24V+				035		RD	
24V+				196		RD	
24V+				204		RD	
24V+				212		RD	
24V+		12		107		RD	
24V+				115		RD	
24V+				123		RD	
24V+				131		RD	
24V+				139		RD	
24V+				147		RD	
24V+				155		RD	_
24V+				163		RD	\square
24V+		14		043		RD	+
24V+				051		RD DD	+
24V+				059		KD ND	4
24V+				075		KD ND	
24V+				0/5		KD DD	
24V+				001			
24V+				000			4
2411	4	26		099 215		RK	╉───┤
24 V-	4	20 20		210		BK	+
24 V-	4	20 20	CIV RELAV 01	207 ∆2		BK	+
24 V-	4	30	CIV_RELAT_01	M2 ∆0		BK	+
24 V-	4		CIV_RELAT_02	M2 ∆0		BK	+
24 V-	1		CIV RELAT_03	 ∆ว		BK	+
241-	1		CIV RELAT_04	Δ2		BK	+
241-	1		CIV RELAT_05	Δ2		BK	+
NC	1	2	014_11200	, \ ∠			+
NC	1	4					1



		C	V_RELAY_01				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV_DO_01	CIV_RELAY_01	A1	CIV_TB_DIO	1	24		
24V-		A2	CIV_PS_CP	28	20	BK	
CIV_RL_LI1_IN		11	CIV_CP	175		BK	
CIV_RL_LI1_OUT	1	14	1	171	1	WH	
NC	1	12					

		CI	V_RELAY_02				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV_DO_02	CIV_RELAY_02	A1	CIV_TB_DIO	3	24		
24V-		A2	CIV_RELAY_01	A2	20	BK	
CIV_RL_LI2_IN		11	CIV_CP	183		PR	
CIV_RL_LI2_OUT		14		179		PK	
N.C.		12					

CIV_RELAY_03								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
CIV_DO_03	CIV_RELAY_03	A1	CIV_TB_DIO	5	24			
24V-		A2	CIV_RELAY_02	A2	20	BK		
AC L		11	CIV_AC_MGTH2	2		BR		
CIV_RL_Cx_L		14	CIV_AC_OUT	2		BR		
N.C.		12					1	

		CI	V_RELAY_04				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV_DO_04	CIV_RELAY_04	A1	CIV_TB_DIO	7	24		
24V-		A2	CIV_RELAY_03	A2	20	BK	
AC L		11		11		BR	
CIV_RL_Fg_L		14	CIV_AC_OUT	8		BR	
N.C.		12					

		C	V_RELAY_05				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV_DO_05	CIV_RELAY_05	A1	CIV_TB_DIO	11	24		
24V-		A2	CIV_RELAY_04	A2	20	BK	
Not used		11	CIV_CP	191		RD	
Not used		14		185		RD/BL	
N.C.		12					

		C	V_RELAY_06				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIV_DO_06	CIV_RELAY_06	A1	CIV_TB_DIO	13	24		
24V-		A2	CIV_RELAY_05	A2	20	BK	
Not used		11	CIV_CP	199		WH/GN	
Not used		14		195		GY/PK	
N.C.		12					

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			CIV_AC_IN				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
AC L	CIV_AC_IN	2	CIV_AC_DIFF	1	20	BR	
AC N		4		3		BL	
AC GND		6	CIV_AC_GND	1		YL/GN	

	CIV_AC_DIFF										
Tested by:			Date:								
SIGNAL		FROM	PIN	TO	PIN	AWG	COLOR	OK			
AC L		CIV_AC_DIFF	2	CIV_AC_MGTH6	1	20	BR				
AC N			4		3	1	BL				

CIV_AC_MGTH6										
Tested by:			Date:							
SIGNAL		FROM	PIN	TO	PIN	AWG	COLOR	OK		
AC L	CIV	/_AC_MGTH6	2	CIV_AC_FILT	1	20	BR			
AC N]		4		3		BL			

		(CIV_AC_FILT				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
GND	CIV_AC_FILT	2	CIV_AC_GND	2	20	YL/GN	
AC L		4	CIV_AC_CP	1		BR	
				5		BR	
				9		BR	
				13		BR	
AC N		5		3		BL	
				7		BL	
				11]	BL	
				15]	BL	

				CIV_AC_CP				
Tested by:			Date:					
SIGNAL		FROM	PIN	TO	PIN	AWG	COLOR	OK
AC L		CIV_AC_CP	2	CIV_AC_OUT	14		BR	
AC N			4		16		BL	
AC L			6	CIV_UPS	1		BR	
AC N			8		3		BL	
AC L	1		10	CIV_PS_SRC	3	1	BR	
AC N	1		12		2	1	BL	
AC L	1		14	CIV_MGTH2	1]	BR	
AC N	1		16		3	1	BL	

CIV_AC_MGTH2										
Tested by:		Date:								
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK			
AC L	CIV_AC_MGTH2	2	CIV_RELAY_03	11		BR				
			CIV_RELAY_04	11		BR				
AC N		4	CIV_AC_OUT	4		BL				
				10						

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		(CIV_AC_OUT				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
AC L	CIV_AC_OUT	1	CIV_AC_Cx		20	BR	
AC N		3				BL	
AC GND		5				YL/GN	
AC L		7	CIV_AC_Fg			BR	
AC N		9				BL	
AC GND		11				YL/GN	
AC L		13	CIV_FAN			BR	
AC N		15				BL	
AC GND		17				YL/GN	
AC L		2	CIV_RELAY_03	14		BR	
AC L		8	CIV_RELAY_04	14		BR	
AC N		4	CIV_AC_MGTH2	6		BL	
AC N		10				BL	
GND		6	CIV_AC_GND	6		YL/GN	
		12		7		YL/GN	
GND		18		8		YL/GN	
ACL		14	CIV_AC_CP	2		BR	
AC N		16		4		BL	

CIV_AC_UPS											
Tested by:			Date:								
SIGNAL		FROM	PIN	TO	PIN	AWG	COLOR	OK			
AC L		CIV_AC_UPS	4	CIV_PLC_CPS	5	20	BR				
GND			5		7		GN/YL				
AC N			6		6		BL				
AC N			1	CIV_AC_CP	4		BR				
AC L			3		2		BL				
GND			2	CIV_AC_GND	4]	GN/YL				

		C	CIV_AC_GND				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
GND	CIV_AC_GND	1	CIV_AC_IN	6	20	YL/GN	
		2	CIV_AC_FILT	2			
		3	CIV_PS_SRC	1			
		4	CIV_AC_UPS	2			
		5	CIV_PLC_CPS	7			
		6	CIV_AC_OUT	6			
		7		12			
		8		18			

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9 APPENDIX B: Comp. III Connection Tables

CIII_TB_ACI										
Tested by:		Date:								
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK			
CIII_AI_01+	CIII_TB_ACI	1	CIII_CP	004	24	PR				
CIII_AI_01-		2		800		GY/PK				
CIII_AI_02+		3		012		RD				
CIII_AI_02-		4		016		BR				
CIII_AI_03+		5		020		BK				
CIII_AI_03-		6		024		GY				
CIII_AI_04+		7		028		GN				
CIII_AI_04-		8		032		YL				
CIII_AI_05+		11		036		RD/BL				
CIII_AI_05-		12		040		BR/GN				
CIII_AI_06+		13		044		WH				
CIII_AI_06-		14		048		WH/GN				
CIII_AI_07+		15		052		WH/YL				
CIII_AI_07-		16		056		BR/YL				
CIII_AI_08+		17		060		BL				
CIII_AI_08-		18		064		PK				
CIII_AI_09+		21		068		PR				
CIII_AI_09-		22		072		GY/PK				
CIII_AI_10+		23		076		RD				
CIII_AI_10-		24		080		BR				
CIII_AI_11+		25		084		BK				
CIII_AI_11-		26		088		GY				
CIII_AI_12+		27		092		GN				
CIII_AI_12-		28		096		YL				
CIII_AI_13+		31		100		RD/BL				
CIII_AI_13-		32		104		BR/GN				
CIII_AI_14+		33		108		WH				
CIII_AI_14-		34		112		WH/GN				
CIII_AI_15+	1	35		116	1	WH/YL				
CIII_AI_15-		36		120	1	BR/YL				
CIII_AI_16+		37		124	1	BL				
CIII_AI_16-		38		128		PK				
N.C.		9								
N.C.		10								
N.C.		19								
N.C.		20								
N.C.		29								
N.C.		30								
N.C.		39								
N.C.		40								

	CIII_TB_AVO								
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Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIII AO 01+	CIII TB AVO	1	CIII CP	132	24	RD	
CIII AO 01-		2	-	136		BK	
CIII AO 02+		11		140		PK	
		12		144		BR	
		21		1/18		WH	
		21		152		GN	
		21		152		GV	
		22		150		VI	
		J۲ ک		100			
		3		0		RD	
		4		8		DN	
		5		3		RD	
MASTER		8		4		BK	
OVERRIDE 4		10				DI/	
KZ		13		11		PK	
COMMON 2		14		18		BR/YL	
CONTROL 2		15		13		PK	
MASTER		18		14		BR/YL	
OVERRIDE 4							
R3		23		21		WH	
COMMON 3		24		28		WH/GN	
CONTROL 3		25		23		WH	
MASTER		28		24		WH/GN	
OVERRIDE 4							
R4		33		31		GY	
COMMON 4		34		38		WH/YL	
CONTROL 4	1	35		33		GY	
MASTER		38		34		WH/YL	
OVERRIDE 4							
N.C.		6					
Reference_1		7					
N.C.		9					
N.C.		10					
N.C.		16					
Reference 2		17					
N.C.		19					
N.C.		20					
N C		26					
Reference 3		20					
NC		20					
N.C.		27					
N.C.		3U 24					
N.C.		30					
Reierence_4		31					
N.C.		39					
N.C.	1	40					

				(CIII_TB_ACO							
	Tested by	:		Date:								
	SIGN	JAL	FROM	PIN	TO		PIN	AWG	COL	OR	OK	
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CIII AO 05+	CIII TB ACO	10	CIII CP	164	24	YL	
CIII AO 06+		20	_	172		GN	
CIII AO 07+		30		180		RD	
CIII AO 08+		40		188		WH	
24V+		9	CIII PS CP	12	20	RD	
		19			-	RD	
		29				RD	
		39				RD	
N.C.		10					
N.C.		20					
N.C.		30					
N.C.		40					
Monitor_1+		1					
N.C.		3					
N.C.		4					
N.C.		5					
N.C.		6					
N.C.		7					
N.C.		8					
Monitor_2+		11					
N.C.		13					
N.C.		14					
N.C.		15					
N.C.		16					
N.C.		17					
N.C.		18					
Monitor_3+		21					
N.C.		23					
N.C.		24					
N.C.		25					
N.C.		26					
N.C.		27					
N.C.		28					
Monitor_4+		31					
N.C.		33				L	
N.C.		34				L	
N.C.		35				L	
N.C.		36				L	
N.C.		37				ļ	
N.C.		38					

CIII_TB_DI										
Tested by:		Date:								
SIGNAL	FROM	PIN	TO		AWG	COLOR	OK			
CIII_DI_01	CIII_TB_DI	1	CIII_CP	200	24	PR				

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		<u>^</u>		0.07		0)//D)//	
CIII_DI_02		2		007		GY/PK	
CIII_DI_03		5		015		RD	
CIII_DI_04		6		023		BR	
CIII_DI_05		11		031		BK	
CIII_DI_06		12		039		GY	
CIII_DI_07		15		047		GN	
CIII DI 08		16		055		YL	
CIII DI 09		21		063		RD/BL	
CIII DI 10		22		071		BR/GN	
CIII_DI_11		25		079		WH	
CIII_DI_12	1	26		087		WH/GN	
CIII DI 13		31		095		WH/YL	
CIII DI 14		32		103		BR/YL	
CIII DI 15		35		111		BL	
CIII DI 16	1	36		119		PK	
24V+		3	CIII PS CP	20	20	RD	
		7				RD	
		13	1			RD	
		17	1			RD	
		23	1			RD	
		27				RD	
		33				RD	
		37				RD	
24V-		4		02		BK	
		8				BK	
		14				BK	
		18				BK	
		24				BK	
		28	1			BK	
		34	1			BK	
		38	1			BK	
N.C.	1	9					
N.C.	1	10					
N.C.	1	19					
N.C.	1	20					
N.C.	1	29					
N.C.	1	30					
N.C.	1	39					
N.C.	1	40					

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			CIII_TB_DO				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIII_DO_01	CIII_TB_DO	1	CIII_RELAY_01	A1	24	RD	
CIII_DO_02		3	CIII_RELAY_02	A1		BK	
CIII_DO_03		5	CIII_RELAY_03	A1		PK	
CIII_DO_04		7	CIII_RELAY_04	A1	1	BR	
CIII_DO_05		11	CIII_RELAY_05	A1	1	WH	
CIII_DO_06	1	13	CIII_RELAY_06	A1	1	GN	
CIII_DO_07		15	CIII_RELAY_07	A1		GY	
CIII_DO_08		17	CIII_RELAY_08	A1		YL	
CIII_DO_09		21	CIII_RELAY_09	A1		BL	
CIII_DO_10		23	CIII_RELAY_10	A1	1	PR	
CIII DO 11		25	CIII CP	147		RD	
CIII DO 12		27	_	155		BK	
CIII_DO_13		31		163		PK	
CIII_DO_14		33		171		BR	
CIII_DO_15		35		179	1	WH	
CIII_DO_16		37		187	1	GN	
24V+		9	CIII PS CP	04	1	RD	
		29				RD	
24V-	1	19				BK	
		39				BK	
N.C.		2			1		
N.C.		4			1		
N.C.		6			1		
N.C.	1	8			1		
N.C.		10			1		
N.C.		12					
N.C.		14					
N.C.		16					
N.C.	1	18					1
N.C.	1	20					1
N.C.	1	22					1
NC		24			1		
N.C.	1	26			1		1
N.C.	1	28			1		1
N.C.	1	30			1		1
N.C.	1	32			1		1
N.C.	1	34			1		1
N.C.	1	36			1		1
N.C.	1	38			1		+
N.C.	1	40			1		+

CIII_PS_SRC									
Tested by:		Date:							
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK		
GND	CIII_PS_SRC	1	CIII_AC_GND	03	20	YL/GN			
AC N		2	CIII_AC_CP	12		BL			
AC L		3		10		BR			
24V+		4	CIII_PS_CP	1		RD			
24V-		5		15		BK			
24V+		7]	13		RD			
24V-		8		27		BK			

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Tested by: Proc. Proc.				CIII_PS_CP				
SIGNAL FROM PIN TO PIN AWG COLOR OK 2AV- CIL/PS_CP 1 CIL/PS_CP 3 RD RD 2AV 15 5 S RD RD RD RD 2AV 15 5 S S RD RD<	Tested by:		Date:					
24V- CIIL.PS_C.P 1 CIIL.PS_C.RC 4 20 RD 21V- 15 5 7 8 8K 8K 21V- 21 15 5 7 8 8K 8K 21V- 21 3 5 7 9 9 10 8K	SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
24V- 13 7 K0 K0 24V- 7 8 K K 24V+ 1 CIIL_PS_CP 3 K K 24V+ 5 7 8 K K 24V+ 1 1 RD K K 24V+ 1 1 RD K K 24V 21 RD K K K 24V- 23 RD K K K 24V- 24V- 003 RD K K 24V- 24V- 003 RD K K 24V- 005 RD K K K 24V- 005 RD K K 24V- 005 RD K K 24V- 007 RD K K 24V- 107 RD K K 24V- 107 </td <td>24V+</td> <td>CIII_PS_CP</td> <td>1</td> <td>CIII_PS_SRC</td> <td>4</td> <td>20</td> <td>RD</td> <td></td>	24V+	CIII_PS_CP	1	CIII_PS_SRC	4	20	RD	
24V- 10 3 3 10 3 24V- 1 CIIL_PS_CP 3 RD 1 24V- 3 7 7 7 RD 1 24V- 7 7 7 7 RD 1 24V- 7 7 7 7 RD 1 24V- 11 13 RD 1 1 24V- 15 17 19 RD 1 24V- 10 23 RK 1 24V- 23 25 RD 1 24V+ 23 25 RD 1 24V+ 23 25 RD 1 24V+ 043 RD 1 1 24V+ 043 RD 1 1 24V+ 043 RD 1 1 24V+ 067 RD 1 1 24V+ 067 RD 1 1 24V+ 075 RD 1 1 24V+ 107 RD 1 1 24V+ 107 RD 1 1 24V+ 107 RD 1 </td <td>24V+</td> <td></td> <td>13</td> <td></td> <td>/</td> <td></td> <td>RD</td> <td></td>	24V+		13		/		RD	
24/ 2 3 5 8 1 24/- 3 5 7 8 1 24/- 5 7 7 9 RD 1 24/- 7 9 11 RD 1 RD 1 24/- 11 13 RD 1 RD 1 RD 1 24/- 11 17 19 RL 1 RD 1 RD 1 RD 1 RD 1 RD 1 1 RD 1 RD 1 RD 1 1 RD 1	24V-	-	15		5		BK	
24V- 3 RD RD 24V- 5 7 RD RD 24V- 7 9 11 RD RD 24V- 7 9 11 RD RD RD 24V- 11 13 RD RD </td <td>24V-</td> <td></td> <td>27</td> <td></td> <td>8</td> <td></td> <td>BK</td> <td></td>	24V-		27		8		BK	
24V- 3 7 9 83 83 24V- 7 9 11 80 1 24V- 9 11 13 80 1 24V- 11 13 80 1 1 24V- 17 19 8K 1 24V- 21 23 8K 1 24V- 23 25 8K 1 24V- 23 25 8K 1 24V- 23 7 8K 1 24V- 23 8K 1 1 24V- 23 8K 1 1 24V- 103 8D 1 1 24V- 061 8D 1 1 24V- 107 8D 1 1 24V- 107 8D 1 1 24V- 107 8D 1 1 24V- 161	24V+	_	2	CIII_PS_CP	ა ნ		RD	
24V- 2 -	24V+		ა ნ		3		RD	
24V- 2 1 <th1< th=""> <th1< th=""> <th1< th=""> <th1< th=""></th1<></th1<></th1<></th1<>	24V+	-	7		0		PD	+
24/4 1 <th1< th=""> <th1< th=""> <th1< th=""> <th1< th=""></th1<></th1<></th1<></th1<>	241/4	-	9		, 11		RD	+
24/c 15 17 19 19 19 19 10 10 11 10 11 10 11 10 11 10 11 10 11 10 11 10 11 10 11 1	$24V_{+}$	-	11		13		RD	+
24V 17 19 21 18K 18K 24V 21 23 23 18K 18K 18K 24V 23 25 27 18K 18K 18K 18K 24V 25 27 17 18K 18K<	241/-	-	15		17		BK	+
24V. 21 21 23 23 23 23 23 23 23 23 23 23 23 23 25 27 21 23 25 27 27 26 CIII_CP 003 20 27 80 20 23 25 27 80 20 20 20 20 20 20 20 20 20 20 80 20 20 20 20 80 20	24V-		17		19		BK	+
24V. 21 23 25 24V. 25 27 8K 8K 24V. 25 27 8K 8K 24V. 035 8K 8K 8K 24V. 035 969 8D 8D 8D 24V. 067 067 8D 8D 8D 8D 24V. 067 075 8D	24V-		19		21		BK	1
24V. 25 27 24V. 25 27 24V. 6 CIIL_CP 003 24V. 027 027 24V. 027 035 24V. 035 027 24V. 043 027 24V. 043 035 24V. 043 067 24V. 067 RD 24V. 067 RD 24V. 067 RD 24V. 067 RD 24V. 075 RD 24V. 076 RD 24V. 106 RD 24V. 107 RD 24V. 115 RE 24V. 120 166 24V. 183 24V. 183 24V. 183 24V. RELAY_01 A2 RELAY_03 A2 RELAY_04 A2 RELAY_06 A2	24V-		21		23		BK	
24V. 25 27 BR RD 24V. 003 007 RD RD RD 24V. 043 051 RD RD RD RD 24V. 043 051 RD	24V-		23		25		BK	1
244+ 6 CIIL_CP 003 RD RD 244+ 035 043 RD RD RD 244+ 051 043 RD	24V-		25		27		BK	
244+ 07 RD RD 244+ 035 RD RD RD 244+ 051 RD RD RD RD 244+ 051 RD	24V+]	6	CIII_CP	003		RD	L
244, 035 RD RD 244, 043 043 043 RD RD 244, 051 053 RD	24V+]			027		RD	
244y- 043 061 RD 1 244y- 061 061 RD 1 244y- 061 059 067 RD 1 244y- 063 075 RD 1 1 244y- 063 075 RD 1 244y- 063 RD 1 1 244y- 063 RD 1 244y- 075 RD 1 244y- 107 RD 1 244y- 107 RD 1 244y- 107 RD 1 244y- 115 RD 1 244y- 116 8K 1 244y- 116 8K 1 244y- 116 8K 1 244y- 1167 8K 1 244y- 1175 8K 1 244y- 1176 1 1 244y- 110 2 1 244y-<	24V+]			035		RD	
244+ 051 RD 244+ 059 RD RD 244+ 075 RD RD 244+ 075 RD RD 244+ 091 RD RD 244+ 091 RD RD 244+ 091 RD RD 244+ 091 RD RD 244+ 115 RD RD 244+ 115 RD RD 244+ 116 RB RE 244- 176 RB RE 244- 175 RD RE 244- 175 RD RE 244- 183 RE RE 244- 183 RE RE 244- 183 RE RE 244- 183 RE RE 244- RELAY_01 A2 RE 244- RELAY_06 A2 RE 244- RELAY_06 A2 RE 244- RELAY_07 A2 RE 244- RELAY_07 A2 RE RELAY_07 A2 RE RE 244- RE	24V+				043		RD	
24/+ 059 RD RD 24/+ 067 RD RD RD 24/+ 075 RD RD RD RD 24/+ 099 RD	24V+	1			051		RD	
24/+ 067 RD RD 24/+ 075 RD RD 24/+ 091 RD RD 24/+ 091 RD RD 24/+ 107 RD RD 24/+ 115 RD RD 24/+ 196 RD RD 24/+ 196 RD RD 24/- 168 BK RELAY 24/- 159 BK RELAY 24/- 167 BK RELAY 24/- 183 BK RELAY 24/- 183 BK RELAY 24/- 191 BK RELAY 24/- 183 BK RELAY 24/- RELAY 02 A2 24V- RELAY A2 BK 24V- 24V- RELAY A2 24V- 24V- RELAY A2 24V- 24V- RELAY A2 24V- 24V- RELAY A2 24V- 24 RELAY A2 24V- 24 RELAY A2 24V- 24 RELAY B4 24V-	24V+				059		RD	
24/+ 075 RD RD 24/+ 091 093 RD RD 24/+ 099 RD 107 RD 107 24/+ 115 RD 107 RD 107 24/+ 116 BK 107 RD 107 24/+ 116 BK 107 RD 107 24/- 115 RD 107 RD 107 24/- 116 BK 107 RD 107 24/- 115 RD 107 RD 107 24/- 116 RELAY_01 A2 RELAY_01 107 24/- 24/- 183 BK 108 24/- 24/- RELAY_02 A2 107 24/- 24/- RELAY_03 A2 107 24/- RELAY_06 A2 108 108 24/- RELAY_06 A2 107 11 24/- 24 10 <td>24V+</td> <td>4</td> <td></td> <td></td> <td>067</td> <td></td> <td>RD BB</td> <td>4</td>	24V+	4			067		RD BB	4
24/+ 083 RD RD 24/+ 099 RD RD RD 24/+ 107 RD RD RD RD 24/+ 107 RD	24V+				075		RD	
24V+ 091 RD RD 24V+ 107 RD RD RD 24V+ 115 RD RD RD RD 24V- 116 RD	24V+	-			083		RD	
24V+ 009 RD RD 24V+ 115 RD RD RD 24V- 115 RD RD RD RD 24V- 116 RD	24V+				091		RD	
24V+ 107 RD RD 24V+ 115 RD RD RD 24V- 196 RD RD RD RD 24V- 116 BK BK RD	24V+				099		RD	
24V- 113 113 110 110 24V- 113 110 110 110 24V- 111 110 110 110 24V- 110 110 110 110 24V- 12 111 110 110 24V-	24V+	-			107		RD PD	
24V- 176 176 176 24V- 176 184 176 24V- 184 184 24V- 192 166 24V- 151 184 24V- 157 184 24V- 167 184 24V- 167 183 24V- 191 184 24V- 183 184 24V- 183 184 24V- 184 184 24V- 11 12 24V- 11 12 24V- 13 24V- 14 24V- 14	24V+	-			115		RD	+
24V- 176 184 24V- 184 184 24V- 192 24V- 151 24V- 157 24V- 167 24V- 175 24V- 183 24V- 191 24V- 8K 24V- 183 24V- 8K 24V- 98 24V- 99 24V- 99 24V- 90 24V- 90 24V- <td< td=""><td>24V-</td><td></td><td>22</td><td></td><td>168</td><td></td><td>BK</td><td>+</td></td<>	24V-		22		168		BK	+
24V- 184 192 24V- 151 151 24V- 151 151 24V- 151 157 24V- 183 167 24V- 183 184 24V- 183 167 24V- 183 167 24V- 183 184 24V- 183 167 24V- 244 24 24V- 244 24 24V- 24 16 24V- 24 12 11 24V- 24 12 11 24 24V- 24 13 17 24V- 24 13 17 24V- 24 13 17 24V- 24 13 17	24V-		22		176		BK	1
24V- 192 182 151 24V- 159 151 159 24V- 167 175 183 24V- 191 A2 184 184 24V- 191 A2 183 191 24V- 191 A2 183 184 115 24V- 24V- 191 A2 116 116 116 116 24V- 24V- 191 A2 1191 116	24V-				184		BK	1
24V- 151 BK BK 24V- 167 BK BK BK 24V- 175 BK BK BK BK 24V- 175 BK	24V-				192		BK	1
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	24V-				151		BK	1
24V- 167 175 24V- 183 184 24V- 191 185 24V- 191 184 24V- 184 191 24V- 184 184 24V- 184 184 24V- 110 10 24V- 28 RELAY_10 12 24V- 12 112 113 13 24V- 13 17 13 17 24V- 237 37 13 17 24V- 24 13 17 18 16 24V- 24 18 18	24V-				159		BK	
24V- 175 183 24V- 191 191 24V- RELAY_01 A2 24V- RELAY_02 A2 24V- RELAY_03 A2 24V- RELAY_04 A2 24V- RELAY_06 A2 24V- RELAY_07 A2 24V- RELAY_00 A2 24V- RELAY_00 A2 24V- RELAY_00 A2 24V- RELAY_00 A2 24V- 28 RELAY_07 11 12 CIII_TB_ACO 09 BK BK 24V- 29 BK BK BK 24V+ 33 33 RD RD 24V+ 24 04 BK BK 24V-	24V-				167		BK	
24V- 183 191 24V- 191 A2 24V- RELAY_02 A2 24V- RELAY_03 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_07 A2 24V- RELAY_09 A2 24V- RELAY_10 A2 24V- RELAY_10 A2 24V- 8K BK 24V- 12 CIII_TB_ACO 09 24V- 39 07 RD RD 24V+ 33 33 RD RD 24V+ 33 33 RD RD 24V- 33 33 RD RD 24V- 24 08 BK BK	24V-				175		BK	
24V- 191 BK 24V- RELAY_02 A2 24V- RELAY_03 A2 24V- RELAY_04 A2 24V- RELAY_05 A2 24V- RELAY_06 A2 24V- RELAY_07 A2 24V- RELAY_06 A2 24V- RELAY_07 A2 24V- RELAY_08 A2 24V- RELAY_10 A2 24V- RELAY_10 A2 24V- RELAY_10 A2 24V- RELAY_07 A2 24V- RELAY_10 A2 24V- BK BK 24V- B RELAY_07 24V- B BK BK 24V- 39 BK BK 24V- 39 BK BK 24V+ 33 RD RD 24V+ 33 RD RD 24V- 24 04 BK BK 24V- 14 18 BK B	24V-				183		BK	
24V- 24 24V- RELAY_02 A2 24V- RELAY_03 A2 24V- RELAY_04 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_07 A2 24V- RELAY_09 A2 24V- RELAY_07 11 24V- 28 RELAY_07 11 12 CIII_TB_ACO 09 BK BK 24V- 39 BK BK BK 24V+ 33 RD RD RD 24V+ 33 37 RD RD 24V- 04 08 BK BK 2	24V-				191		BK	
24V- RELAY_02 A2 24V- RELAY_03 A2 24V- RELAY_05 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_07 A2 24V- RELAY_07 A2 24V- RELAY_09 A2 24V- RELAY_09 A2 24V- RELAY_09 A2 24V- RELAY_09 A2 24V- RELAY_10 A2 24V- RELAY_10 A2 24V- RELAY_07 11 24V- RELAY_07 11 24V- 28 RELAY_07 11 12 CIII_TB_ACO 09 BK 24V- 29 BK BK 24V+ 33 RD RD 24V+ 33 RD RD 24V+ 33 RD RD 24V- 08 BK BK 24V- 08 BK BK 24V- 08 BK <td>24V-</td> <td></td> <td>26</td> <td>RELAY_01</td> <td>A2</td> <td></td> <td>BK</td> <td></td>	24V-		26	RELAY_01	A2		BK	
24V- RELAY_03 A2 24V- RELAY_04 A2 24V- RELAY_05 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_06 A2 24V- RELAY_08 A2 24V- RELAY_09 A2 24V- RELAY_10 A2 24V- RELAY_10 A2 24V- RELAY_10 A2 24V- RELAY_10 A2 24V- RELAY_07 11 24V- 28 RELAY_07 11 24V- 29 BK BK 24V- 29 BK BK 24V+ 29 BK BK 24V+ 33 37 RD RD 24V+ 24 04 BK BK 24V- 14 18 BK BK	24V-			RELAY_02	A2		BK	
24V- RELAY_04 A2 24V- RELAY_05 A2 24V- RELAY_06 A2 24V- RELAY_07 11 24V- RELAY_07 11 24V- 08 RELAY_07 11 24V- 12 CIII_TB_ACO 09 24V+ 39 BK BK 24V+ 33 RD RD 24V+ 33 RD RD 24V+ 33 RD RD 24V+ 24 04 BK BK 24V- 24 04 BK BK 24V- 18 BK BK BK	24V-			RELAY_03	A2		BK	
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24V- RELAY_10 A2 24V- 28 RELAY_10 A2 24V- 08 RELAY_07 11 24V- 08 RELAY_07 11 12 CIII_TB_ACO 09 BK 24V- 29 BK BK 24V- 39 BK BK 24V- 39 BK BK 24V- 29 BK BK 24V+ 13 RD RD 24V+ 17 RD RD 24V+ 33 RD RD 24V+ 33 RD BK 24V+ 24 04 BK 24V- 14 BK BK	241/-	4		RELAT_00	Δ2		BK	+
24V- 28 RELAY_10 A2 24V- 08 RELAY_07 11 24V- 09 BK 24V- 12 CIII_TB_ACO 09 24V- 29 BK BK 24V- 39 BK BK 24V- 39 BK BK 24V+ 39 BK BK 24V+ 13 RD RD 24V+ 27 RD RD 24V+ 33 RD RD 24V+ 33 RD BK 24V+ 24 04 BK 24V- 14 BK BK	24\/-	1		RELAT_07	Δ2		BK	+
24V+ 08 RELAY_07 11 24V- 12 CIII_TB_ACO 09 24V- 29 24V- 39 24V+ 39 24V+ 39 24V+ 13 24V+ 17 24V+ 33 24V+ 04 24V- 14 24V- 18	24V-	1	28	RELAY 10	Δ2		BK	+
24V- 12 CIII_TB_ACO 09 24V- 29 19 19 24V- 39 11 11 11 24V- 29 39 11 11 11 24V- 39 02 CIII_TB_DI 07 13 13 24V+ 13 17 RD 12 13 12 13 13 24V+ 24V+ 33 17 RD 12 13 13 13 14 10	24V+	1	08	RELAY 07	11		RD	+
24V- 19 19 24V- 29 24V- 39 24V+ 39 24V+ 13 24V+ 17 24V+ 27 24V+ 33 24V+ 33 24V+ 27 24V+ 33 24V+ 37 24V- 04 24V- 14 24V- 18	24V-	1	12	CIII TB ACO	09		BK	+
24V- 29 37 24V+ 39 8K 24V+ 02 CIII_TB_DI 07 24V+ 13 RD 24V+ 17 RD 24V+ 27 RD 24V+ 33 RD 24V+ 33 RD 24V+ 33 RD 24V+ 04 8K 24V- 04 8K 24V- 14 8K 24V- 18 8K	24V-	1		1	19		BK	1
24V- 39 BK 24V+ 24V+ 02 CIII_TB_DI 07 RD RD 24V+ 13 17 RD RD <td< td=""><td>24V-</td><td>1</td><td></td><td></td><td>29</td><td></td><td>BK</td><td>1</td></td<>	24V-	1			29		BK	1
24V+ 02 CIII_TB_DI 07 RD RD 24V+ 13 17 RD RD RD RD 24V+ 27 33 RD R	24V-	1			39		BK	1
24V+ 13 RD 24V+ 17 RD 24V+ 27 RD 24V+ 33 RD 24V- 04 BK 24V- 08 BK 24V- 14 BK	24V+]	02	CIII_TB_DI	07		RD	L
24V+ 17 RD 24V+ 27 RD 24V+ 33 RD 24V- 04 BK 24V- 08 BK 24V- 14 BK 24V- 18 BK	24V+]			13		RD	
24V+ 27 RD 24V+ 33 RD 24V- 37 RD 24V- 04 BK 24V- 14 BK 24V- 18 BK	24V+]			17		RD	
24V+ 33 RD 24V+ 37 RD 24V- 04 BK 24V- 08 BK 24V- 14 BK 24V- 18 BK	24V+				27		RD	
24V+ 37 RD 24V- 04 BK 24V- 08 BK 24V- 14 BK 24V- 18 BK	24V+]			33		RD	
24V- 24 04 BK 24V- 08 BK 24V- 14 BK 24V- 18 BK	24V+	1			37		RD	
24V- 08 BK 24V- 14 BK 24V- 18 BK	24V-	4	24		04		BK	
24V- 14 BK 24V- 18 BK	24V-	4			08		BK	<u> </u>
	24V-	4			14		BK	4
	24V-	I	I I		18	l	RK	1
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24V-			24	BK	
24V-			28	BK	
24V-			34	BK	
24V-			38	BK	
24V+	04	CIII_TB_DO	09	RD	
24V+			19	RD	
24V+			29	RD	
24V+			39	RD	

CIII_RELAY_01								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
CIII_DO_01	CIII_RELAY_01	A1	CIII_TB_DO	01	24	RD		
24V-		A2	CIII_PS_CP	28	20	BK		
CIII_RL_BT_IN		11	CIII_CP	123	24	YL		
CIII_RL_BT_OUT		14		127		GN		
N.C.		12						

CIII_RELAY_02								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
CIII_DO_02	CIII_RELAY_02	A1	CIII_TB_DO	03	24	BK		
24V-		A2	CIII_RELAY_01	A2	20	BK		
AC L		11	CIII_AC_MGTH2	02		BR		
CIII_AC_Ac_L		14	CIII_AC_OUT	02		BR		
N.C.		12						

	CIII_RELAY_03								
Tested by:		Date:							
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK		
CIII_DO_03	CIII_RELAY_03	A1	CIII_TB_DO	05	24	PK			
24V-		A2	CIII_RELAY_02	A2	20	BK			
AC L		11	CIII_RELAY_02	11B		BR			
CIII_AC_Bs_L		14	CIII_AC_OUT	08		BR			
N.C.		12							

CIII_RELAY_04								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
CIII_DO_04	CIII_RELAY_04	A1	CIII_TB_DO	07	24	BR		
24V-		A2	CIII_RELAY_03	A2	20	BK		
AC L		11		11B		BR		
CIII_AC_Comp_L		14	CIII_AC_OUT	14		BR		
N.C.		12						

CIII_RELAY_05								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
CIII_DO_05	CIII_RELAY_05	A1	CIII_TB_DO	11	24	WH		
24V-		A2	CIII_RELAY_04	A2	20	BK		
AC L		11	CIII_RELAY_04	11B		BR		
CIII_AC_CV_L		14	CIII_AC_OUT	20		BR		
N.C.		12						



		C	II_RELAY_06				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
CIII_DO_06	CIII_RELAY_06	A1	CIII_TB_DO	13	24	GN	
24V-		A2	CIII_RELAY_05	A2	20	BK	
AC L		11	CIII_RELAY_05	11B		BR	
CIII_AC_Heat_L		14	CIII_AC_OUT	26		BR	
N.C.	1	12					

CIII_RELAY_07									
Tested by:		Date:							
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK		
CIII_DO_07	CIII_RELAY_07	A1	CIII_TB_DO	15	24	GY			
24V-		A2	CIII_RELAY_06	A2	20	BK			
24V+		11	CIII_PS_CP	08		RD			
CIII_MV_L1+		14	CIII_CP	11	24	RD			
CIII_MV_L1+				19		RD			
N.C.		12							

CIII_RELAY_08								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
CIII_DO_08	CIII_RELAY_08	A1	CIII_TB_DO	17	24	YL		
24V-		A2	CIII_RELAY_07	A2	20	BK		
AC L		11	CIII_RELAY_06	11B		BR		
CIII_AC_Safe_L		14	CIII_AC_OUT	32		BR		
N.C.		12						

CIII_RELAY_09								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
CIII_DO_09	CIII_RELAY_09	A1	CIII_TB_DO	21	24	BL		
24V-		A2	CIII_RELAY_08	A2	20	BK		
Not used		11	CIII_CP	131	24	YL		
		14		135	24	GN		
		12						

CIII_RELAY_10									
Tested by:		Date:							
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK		
CIII_DO_10	CIII_RELAY_10	A1	CIII_TB_IO_DO	23	24	PR			
24V-		A2	CIII_RELAY_09	A2	20	BK			
Not used		11	CIII_CP	139	24	YL			
		14		143	24	GN			
		12							

CIII_AC_IN								
Tested by:	by: Date:							
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
AC L	CIII_AC_IN	2	CIII_AC_MGTH6	1	20	BR		
AC N		4		3		BL		
AC GND		6	CIII_AC_GND	1		YL/GN		

CIII_AC_MGTH6							
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
AC L	CIII_AC_MGTH6	2	CIII_AC_DIFF	1	20	BR	
AC N		4		3		BL	

CIII_AC_DIFF							
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK

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ACI	CIII AC DIFF	2	CIII AC FILT	1	20	BR	
NOL		2		1	20	DIX	
AC N		Λ		3		BI	
ACIN		4		5		DL	

		(CIII_AC_FILT				
Tested by:		Date:					
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK
GND	CIII_AC_FILT	2	CIII_AC_GND	10	20	YL/GN	
AC L		4	CIII_AC_CP	1		BR	
				5		BR	
				9		BR	
				13		BR	
AC N		5		3		BL	
				7		BL	
				11		BL	
	1			15	1	BI	

CIII_AC_CP								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
AC L	CIII_AC_CP	2	CIII_AC_OUT	38		BR		
AC N		4	1	40		BL		
AC L		6	CIII_UPS	1		BR		
AC N		8		3		BL		
ACL		10	CIII_PS_SRC	3		BR		
AC N		12		2		BL		
ACL		14	CIII_MGTH2	1		BR		
AC N		16		3		BL		

CIII_AC_MGTH2									
Tested by:		Date:							
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	ŌK		
AC L	CIII_AC_MGTH2	2	CIII_RELAY_02	11		BR			
AC N		4	CIII_AC_OUT	04		BL			
AC N				10		BL			
AC N				16		BL			
AC N				22		BL			
AC N	_			28		BL			
AC N		1		34	1	BL			

CIII_AC_UPS								
Tested by:		Date:						
SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	OK	
AC L	CIII_AC_UPS	4	CIII_PLC_CPS	5	20	BR		
GND		5		7		GN/YL		
AC N		6		6		BL		
AC N		1	CIII_AC_CP	4		BR		
AC L		3		2		BL		
GND		2	CIII_AC_GND	4		GN/YL		

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MELISSA

Contract Number: ESTEC/CONTRACT: 15671/01/NL/ND

Technical Note: 72.4 VOLUME I-b

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Written by:	Jordi Duatis
Revised by:	Joan Mas
Quality Assurance:	Sònia Ferrer
Approved by:	Joan Mas



Document Change Log

Version	Issue	Date	Observations
Draft		05 March'04	Reviewed
1	0	19 April '04	Issued for ESA review
1	1	28 July '04	Implements ESA comments dated 21/07/04



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1 SCOPE

This document contains the Test Plan and Procedures designed to validate the implementation of the Control System Demonstrator designed and built following the system architecture proposed in [A4]. The test procedures will cover:

- Local regulation loops.
- In-plant verification of the Control law for the *Spirulina* compartment (variables, loops etc.) with the new control HW.
- In-plant verification of the Control law for the Nitrifying compartment (variables, loops etc.) with the new control HW.
- Non-nominal tests to verify alarm management

Tests will be conducted at the UAB premises after the Control System Demonstrator is installed and connected to the MELISSA plant.

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

- [A1] MELISSA. Adaptation for Space, Phase 1. Statement of Work. TOS-MCT/2000/2977/ln/CL. Issue 5. April 2001.
- [A2] MELISSA. Adaptation for Space-Phase 1. Proposal issued by NTE. MEL-0000-OF-001-NTE. Issue 2. October 2001.
- [A3] Memorandum of Understanding between the UAB and NTE S.A. MEL-0000-SP-007-NTE. Version 1. Issue 0. 21 January 2002.
- [A4] MELISSA Control System Architecture and Trade-off. TN 72.3. Version 1. Issue 0. December 2002.

2.2 Reference Documents

- [R1] Definition of the control requirements for the MELISSA Loop. TN 72.2, v. 1.2, November 2002 (MEL-3100-SP-010-NTE).
- [R2] Photoheterotrophic Compartment Set-up. TN 37.6. UAB, February 1998.
- [R3] Nitrifying Compartment Studies. TN 25.310. UAB, September 1996.
- [R4] Set-up of the Photosynthetic Pilot Reactor. TN. 37.2. UAB, April 1998.
- [R5] Spirulina Controller. TN 72.3.1, v. 1.0, ADERSA, March 2003.
- **[R6]** Nitrite Controller Test Plan and Procedure. TN 72.3.4, v. 1.1, SHERPA, February 2004.
- [**R7**] Test Plan and Procedure for the Spirulina Controller. TN 72.3.3, v. 1.0, ADERSA, October 2003.
- [**R8**] Nitrite Controller. TN 72.3.2, v. 1.1, ADERSA, October 2003.
- [R9] Control System Demonstrator System Test Plan and Procedure, TN 72.4 VIa, v. 1.1, July 2004 (MEL-3310-PL-024-NTE).

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3 TEM UNDER TEST

The Item under Test is the Melissa Control System Demonstrator consisting of:

- Control System Rack III for CIII
- Control System Rack IV for CIV
- Control SW running on Rack III and Rack IV
- Supervisory SW running on Client and Server PC.

4 TEST PLAN

Tests will be conducted at Compartment level and independently. For every Compartment a System Test and a Functional Test will be performed.

4.1 System Test Plan

The System Test will be carried out at NTE's facilities using external hardware to simulate the sensors and actuators that interact with every compartment. The System Test Plan's purpose is to check that the control hardware is properly built and connected and that every single function is implemented as specified in the design documents. The test procedures will be designed to cover end-to-end system functions. This Plan and Procedures is documented in the System Test Plan and Procedures Document [R9].

4.2 Functional Test Plan

The Functional Test will be conducted at UAB's facilities with the Control System Demonstrator connected to the Pilot Plant. To test the functionality of every compartment the following sequence will be followed:

1. Set-up:

- Objective: to carry out the transition from the old control system to the new one.
- Success criteria: the new control system is able to control and monitor all the compartment's input and output variables and control loops.

2. Alarm test:

- Objective: verify that the system properly detects an anomaly. Temperature difference, over-temperature and liquid level anomalies are checked for CIII. Temperature and no gas anomalies are checked for CIV.
- Success criteria: the system responds with an alarm notification upon detecting the anomaly

3. Compartment transition:

- Objective: defining a set point for a selected compartment's parameter and validate the compartment's transition to achieve this point.
- Success criteria: the system performs the required control actions so that the compartment is able to reach the new set point successfully in a stable manner.

Detailed test procedures are developed in chapter 5 for CIII and in chapter 6 for CIV.

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5 CIII FUNCTIONAL TEST PROCEDURES

5.1 Compartment set-up

The compartment set-up with the new control system is considered as part of the test plan, since all local regulation loops, connections, measures and control actions will be validated and verified. Local regulation loops will be verified comparing measures and control actions with respect to the previous control system. Perturbations will be induced and results compared. Expected responses need to take place within the appropriate timing.

Five local control loops will be verified in Compartment III:

- pH Control loop
- Dissolved Oxygen (DO) control loop
- Temperature control loop
- Liquid Level control loop
- Pressure control loop

5.1.1 pH control

pH control is performed actuating over a valve to regulate input flow of CO_2 into the compartment, and actuating over a base medium pump and an acid medium pump. Two probes, one located on the base and one on the top of the compartment, measure pH. The global pH is measured as an average of the two probes.

It shall be checked that pH set point is reached after provoking perturbations. This shall be performed to check CO₂, base and acid addition.

Perform variations of the pH set point and verify that pH measure reaches the set point and is maintained inside the dead-band.

5.1.2 Dissolved Oxygen control

Dissolved Oxygen (DO) control is performed actuating over a valve that regulates O_2 and N_2 input flow. DO is measured by two probes, located on the top and on the bottom of the compartment. Again, global DO is measured as an average of two probes.

It shall be checked that DO set point is reached after provoking perturbations.

Perform variations of the DO set point and verify that the DO measure reaches the set point and is maintained inside the dead band.

5.1.3 Temperature control

Temperature regulation is performed by actuating over a heater (resistance inside the reactor) and a valve that regulates the flow of a cooling bath. Two probes located on the top and the

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bottom of the compartment measure the temperature. The compartment's temperature is the measured average values.

It shall be checked that temperature set point is reached after provoking perturbations.

Perform variations of the temperature set point and verify that the temperature measure reaches the set point and is maintained inside the dead band.

5.1.4 Liquid Level control

Liquid level is regulated actuating over the output liquid pump. Two sensors placed in the reactor's upper part measure the high and low liquid level status. When level is high, the output pump increases the output flow rate and it decreases the output flow rate when the level is low.

It shall be checked that the liquid output pump increases/decreases the flow rate when level high/low is reached.

Manually actuate over the input pump to provoke the level high and low status and check output flow rate is modified accordingly.

5.1.5 Pressure control

Pressure is regulated actuating over a valve placed on the top of the reactor that is opened when an overpressure is reached.

It shall be checked that the valve is opened in case of overpressure.

Set the pressure set point to a low value and provoke an overpressure and verify valve is opened and pressure restored.

5.2 Alarms

5.2.1 Temperature difference alarm

This alarm is activated when the temperatures measured by the top and the bottom probes have a difference greater that a given value. When this alarm is activated, the liquid input pump is stopped.

It shall be checked that alarm is notified and liquid input pump stopped.

Induce a temperature difference between top and bottom probes and verify that alarm is notified and input pump stopped.

5.2.2 Over temperature alarm

This alarm is activated when the temperature reaches a given value above the set point. When this alarm is activated, the temperature regulation loop is set to OFF.

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It shall be checked that alarm is notified and loop is set to OFF.

Reduce the set point below the margin and verify that the over temperature alarm is notified and the loop is set to OFF.

5.2.3 Liquid level alarm

This alarm is notified when liquid level remains continuously high during a given time. When this alarm is activated, the liquid input pump is stopped.

It shall be checked that alarm is notified and liquid input pump is stopped.

Modify manually the liquid input pump causing a level high during the programmed period. Verify that alarm is notified and the liquid input pump stopped.

5.3 Nitrite Estimator

5.3.1 Introduction

The Nitrite Estimator calculates the estimated value of Nitrite (NO_2) in the compartment, taking as inputs, among others, the concentrations of Nitrate (NO_3) and Ammonia (NH_4) present on the gas and liquid phases. Some values are provided on-line (Nitrate, Ammonia and current liquid input flow) and the rest are input from the console. In addition, regulates the liquid input flow according to the applied Nitrite constraint.

Before proceeding to the test procedure the proper integration of the Nitrite Estimator control law into the control system shall be checked following the procedure defined in [R8].

The test procedure will consist of two parts:

• A short test to check the data processing itself (refer to par. 5.3.2)

• A long test concerning more precisely the behaviour of the control (refer to par.5.3.3)

The detailed instructions provided in paragraphs 5.3.2 and 5.3.3 are extracted from [R6]

Test results of both tests are to be checked and validated by SHERPA.

5.3.2 Short Test

Duration: around 6h.

Before starting, the constraint on NO₂ is set to a high value (1 10^{-3} mole/l, green curve of the upper graph on figure 1) and the requested flow rate is equal to the measured flow rate (0.4 l/h, green curve of the lower graph on figure 1). One sampling periods after the control has been turned on, the requested flow rate is moved to a high value (for example, 0.8 l/h or more). Then, 1.5 h later, the constraint on NO₂ is moved to a low value (1 10^{-5} mole/l). The test can be stopped a short time after the 3 h of duration. The short test is plotted on the figure 1.

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5.3.3 Long Test

Duration: around 20 h.

The conditions of the long test will depend on the results of the short one. The aim is to check that the control of the pilot plant is similar to the simulated one. Again, the requested flow rate is changed after one sampling period (0.1 h). An example of the long test is plotted on the figure 2.





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Figure 2: Nitrite estimator long test

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6 CIV FUNCTIONAL TEST PROCEDURES

6.1 Compartment set-up

As in the Compartment III, the compartment set-up will be considered as part of the test plan, since all local regulation loops, connections, measures and control actions will be validated and verified.

Local regulation loops will be verified comparing measures and control actions with respect to the previous control system. Perturbations will be provoked and results compared.

6.1.1 Biomass sensor

Biomass sensor is cleaned periodically by blowing air into the conduction. The last measured value is held during the operation and measurement is restored after a given time is elapsed.

It shall be checked that sensor-cleaning action is performed periodically. In addition it shall be checked that the biomass measured value remains stable while the cleaning operation takes place plus a short time after.

Verify biomass sensor measure during a cleaning period.

6.1.2 Gas flow control

Gas flow set points are provided by the supervision actuating over a set of flow controllers that regulate gas input and output flow rates. Low variations of pressure are compensated actuating over the flow controllers. In addition, in case of overpressure a valve placed on the top of the reactor is opened.

It shall be checked that variation of flow rate set points are translated to the corresponding flow controllers, low variations of over pressure increase/decrease input/output flow rates and in case of an overpressure, the safety valve is opened.

Actuate over the flow controllers manually to provoke low over pressure and verify that set points are modified to compensate it. Modify the pressure set point and verify that safety pressure valve is opened.

6.1.3 pH control

pH control is performed actuating over a valve to regulate input flow of CO_2 into the compartment, and actuating over a base medium pump and an acid medium pump. One probe located on the base of the compartment measure the pH.

It shall be checked that pH set point is reached after provoking perturbations. This shall be performed to check CO₂, base and acid addition.

Perform variations of the pH set point and verify that pH measure reaches the set point and is maintained inside the dead-band.

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6.2 Alarms

6.2.1 Temperature alarm

This alarm is activated when temperature is a given value over the set point. When this alarm is activated, the light is set to a safety value and liquid input and output pumps are stopped.

It shall be checked that alarm is notified, light is set to the safety value and liquid input and output pumps are stopped.

Reduce the set point below the margin and verify that over temperature alarm is notified, light is set to the safety value and liquid input/output pumps are stopped.

6.2.2 No Gas alarm

This alarm is activated when input gas flow is near to 0. This means that gas supply has been interrupted externally. When this alarm is activated, the light is set to a safety value and liquid input and output pumps are stopped.

It shall be checked that alarm is notified, light is set to the safety value and liquid input and output pumps are stopped.

Interrupt the gas supply and verify that No Gas alarm is notified, light is set to the safety value and liquid input/output pumps are stopped.

6.3 Biomass Production

6.3.1 Introduction

The Biomass Production control law regulates the production of biomass (Spirulina), taking as inputs the current biomass concentration, current and required liquid input flow rate and current light flux. These values are provided on-line, even the liquid input flow rate and the light flux are not measured but computed from the set points. The controlled variable is the light flux.

Before proceeding to the test procedure the proper integration of the Biomass Production control law into the control system shall be checked following the procedure defined in [R5].

To validate the control law of the Spirulina compartment two tests will be performed:

• A short one to test the data processing itself (refer to par. 6.3.2)

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• A long one to test the internal variables of the control (refer to par. 6.3.3) The detailed instructions provided in paragraphs 6.3.2 and 6.3.3 are excerpts from [R7].

Test results will be validated by SHERPA.

6.3.2 Short Test

Duration: around 6 h.

The proposed protocol is illustrated in the figure 3. At the beginning of the test, the level2 setpoint is set equal to the measured value of the Controlled Variable (i.e. the biomass production which is equal to the product of the biomass concentration and of the input flow rate). Two hours later, the level2 setpoint is set to a very high value (2 g/h in the upper graph of figure 3). Then 2 hours later, it is set to a very low value (0.1 g/h). The test is terminated 2 hours later.





6.3.3 Long Test

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Duration: around 200 h.

The objective is to test the behavior of the control. Therefore, it is proposed to move successively the set point and the disturbance (input flow rate).

An example of this protocol is shown in the figure 4. At the beginning of the test, when the closed loop system is at steady state, (t=5 h, on figure 4), a step of level2 production set point is applied (here, from 0.75 to 0.9 g/h, red curve of the top graph). The amplitude of the step is not too high so that the set point can be reached in a reasonable period of time. The interest is to check that the CV (Controlled Variable) converges towards its set point with no gap. When the CV is stable on its set point (at time t=100 h on figure 4), a step is applied on the disturbance (the input flow rate is moved from 0.77 to 0.5 l/h). The amplitude of the step is high enough so that the realizable production set point (red curve of the top graph) is lower than the level2 set point (green curve of the top graph). This allows to check that the biomass concentration does not overshoot its upper constraint (blue and green curves, respectively, of the third graph).



Figure 4: Spirulina control law long test

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1 SCOPE

This document presents the HW design of the Control System Demonstrator to be installed in the MELISSA Pilot Plant at UAB (E) premises for compartments III and IV. Chapters 4 to 7 the mechanical and electrical design of the three racks that conform the Control System Demonstrator, (namely racks for CIII, CIVa and Supervisory HW).

Appendix A addresses the capabilities of the Demonstrator HW in order to implement redundancy.

Appendices B and C contain detailed tables showing the electrical interconnections of the different modules within racks III and IV. Appendix D contains the cable colour codes and Appendix E lists the complete HW part lists implemented in the Demonstrator.

Appendix F addresses the expansion capabilities of the racks III and IV in order to adapt to potential future modification or expansion of the associated bioreactors.

Finally Appendix G explains the electrical protection design measures implemented in the racks to guarantee their safe operation.

2 REFERENCE DOCUMENTS

2.1 Applicable documents

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- [A2] MELISSA. Adaptation for Space-Phase 1. Proposal issued by NTE. MEL-0000-OF-001-NTE. Issue 2. October 2001.
- [A3] Memorandum of Understanding between the UAB and NTE S.A. MEL-0000-SP-007-NTE. Version 1. Issue 0. 21 January 2002.
- [A4] Reglamento de Baja Tensión (RBT), July 2002.
- [A5] MELISSA Control System Architecture and Trade-off. TN 72.3. Version 1. Issue 0. February 2003.

2.2 Reference Documents

- [R1] Definition of the control requirements for the MELISSA Loop. TN 72.2, v. 1.2, November 2002 (MEL-3100-SP-010-NTE).
- [R2] Photoheterotrophic Compartment Set-up. TN 37.6. UAB, February 1998.
- [R3] Nitrifying Compartment Studies. TN 25.310. UAB, September 1996.
- [R4] Set-up of the Photosynthetic Pilot Reactor. TN. 37.2. UAB, April 1998.
- [R5] Control System Demonstrator Test Plan and Procedure, TN 72.4 Volume Ib, v.1.1, July 2004 (MEL-3310-PL-039-NTE.).
- **[R6]** Modicon Quantum Automation Series Hardware Reference Guide. 840 USE 100 00 version 10.0, 2002.

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3 ACRONYMS LIST

- AWGAmerican Wire GaugeHSBYHot StandBY
- PLC Programmable Logic Controller
- RBT Reglamento de Baja Tensión (Low Voltage Regulation)
- STP Shielded Twisted Pair
- UAB Universitat Autònoma de Barcelona

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4 INTRODUCTION

This document describes the hardware design of the Control System demonstrator to be installed at the MELISSA Pilot Plant (UAB's premises).

This demonstrator has been designed as to permit the verification of some key aspects of the new MELISSA Control System Architecture described in [A5]. The aspects to be verified as previously agreed with ESA, are the following:

- In-plant verification of the Control law for the *Spirulina* compartment (variables, loops etc.) with the new control HW.
- In-plant verification of the Control law for the Nitrifying compartment. (Variables, loops etc.) with the new control HW.
- Non-nominal tests to verify alarm management

These verification objectives are developed in a specific Test Plan and Procedure produced by NTE in co-ordination with the UAB, [R5].

Based on these verification objectives NTE proposed for implementation the Control System demonstrator for compartments CIII and CIV shown in Figure 4-1. This diagram presents the demonstrator conceptual design and how it is implemented in terms of equipment and products. Redundant elements are displayed in grey and are not physically implemented within the demonstrator HW.

The demonstrator HW presents the following configuration:

- Client computer
- Supervisory rack, housing the supervision server and the Ethernet switch
- Compartment III (CIII) rack, housing the CIII PLC and auxiliary electronic equipment, implementing the local control for the MELISSA Nitrifying compartment and providing electrical interface to the Plant's sensors and actuators related to CIII.
- Compartment IV (CIV) rack, housing the CIV PLC and auxiliary electronic equipment implementing the local control for the MELISSA Spirulina compartment and providing electrical interface to the Plant's sensors and actuators related to CIV.
- HMI Touch screen

All these elements are to be interconnected through an Ethernet network.

The following chapters present the detailed design of the above-defined elements.

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Figure 4-1: Control System demonstrator concept

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5 Supervision Client computer

This computer is used to visualize supervision displays and to upload / download PLC programs.

No specific design is associated to this element, whose characteristics are standard. Some detailed information is presented hereafter:

MEL_SUPV_CLI01	
Model:	Dell OptiPlex GX260 P4 1.8 GHz
Power supply:	220 VAC 50 Hz
Main SW components:	MS Windows XP Professional Edition
-	Concept V2.6 XL EN
	iFix Client
Physical location:	Plant's control loop

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6 Supervision Rack

This rack has to be placed in a conditioned room (UAB Plant Control room). Allocates an Ethernet switch (MEL_SWITCH01) and the Supervision Server (MEL_SUPV_SERV01). No specific design is associated to this element, whose characteristics are standard. Some detailed information is presented hereafter:

MEL_SUPV_SERV01	
Model:	Dell Power Edge 2600
Power supply:	2x220 VAC 50 Hz redundant.
Storage:	2 SCSI disks 36 GB in Raid 3 configuration
	1 Floppy
	1 CDR
	1 Tape (for backup purposes)
Main SW components:	MS Windows 2000 Server
	iFix Server Only
Physical location:	Plant's control room

MEL_SWITCH01	
Model:	3Com - Super Stack 3
Power supply:	220 VAC 50 Hz redundant.
Characteristics:	16 x 10/1000 Mbps Standard Ethernet ports

• Dimensions (h x w x l): 625 X 600 X 800 mm

The rack's elements are presented in the next diagram:

MEL_SWITCH01	
	7
MEL_SUPV_SERV01	

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7 Compartment CIII rack (CIII_RACK)

Compartment CIII rack houses the hardware necessary to implement the control of the Compartment CIII bioreactor. This hardware covers (at least) the functionality of the current control system placed at the UAB for the CIII Compartment.

7.1 Introduction

MELISSA's CIII bioreactor is based on a Nitrifying reactor. The inputs are the liquid output of the compartment II and gas outputs from other compartments via a Buffer Tank. Its main function is to transform Ammonia to Nitrates producing Nitrate in the liquid phase and CO2 in the gas phase.

For information purposes, next table lists and describes the CIII control loops.

Loop	Description
CIII-CL-P	Maintain the pressure of the gas phase
CIII-CL-Ph	Maintain the pH in culture medium
CIII-CL-T	Maintain temperature of the culture
CIII-CL-Fl	Regulate input/output liquid flow
CIII-CL-NH4	Maintain Ammonium concentration
CIII-CL-O2	Oxygen concentration
CIII-CL-St	Stirring (Not implemented)

The following paragraphs present the control HW for this CIII (referred to as CIII_RACK) in terms of detailed mechanical and electrical design description

7.2 Mechanical design

The CIII control HW is implemented in the corresponding rack (referred to as CIII_RACK). It provides mechanical housing to the following elements:

- A mounting board to place the electronics.
- PLC modules (CIII_PLC) attached to the rack's Backplane
- Connection elements (CIII_EXT_Eth, CIII_AC_OUT, CIII_AC_IN, CIII_CP)
- Power Supply for I/O (CIII_PLC_IO)
- Auxiliary electrical elements (CIII_PS, CIII_AC_GND and CIII_AC_UPS)
- Relay panel (CIII_Relay)
- It reserves free space for a secondary future redundant PLC.

The mechanical characteristics of the CIV rack are the following:

- Brand and model: RITTAL TS 8
- Ruggerised for laboratory environment
- Dimensions (h x w x l): 200 X 61 X 62 cm
- Includes a Fan system with 2 units for thermal dissipation
- Includes four wheels for mobility

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Note: it must be ensured that all the rack's mechanical elements are properly interconnected in order to ensure a proper electrical grounding.

The following diagram depicts the distribution of the main blocks in the mounting board:

CIII_PLC
CIII_ AC_I N C_OUT CIII_CP
Secondary PLC Not Included
CIII_ ETH ER CIII_R ELAY CIII_TB
CIII_AC CIII_PS
CIII_GND
CIII_UPS

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The following diagram presents the internal mechanical layout corresponding to the CIII_RACK:



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7.3 Electrical design

CIII_RACK electrical design is described by defining the electrical interfaces, the rack's elements and their electrical interconnection.

The rack is externally powered from a line protected from power cuts by a generator that starts after 1 minute of power interruption (provided by UAB). Input power is limited by a magnetothermic at 6A. In addition to prevent possible hazards caused by current leaks a differential at 30 mA sensibility is also placed at the input.

Output signals (analogue and digital) and power lines have been dimensioned taking into account the current system at UAB.

7.3.1 CIII External Electrical Interfaces

The electrical interface description covers the I/O interface (i.e. interface with the Plant's sensors and actuators related to CIII), the network interface and the power interface.

7.3.1.1 CIII I/O Interface

The following table lists and describes all the I/O electrical signals interfacing between CIII_RACK and the rest of the Plant:

- Type: A (analogue signal) or D (digital signal)
- IO: I (Input signal) / O (Output signal)
- N: numerical identifier
- Name: mnemonic signal identifier
- Device: name of the Plant's device related to the signal
- Electric range: signal's electrical characteristics
- Measurement range: measurement range of the associated physical parameter
- Description: function of the signal
- Remarks: additional information

Туре	10	Ν	Name	Device	Electric Range	Measurement Range	Description	Remarks
А	Ι	01	CIII_MV_DObot	Oxygen analyzer	4-20 mA	0 – 100 %	DO at bottom	
А	Ι	02	CIII_MV_DOtop	Oxygen analyzer	4-20 mA	0 – 100 %	DO at top	
A	Ι	03	CIII_MV_NH4	Ammonium analyzer	4-20 mA	0 – 200 ppm N- NH4+	Ammonium concentration at top	
A	Ι	04	CIII_MV_NO3	NO3 analyzer	4-20 mA	0 – 1000 ppm N-NO3-	Nitrate concentration	
А	l	05	CIII_MV_P	Pressure sensor	4-20 mA	0 – 1000 mb	Pressure at top of the gas phase	
А	Ι	06	CIII_MV_PHb	pH meter	4-20 mA	3 – 13	pH at bottom	
А	I	07	CIII_MV_PHt	pH meter	4-20 mA	1.5 – 11.5	pH at Top	
A	Ι	08	CIII_MV_PsI	Sampling line pressure sensor	4-20 mA	-10 – 15 mb	Pressure sensor for the sampling line	

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Туре	10	N	Name	Device	Electric Range	Measurement Range	Description	Remarks
А	Ι	09	CIII_MV_Tb	Thermometer	4-20 mA	0.2 – 147 °C	Temperature at bottom	
А	Ι	10	CIII_MV_Tt	Thermometer	4-20 mA	0.2 – 147 °C	Temperature at top	
А	0	01	CIII_FC_CO2	CO2 flow controller	0-5 V	0 – 100 %	CO2 mass flow meter	
А	0	02	CIII_FC_N2	N2 flow controller	0-5 V	0 – 150 %	N2 flow controller	
А	0	03	CIII_FC_02	O2 flow controller	0-5 V	0 – 100 %	O2 flow controller	
А	0	05	CIII_PM_Ac	Acid pump	4-20 mA	0 – 100 %	Acid pump	
А	0	06	CIII_PM_Bs	Base pump	4-20 mA	0 – 100 %	Base pump	
А	0	07	CIII_PM_FI	Input media pump	4-20 mA	0 – 100 %	Input media pump	not used
А	0	08	CIII_PM_L	Output liquid pump	4-20 mA	0 – 100 %	Output liquid pump	
D	Ι	01	CIII_CAL_NH4	Ammonium analyzer	0-24 V	0-1 (=calibrating)	Analyzer calibration indicator	
D	Ι	02	CIII_CAL_NO3	NO3 analyzer	0-24 V	0-1 (=calibrating)	Nitrate calibration indicator	
D	Ι	03	CIII_MV_L1	Level sensor	0-24 V	V 0-1 (=level Level measurement top reached)		Replace relay to switch between sensors
D	Ι	04	CIII_MV_L2	Level sensor	0-24 V	1-0 (=level reached)	Level measurement bottom	Inverse logic
D	I	05	CIII_MVI_Lbt	Level sensor	0-24 V	0-1 (=level reached)	Indicator of max level reached for a buffer tank	to be incorporated
D	0	01	CIII_PM_Lbt	Pump buffer tank	0-24 V	0-1 (=Active)	Activation of the pump for the buffer tank	Relay
D	0	04	CIII_RL_Comp	Compressor	0-24 V	0-1 (=Active)	Compressor activation	Relay
D	0	05	CIII_RL_CV	Cooling valve	0-24 V	0-1 (=Active)	Cooling valve	Relay
D	0	06	CIII_RL_HT	Heater resistance	0-24 V	0-1 (=Active)	Heater	Relay
D	0	07	CIII_RL_Lp	Level sensor	0-24 V	0-1 (=Active)	Relay to have a pulse in the level sensor lecture	Relay
D	0	08	CIII_RL_P	Pressure solenoid valve	0-24 V	0-1 (=Active)	Solenoid valve for pressure regulation	Relay. Valve activated via relay at 220 V / 6 W
D	0	09	CIII_RL_Ac	Acid pump	0-24 V	0-1 (=Active)	Relay acid pump	Relay
D	0	10	CIII_RL_Bs	Base pump	0-24 V	0-1 (=Active)	Relay base pump	Relay

7.3.1.2 CIII Control network interface

Standard STP-Cat5 Ethernet connection (RJ-45)

7.3.1.3 CIII AC Input power interface

220 VAC 50 Hz (AC L, AC N)

Proper conditioned ground shall be provided.

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7.3.1.4 CIII AC Output interface

Output AC interface is implemented to provide 220VAC/50Hz (commuted by relays) to:

- Acid pump
- Base pump
- Compressor (not used)
- Cooling valve
- Heater
- Safety pressure valve

The output is protected by a magnetothermic at 2 A.

7.3.2 CIII Internal Electrical Interfaces

7.3.2.1 Wiring

There are three types of wires identified according to applicable regulations:

Net	Requirements	Wire characteristics
I/O Signals	Maximum power 24V/2 A	24AWG
	(Digital outputs 140DDO88500)	
	Colors specified in each	
	connection table	
24V	Maximum power 24V 5A (max.	1mm section
	power supply output)	
	Red: 24V	
	Black: Return	
220VAC	Limited at 6A at power input.	1 mm section
		Insulating cover nominal
		voltage 750 V

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7.3.2.2 Connecting components overview.

Next schematic shows the various CIV_RACK components in a block diagram.



7.3.2.2.1 Naming convention

Each block is identified by a label formed as follows:

CIII_XXXX_YYYY, where

CIII: Element part of the Compartment III configuration.

XXXX:

PLC: Is part of the PLC placed in the CIIII_RACK TB: Terminal Blocks PS: Power supply AC: Elements connected to the 220VAC net. RELAY: Relay elements. ETHER: Ethernet connection CP: Connection Panel.

YYYY (only in sub-elements as part of previous XXXX) IO: Input/Output signals.

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7.3.2.2.2 CIII_PLC

Compartment CIII Quantum (by Schneider) Programmable Logic Controller mounted on a backplane with 10 available slots. The PLC module distribution is displayed in the following table, showing the manufacturer reference identification (140XXXXXXX), the description of the module and the mnemonic identification used in CIII_RACK. For description easiness, modules 4 to 8 are grouped into the CIV_PLC_IO element.

1	2	3	4	5	6	7	8	9	10
140CPS11420	140CPU43412A	140NOE77101	140ACI04000	140AVO02000	140ACO02000	140DDI84100	140DDO84300		
Backplane Power Supply module	CPU module	Ethernet module	16 Analog input 4- 20 mA	4 Analog output 0-5V	4 Analog output 0-20/4-20 mA	16 Digital inputs 10-60 VCC	16 Digital outputs 10-60 VCC		
CIII_PLC_CPS		CIII_PLC_NOE	CIII_PLC_IO_ACI	CIII_PLC_IO_AVO	CIII_PLC_IO_ACO	CIII_PLC_IO_DDI	CIII_PLC_IO_DDO		

7.3.2.2.3 CIII_TB

Block defining the group of connectors corresponding to the CableFast Terminal Blocks. The purpose of this block is to replicate the connections corresponding to the CIII_PLC_IO element (PLC's I/O signal, either Analogue or Digital) so that connections and/or modifications cannot be done directly onto the PLC modules.

	CIII_PLC_IO_ACI	CableFast	CIII_TB_ACI	
0	CIII_PLC_IO_AVO	CableFast	CIII_TB_AVO	В
PLC	CIII_PLC_IO_ACO	CableFast	- CIII_TB_ACO	II_T
	CIII_PLC_IO_DDI	CableFast	- CIII_TB_DDI	CI
	CIII_PLC_IO_DDO	CableFast	- CIII_TB_DDO	

Connection between CIV_PLC_IO and CIV_TB are implemented by means of premanufactured CableFast cables. This system allows the connection of pre-wired cables to I/O cards, carrying the signals to a terminal block point to point by means of a standard 50 pin "D" connector.

7.3.2.2.4 CIII_PS and CIII_RELAY

CIII_PS supplies 24Vdc for distribution within the CIII_RACK. Two components are defined within this element:

- CIII_PS_SRC: Power Supply, model Telemecanique ABL7RE2405
- CIII_PS_CP: Connector panel for distribution of 24 Vdc where needed within the various rack's elements. Connector type Phoenix UN 1,5 N (26-16 AWG 17,5 A 500 V).

	CIII_PS
CIII_PS_SRC	CIII_PS_CP
CIII_FS_SKC	CIII_F5_CF

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CIII_RELAY encompasses the set of ten relays needed to activate certain external devices:

	CIII_RELAY									
CIII_RELAY_01	CIII_RELAY_02	CIII_RELAY_03	CIII_RELAY_04	CIII_RELAY_05	CIII_RELAY_06	CIII_RELAY_07	CIII_RELAY_08	CIII_RELAY_09	CIII_RELAY_10	

The generic connection table for the relays is as follows:

Rel.	Signal	Commuted (11-12/14)	Description
1	CIII_PM_Lbt	24 V	Activation of the pump for
			the buffer tank
2	CIII_RL_Ac	AC L (220V ?W)	Not used
3	CIII_RL_Bs	AC L (220V ?W)	Not used
4	CIII_RL_Comp	AC L (220V ?W)	Not used
5	CIII_RL_CV	AC L (220V 6W)	Cooling valve
6	CIII_RL_HT	AC L (220V 3600)	Heater resistance
7	CIII_RL_Lp	24 V	Liquid level pulse
			generation
8	CIII_VL_P	AC L (220V 6W)	Safety pressure valve
9	Not used	Contact	Acid pump
10	Not used	Contact	Base pump

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7.3.2.2.5 CIII_AC

This element encapsulates the external AC power input, its conditioning and distribution to the rest of the rack's elements, where required. Next diagram shows the components within this element:



- CIII_AC_IN: external 220 V AC input power connector type UK 2,5 N (24-14 AWG 24 A 800 V).
- CIII_AC_DIFF: Current leaks protection at 30 mA.
- CIII_AC_MGTH6: Magnetothermic protection device to implement in-house over current protection at 6A (Merlin Gerin C60N/C6).
- CIII_AC_FILT: standard AC Input filter (YUNPEN YK06T1 230V 50Hz 6A).
- CIII_AC_CP: connection panel for distribution of filtered 220V AC internally to the rack. Connector type Phoenix UK 1,5 N (26-16 AWG 17,5 A 500 V).
- CIII_AC_OUT: connector to distribute the conditioned 220V AC to external devices. Connector type Phoenix ZFKK 1,5-MSTBV-5,08 (24-14 AWG 12 A 250 V).
- CIII_AC_UPS: Uninterrupted Power Supply (UPS), included to maintain under power the PLC in the event of a plant's power interruption during no less than 1 minute. Characteristics:
 - UPS 250 VA, 230V, 165 Watts, 230 Vin 50/60 Hz.
 - APC POWERSTACK 250VA
- CIII_AC_MGTH2: Magnetothermic device to implement an over current protection at 2A of the external powered devices. (Merlin Gerin C60N/C2).
- CIII_AC_GND: metallic strip for rack grounding purposes.

7.3.2.2.6 CIII_ETHER

RJ45 Ethernet connector to connect the system's Control Network to the PLC network module (CIII_PLC_NOE). Connector type RJ45 Cat 5 shielded.

7.3.2.2.7 CIII_CP

Connection panel to perform signal connections from the CIII_RACK to the external plant's sensors and actuators related to CIII.

Connector type Phoenix ZFKK 1,5-MSTBV-5,08 (24-14 AWG 12 A 250 V).

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7.3.2.3 Elements inter-connection diagram

The following diagram shows the electrical connections for the CIII_RACK elements.

Detailed connection tables according to this diagram are provided in Appendix B.

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7.3.2.4 Electrical Schematic

The following diagram presents the electrical power distribution circuitry implemented in Rack CIII.

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8 Compartment CIV rack (CIV_RACK)

Compartment CIV rack houses the hardware necessary to implement the control of the Compartment CIV bioreactor. This hardware covers (at least) the functionality of the current control system placed at the UAB for the CIV Compartment.

8.1 Introduction

MELISSA's compartment CIV bioreactor is based on a photosynthetic reactor. CIV inputs are the liquid phase from the compartment CIII and the gas outputs generated in other compartments through a buffer tank. The main function of CIV is to convert Nitrates into edible biomass and CO2 into O2. Therefore, the resulting output products are O2 in the gas phase and edible biomass in the solid phase.

LoopDescriptionCIV-CL_CxMaintain biomass concentrationCIV_CL_FrMaintain light intensity inside the bioreactorCIV_CL_GMaintain gas concentrationsCIV_CL_PMaintain the pressure of the gas phase (gas flow)CIV_CL_pHMaintain the pH set point in the cultureCIV_CL TMaintain temperature of the culture (not controlled by the PLC)

For information purposes, next table lists and describes the CIV control loops.

The following paragraphs present the control HW for this CIV (referred to as CIV_RACK) in terms of detailed mechanical and electrical design description

8.2 Mechanical design

The CIV control HW is implemented in the corresponding rack (referred to as CIV_RACK). It provides mechanical housing to the following elements:

- PLC modules (CIV_PLC) attached to the rack's Backplane
- Connection elements (CIV_EXT_Eth, CIV_AC_OUT, CIVAC_IN, CIV_CP)
- Power Supply for I/O (CIV_PLC_IO)
- Auxiliary electrical elements (CIV_PS, CIV_AC_GND and CIV_AC_UPS)
- Relay panel (CIV_Relay)
- It reserves free space for future redundant CIV_PLC

The mechanical characteristics of the CIV rack are the following:

- Brand and model: RITTAL TS 8
- Ruggerised for laboratory environment
- Includes a Fan system with 2 units for thermal dissipation
- Includes four wheels for mobility
- Dimensions (h x w x l): 200 X 61 X 62 cm

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Note: it must be ensured that all the rack's mechanical elements are properly interconnected in order to guarantee a proper electrical grounding.

The following diagram depicts the distribution of the main blocks in the mounting board:

CIV_PLC
CIV_ EXT _Eth N CIV_A C_OUT CIV_EXT_IO
Secondary PLC Not Included
CIV_PLC_IO
CIV_AC CIV_PS CIV_REL AY
CIV_GND
CIV_UPS

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The next diagram presents the internal mechanical layout corresponding to the CIV_RACK:



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8.3 Electrical design

CIV_RACK electrical design is described by defining the electrical interfaces, the rack's elements and their electrical interconnection.

The rack will be externally powered from a line protected from power cuts by a generator that starts after 1 minute of power interruption (provided by UAB). Input power is limited by a magnetothermic at 6A. In addition to prevent possible hazards caused by current leaks a differential at 30 mA sensibility is also placed at the input.

Output signals (analogue and digital) and power lines have been dimensioned taking into account the current system at UAB.

8.3.1 CIV External Electrical Interfaces

The electrical interface description covers the I/O interface (i.e. interface with the Plant's sensors and actuators related to CIV), the network interface and the power interface.

8.3.1.1 CIV I/O Interface

The following table lists and describes all the I/O electrical signals interfacing between CIV_RACK and the rest of the Plant:

- Type: A (analogue signal) or D (digital signal)
- IO: I (Input signal) / O (Output signal)
- N: numerical identifier
- Name: mnemonic signal identifier
- Device: name of the Plant's device related to the signal
- Electric range: signal's electrical characteristics
- Measurement range: measurement range of the associated physical parameter
- Description: function of the signal
- Remarks: additional information

Туре	10	Ν	Name	Device	Electric Range	Measurement range	Description	Remarks
A	I	01	CIV_MV_Cx	Biomass sensor	4-20 mA	Configurable	Biomass measurement	Possibly non linear when converting to Kg/m ³ .
A	I	02	CIV_MV_M1	Scale 1	4-20 mA	0 – 150 kg	Mass measurement to determine input flow	
A	I	03	CIV_MV_M2	Scale 2	4-20 mA	0 – 150 kg	Mass measurement to determine input flow	
А	I	04	CIV_MV_P	Pressure sensor	4-20 mA	0 – 1.5 bar	Pressure measurement	
А	Ι	05	CIV_MV_pH	pH sensor	4-20 mA	0 – 14	pH measurement	
A	I	06	CIV_MV_T	Temperature sensor	4-20mA	0 – 150 °C	Temperature measurement	
А	I	07	CIV_MGO_O2	O2 gas sensor	4-20 mA	Configurable	Measure O2 at gas output	Two available scales
A	I	08	CIV_MGO_CO2	CO2 gas sensor	4-20 mA	Configurable	Measure CO2 at gas output	Two available scales

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Туре	10	N	Name	Device	Electric Range	Measurement range	Description	Remarks
A	I	09	CIV_MV_DO	Dissolved Oxygen sensor	4-20 mA	Configurable	Percent of O2 saturation in the reactor	
А	Ι	13	CIV_MGI_Fg	Flowmeter	0-5 V	0 – 30 nLm*	Gas flow at input	
А	I	14	CIV_MGO_Fg	Flowmeter	0-5 V	0 – 30 nLm	Gas flow at output	
А	I	15	CIV_MV_CO2	CO ₂ flowmeter	0-5 V	0 – 5 nLm	CO ₂ flow measurement	
А	Ι	16	CIV_MV_Fg	Flowmeter	0-5 V	0 – 30 nLm	Gas flow re-circulation	
А	0	01	CIV_FR_CO2	CO ₂ flow regulator	0-5 V	0 – 5 nLm	CO ₂ flow regulation	
A	0	02	CIV_PM_Fgi	Flow regulator	0-5 V	0 – 30 nLm	Gas flow at input regulation	
A	0	03	CIV_PM_Fgo	Flow regulator	0-5 V	0 – 30 nLm	Gas flow at output regulation	
A	0	04	CIV_PM_Fgex	Flow regulator	0-5 V	0 – 30 nLm	Gas flow re-circulation regulation	
А	0	05	CIV_PM_Li1	Liquid input pump1	0-5 V	0 – 100 %	Liquid Pump input1 set point	Possibly non linear
A	0	06	CIV_PM_Li2	Liquid input pump2	0-5 V	0 – 100 %	Liquid Pump input1 set point	Possibly non linear
A	0	07	CIV_PM_LO	Liquid output pump	0-5 V	0 – 100 %	Liquid Pump output set point	Possibly non linear
A	0	09	CIV_PM_Bs	Base pump	4-20mA	0 – 100 %	Additional Base source for pH regulation	
A	0	10	CIV_RG_Ls	Light regulator	4-20 mA	0 – 100 %	Regulator of light supply	Set point is fixed by Supervision. Non linear (Wm ² =54,56x+289x ² - 24,19)
A	0	11	CIV_PM_Ac	Acid pump	4-20 mA	0 – 100 %	Additional Acid source for pH regulation	Acid source can be CO2 or additional acid media
D	-	01	CIV_CAL_CO2O2	CO2/O2 sensor	0-24 V	0 – 1 (=Calibr.)	Calibration indicator of CO2/O2 sensor.	
D	-	02	CIV_ERR_CO2O2	CO2/O2 sensor	0-24 V	0 (=Error) – 1 (=OK)	Error Indicator of CO2/O2 sensor.	
D	-	03	CIV_SCL1_CO2O2	CO2/O2 sensor	0-24 V	0 (= scale 1) – 1 (= scale 2)	CO2/O2 sensor scale indicator	
D	-	04	CIV_SCL2_CO2O2	CO2/O2 sensor	0-24 V	0 (= scale 1) - 1 (= scale 2)	CO2/O2 sensor scale indicator	
D	0	01	CIV_RL_Li1	Enable liquid input pump1	0-24 V	0 – 1 (=active)	Liquid Pump input1 on	Relay. max 300 mA
D	0	02	CIV_RL_Li2	Enable liquid input pump2	0-24 V	0 – 1 (=active)	Liquid Pump input2 on	Relay. max 300 mA
D	0	03	CIV_RL_Cx	Electrovalve	0-24 V	0 – 1 (=cleaning)	Aeration of biomass sensor for cleaning	Relay. Pulse of 20sec each 10 min (220V AC)
D	0	04	CIV_RL_Fg	Pressure valve	0-24 V	0 – 1 (=close)	Pressure safety valve activation	Relay at 220V AC 6W

• nLm: Normal liters per minute.

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8.3.1.2 CIV Control network interface

Standard STP-Cat5 Ethernet connection (RJ-45)

8.3.1.3 CIV AC Input power interface

220 VAC 50 Hz (AC L, AC N) Proper conditioned ground shall be provided.

8.3.1.4 CIV AC Output interface

Output AC interface is implemented to provide commuted 220VAC/50Hz to:

- Aeration Biomass Sensor Electro Valve (6W)
- Safety Pressure Electro Valve (6W)

The output is protected by a magnetothermic at 2 A.

8.3.2 CIV Internal Electrical Interfaces

Due to the large number of connecting elements and the complexity of the wiring, first an overview of the various components within the rack is presented.

Detailed components interconnections are described afterwards by means of interface tables. These tables present the related connectors, connecting points, name of the signal and characteristics of the wiring.

8.3.2.1 Wiring

Three types of wires are identified:

Net	Requirements	Wire characteristics
I/O Signals	Maximum power 24V/2 A	24AWG
_	(Digital outputs 140DDM39000)	
	Colors specified in each	
	connection table	
24V	Maximum power 24V 5A (max.	1 mm section
	power supply output)	
	Red: 24V	
	Black: Return	
220VAC	Limited at 6A at power input.	1 mm section
		Insulating cover nominal
		voltage 750 V

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8.3.2.2 Connecting components overview.

Next schematic shows the various CIV_RACK components.



8.3.2.2.1 Naming convention

Each block is identified by a label formed as follows:

CIV_XXXX_YYYY, where

CIV: Element part of the Compartment IV configuration.

XXXX:

PLC: Is part of the PLC placed in the CIV_RACK TB: Terminal Blocks PS: Power supply AC: Elements connected to the 220VAC net. RELAY: Relay elements. ETHER: Ethernet connection CP: Connection Panel.

YYYY: (only in sub-elements as part of previous XXXX) IO: Input/Output signals.

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8.3.2.2.2 CIV_PLC

Compartment CIV Quantum (by Schneider) Programmable Logic Controller mounted on a backplane with 10 available slots. The PLC module distribution is displayed in the following table, showing the manufacturer reference identification (140XXXXXXX), the description of the module and the mnemonic identification used in CIV_RACK. For description easiness, modules 4 to 9 are grouped into the CIV_PLC_IO element.

1	2	3	4	5	6	7	8	9	10
140CPS11420	140CPU43412 A	140NOE77101	140ACI03000	140AVI03000	140AVO01000	140AVO02000	140ACO13000	140DDM39000	NOT USED
Backplane Power Supply module	CPU module	Ethernet module	8 Analog input 4- 20 mA	8 Analog input 0- 5 V	4 Analog output 0-5 V	4 Analog output 0-5 V	8 Analog output 0-20/4-20 mA	16 Digital inputs / 8 Digital outputs 10-60 VCC	
CIV_PLC_CPS		CIV_PLC_NOE	CIV_PLC_IO_ACI	CIV_PLC_IO_AVI	CIV_PLC_IO_AVO1	CIV_PLC_IO_AVO2	CIV_PLC_IO_ACO	CIV_PLC_IO_DIO	

8.3.2.2.3 CIV_TB

Block defining the group of connectors corresponding to the CableFast Terminal Blocks. The purpose of this block is to replicate the connections corresponding to the CIV_PLC_IO element (PLC's I/O signal, either Analogue or Digital) so that connections and/or modifications cannot be done directly onto the PLC modules.

	CIV_PLC_IO_ACI	CableFast	CIV_TB_ACI	
0	CIV_PLC_IO_AVI	CableFast	CIV_TB_AVI	
, C_J	CIV_PLC_IO_AVO1	CableFast	CIV_TB_AVO1	TB
Id_/	CIV_PLC_IO_AVO2	CableFast	CIV_TB_AVO2	
CIV	CIV_PLC_IO_ACO	CableFast	- CIV_TB_ACO	
	CIV_PLC_IO_DIO	CableFast	CIV_TB_DIO]

Connection between CIV_PLC_IO and CIV_TB are implemented by means of premanufactured CableFast cables. This system allows the connection of pre-wired cables to I/O cards, carrying the signals to a terminal block point to point by means of a standard 50 pin "D" connector.

Figure 8-1 and Figure 8-2 depict the aspect of a Terminal Block and provide references on the connector's numbering.

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Figure 8-1. Terminal block



Figure 8-2. Terminal numbering equivalence and block sizes.

8.3.2.2.4 CIV_PS

This element supplies 24Vdc for distribution within the CIV_RACK. Two components are defined within this element:

- CIV_PS_SRC: Power Supply, model Telemecanique ABL7RE2405
- CIV_PS_CP: Connector panel for distribution of 24 Vdc where needed within the various rack's elements. Connector type Phoenix UN 1,5 N (26-16 AWG 17,5 A 500 V).

	CIV_PS
CIV_PS_SRC	CIV_PS_CP

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8.3.2.2.5 CIV_RELAY

This element encompasses the set of 6 relays needed to activate certain external devices, as shown in the next diagram.



Relays reference is Phoenix EMG 10-REL/KSR-G 24/21-LC, the corresponding schematic is shown in Figure 7-3.



Figure 8-3. Relay schematic EMG 10-REL/KSR-G 24/21-LC

The generic connection table for the relays is as follows:

Relay	Signal	Commuted (11 – 12/14)	Description
1	CIV_RL_Li1	24 V	Liquid Input Pump 1
2	CIV_RL_Li2	24 V	Liquid Input Pump 2
3	CIV_RL_Cx	AC L (220V 6W)	Biomass sensor electro- valve
4	CIV_RL_Fg	AC L (220V 6W)	Safety pressure electro-valve
5	Not used		
6	Not used		

8.3.2.2.6 CIV_AC

This element encapsulates the external AC power input, its conditioning and distribution to the rest of the rack's elements, where required. Next diagram shows the components within this element:

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- CIV_AC_IN: external 220 V AC input power connector type UK 2,5 N (24-14 AWG 24 A 800 V).
- CIV_AC_DIFF: Current leaks protection at 30 mA.
- CIV_AC_MGTH6: Magnetothermic protection device to implement in-house over current protection at 6A (Merlin Gerin C60N/C6).
- CIV_AC_FILT: standard AC Input filter (YUNPEN YK06T1 230V 50Hz 6A).
- CIV_AC_CP: connection panel for distribution of filtered 220V AC internally to the rack. Connector type Phoenix UN 1,5 N (26-16 AWG 17,5 A 500 V).
- CIV_AC_OUT: connector to distribute the conditioned 220V AC to external devices. Connector type Phoenix ZFKK 1,5-MSTBV-5,08 (24-14 AWG 12 A 250 V).
- CIV_AC_UPS: Uninterrupted Power Supply (UPS), included to maintain under power the PLC in the event of a plant's power interruption during no less than 1 minute. Characteristics:
 - UPS 250 VA, 230V, 165 Watts, 230 Vin 50/60 Hz.
 - APC POWERSTACK 250VA
- CIV_AC_MGTH2: Magnetothermic device to implement an over current protection at 2A of the external powered devices. (Merlin Gerin C60N/C2).
- CIV_AC_GND: metallic strip for rack grounding purposes.

8.3.2.2.7 CIV_ETHER

RJ45 Ethernet connector to connect the system's Control Network to the PLC network module (CIV_PLC_NOE). Connector type RJ45 Cat 5 shielded.

8.3.2.2.8 CIV_CP

Connection panel to perform signal connections from the CIV_RACK to the external plant's sensors and actuators related to CIV.

Connector type Phoenix ZFKK 1,5-MSTBV-5,08 (24-14 AWG 12 A 250 V).

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8.3.2.3 Elements inter-connection diagram The following figure presents the connection diagram for the CIV_RACK elements.

Detailed connection tables according to this diagram are provided in Appendix C.

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8.3.2.4 Electrical Schematic

The following diagram presents the electrical power distribution implemented in Rack CIV.

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9 APPENDIX A: Hot-Standby Configuration

The racks have been designed to allocate a second back plane to support the hot-standby (HSBY) configuration following Schneider guidelines.

To transform current configuration into a redundant one, following considerations apply:

- Each HSBY CPU shall be installed in a different back plane.
- Each HSBY CPU back plane shall have the same configuration.
- A CHS-type module that permits fiber optic communications between nominal and redundant PLCs s shall be installed in each HSBY CPU back plane.
- Configurations do not allow local I/O modules.
- Only RIO bus is allowed to communicate with I/O modules.

Therefore, to transform the current configuration to a HSBY, the following tasks need to be performed:

- Install a second back plane (6 position) in the free space between the current (10 position) back plane and the (green) Cable-Fast Terminal Blocks.
- Move CPU from the first back plane to the second.
- Move NOE (Ethernet) module from the first back plane to the second.
- Install a CHS (HSBY module), a 2nd NOE (redundant network) and a CPS (Power supply) modules in the 2on back plane
- Install a RIO module in the 1st back plane.

CPS	CPU	RIO	CHS	NOE(prim.)	NOE (red.)
1	2	3	4	5	6

Therefore the first back plane will be only an I/O back plane communicated via RIO bus to the (two) HSBY CPU back planes.

To configure the Secondary CPU back plane two options are available depending on the number of I/O that need to be redundant and the level of redundancy required:

A.- In case that only a low number of I/O need to be redundant, the second CPU back plane can be fixed in a panel placed in front of the current in the low part of the same rack.

B.- If a considerable number of I/O need to be redundant, a second rack will need to be deployed, with the secondary HSBY CPU back plane, an additional I/O black plane, additional powering electronics, connectors and so on. All I/O back planes will be connected to the same RIO bus, since it will be communicated through both HSBY CPU back planes.

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10 APPENDIX B: CIII Rack Electrical Connection Tables

<u>10.1CIII_TB_ACI: Current Analogue Inputs Terminal Block</u></u>

CableFast Terminal Block corresponding to the PLC's CIII_PLC_IO_ACI module (card 140ACI04000 featuring 16 Analog Inputs 4-20 mA).

The basic connection schematic is:

SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
CIII_AI_01+	CIII_TB_ACI	1	CIII_CP	004	24	PR	
CIII_AI_01-	1	2		008		GY/PK	
CIII_AI_02+		3		012		RD	
CIII_AI_02-		4		016		BR	
CIII_AI_03+		5		020		BK	
CIII_AI_03-		6		024		GY	
CIII_AI_04+		7		028		GN	
CIII_AI_04-		8		032		YL	
CIII_AI_05+		11		036		RD/BL	
CIII_AI_05-		12		040		BR/GN	
CIII_AI_06+		13		044		WH	
CIII_AI_06-		14		048		WH/GN	
CIII_AI_07+		15		052		WH/YL	
CIII_AI_07-		16		056		BR/YL	
CIII_AI_08+		17		060		BL	
CIII_AI_08-		18		064		PK	
CIII_AI_09+		21		068		PR	
CIII_AI_09-		22		072		GY/PK	
CIII_AI_10+		23		076		RD	
CIII_AI_10-		24		080		BR	
CIII_AI_11+		25		084		BK	
CIII_AI_11-		26		088		GY	
CIII_AI_12+		27		092		GN	
CIII_AI_12-		28		096		YL	
CIII_AI_13+		31		100		RD/BL	
CIII_AI_13-		32		104		BR/GN	
CIII_AI_14+		33		108		WH	
CIII_AI_14-		34		112		WH/GN	
CIII_AI_15+		35		116		WH/YL	
CIII_AI_15-		36		120		BR/YL	
CIII_AI_16+		37		124		BL	
CIII_AI_16-		38		128		PK	
N.C.		9					
N.C.		10					
N.C.	1	19					
N.C.	1	20					
N.C.	1	29					
N.C.	1	30					
N.C.		39					
N.C.		40					

10.2CIII TB AVO: Voltage Analogue Outputs Terminal Block

CableFast Terminal Block corresponding to the PLC's CIII_PLC_IO_AVO module (card 140AVO02000 featuring 4 Analog Outputs 0-5V).

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10.3CIII TB ACO: Current Analogue Outputs Terminal Block

CableFast Terminal Block corresponding to the PLC's CIII_PLC_IO_ACO module (card 140ACO02000 featuring 4 Analog Outputs 4-20 mA).



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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_AO_05+	CIII_TB_ACO	10	CIII_CP	164	24	YL	
CIII_AO_06+		20		172		GN	
CIII_AO_07+		30		180		RD	
CIII_AO_08+		40		188		WH	
24V+		9	CIII_PS_CP	14	20	RD	
		19				RD	
		29				RD	
		39				RD	
N.C.		2					
N.C.		12					
N.C.		22					
N.C.		32					
Monitor_1+		1					
N.C.		3					
N.C.		4					
N.C.		5					
N.C.		6					
N.C.		7					
N.C.		8					
Monitor_2+		11					
N.C.		13					
N.C.		14					
N.C.		15					
N.C.		16					
N.C.		17					
N.C.		18					
Monitor_3+		21					
N.C.		23					
N.C.		24					
N.C.		25					
N.C.		26					
N.C.		27					
N.C.		28					
Monitor_4+		31					
N.C.		33					
N.C.		34					
N.C.		35					
N.C.		36					
N.C.		37					
N.C.		38					

10.4 CIII TB IO DI: Digital Inputs Terminal Block

CableFast Terminal Block corresponding to the PLC's CIII_PLC_IO_DI module (card 140DDI84100 featuring 16 Digital Inputs 0-24 V).

C	III_TB_DI	•			CIII	_CP			
					CIII_F	PS_CP			
SIGNAL CIII_DI_01 CIII_DI_02 CIII_DI_03 CIII_DI_04 CIII_DI_05		FROM _TB_DI	PIN 1 2 5 6 11	TC CIII_) CP	PIN 200 007 015 023 031	AWG 24	COLOR PR GY/PK RD BR BK	NOTES
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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_DI_06		12		039		GY	
CIII_DI_07		15		047		GN	
CIII_DI_08		16		055		YL	
CIII_DI_09		21		063		RD/BL	
CIII_DI_10		22		071		BR/GN	
CIII_DI_11		25		079		WH	
CIII_DI_12		26		087		WH/GN	
CIII_DI_13		31		095		WH/YL	
CIII_DI_14		32		103		BR/YL	
CIII_DI_15		35		111		BL	
CIII_DI_16		36		119		PK	
24V+		3	CIII_PS_CP	20	20	BK	
		7				BK	
		13				BK	
		17				BK	
		23				BK	
		27				BK	
		33				BK	
		37				BK	
24V-		4		02		RD	
		8				RD	
		14				RD	
		18				RD	
		24				RD	
		28				RD	
		34				RD	
		38				RD	
N.C.		9					
N.C.		10					
N.C.		19					
N.C.		20					
N.C.		29					
N.C.		30					
N.C.		39					
N.C.		40					

10.5 CIII TB IO DO: Digital Outputs Terminal Block

CableFast Terminal Block corresponding to the PLC's CIII_PLC_IO_DO module (card 140DDO84300 featuring 16 Digital Outputs 0-24 V).



SIGNAL	FROM	PIN	10		PIN	AWG	COLOR	NOTES
CIII_DO_01	CIII_TB_DO	1	CIII_RELAY	/_01	A1	24	RD	
CIII_DO_02		3	CIII_RELAY	/_02	A1		BK	
CIII_DO_03		5	CIII_RELAY	/_03	A1		PK	
CIII_DO_04		7	CIII_RELAY	/_04	A1		BR	
CIII_DO_05		11	CIII_RELAY	(_05	A1		WH	
CIII_DO_06		13	CIII_RELAY	/_06	A1		GN	
CIII_DO_07		15	CIII_RELAY	(_07	A1		GY	
CIII_DO_08		17	CIII_RELAY	/_08	A1		YL	
CIII_DO_09		21	CIII_RELAY	/_09	A1		BL	
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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_DO_10		23	CIII_RELAY_10	A1		PR	
CIII_DO_11		25	CIII_CP	147		RD	
CIII_DO_12		27		155		BK	
CIII_DO_13		31		163		PK	
CIII_DO_14		33		171		BR	
CIII_DO_15		35		179		WH	
CIII_DO_16		37		187		GN	
24V+		9	CIII_PS_CP	04		RD	
		19				RD	
		29				RD	
		39				RD	
N.C.		2					
N.C.		4					
N.C.		6					
N.C.		8					
N.C.		10					
N.C.		12					
N.C.		14					
N.C.		16					
N.C.		18					
N.C.		20					
N.C.		22					
N.C.		24					
N.C.		26					
N.C.		28					
N.C.		30					
N.C.		32					
N.C.		34					
N.C.		36					
N.C.		38					
N.C.		40					

10.6 CIII PS SRC: Power Supply

Basic connection schematic:



SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
GND	CIII_PS_SRC	1	CIII_AC_GND	03	20	YL/GN	
AC N		2	CIII_AC_CP	12		BL	
AC L		3		10		BR	
24V+		4	CIII_PS_CP	1		RD	
24V-		5		15		BK	
24V+		7		13		RD	
24V-		8		27		BK	

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10.7 CIII_PS_CP: Power Supply Connection Panel

Connection panel to distribute 24Vdc:



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
24V+	CIII_PS_CP	1	CIII_PS_SRC	4	20	RD	
24V+	1	13		7		RD	
24V-	1	15		5		BK	
24V-	1	27		8		BK	
24V+		1	CIII_PS_CP	3		RD	
24V+		3		5		RD	
24V+		5		7		RD	
24V+		7		9		RD	
24V+		9		11		RD	
24V+		11		13		RD	
24V-	1	15		17		RD	
24V-	1	17		19		BK	
24V-		19		21		BK	
24V-		21		23		BK	
24V-		23		25		BK	
24V-		25		27		BK	
24V+		6	CIII_CP	003		RD	
24V+				027		RD	
24V+				035		RD	
24V+				043		RD	
24V+	1			051		RD	
24V+				059		RD	
24V+				067		RD	
24V+				075		RD	
24V+				083		RD	
24V+				091		RD	
24V+				099		RD	
24V+				107		RD	
24V+				115		RD	
24V+				196		RD	
24V-	CIII_PS_CP	22		168		BK	
24V-				176		BK	
24V-				184		BK	
24V-				192		BK	
24V-				151		BK	
24V-				159		BK	
24V-				167		BK	
24V-				175		BK	
24V-				183		BK	
24V-				191		ВК	
24V-	1	26	RELAY 01	A2		ВК	
24V-	1	-	RELAY 02	A2		BK	
•	•	•		• • •	•	• • • •	•
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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
24V-			RELAY_03	A2		BK	
24V-			RELAY_04	A2		BK	
24V-			RELAY_05	A2		BK	
24V-			RELAY_06	A2		BK	
24V-			RELAY_07	A2		BK	
24V-			RELAY_08	A2		BK	
24V-			RELAY_09	A2		BK	
24V-			RELAY_10	A2		BK	
24V-		28	RELAY_10	A2		BK	
24V+		08	RELAY_07	11		RD	
24V+		14	CIII_TB_ACO	09		RD	
24V+				19		RD	
24V+				29		RD	
24V+				39		RD	
24V+		02	CIII_TB_DI	07		RD	
24V+				13		RD	
24V+				17		RD	
24V+				27		RD	
24V+				33		RD	
24V+				37		RD	
24V-		24		04		BK	
24V-				08		BK	
24V-				14		BK	
24V-				18		BK	
24V-				24		BK	
24V-				28		BK	
24V-				34		BK	
24V-				38		BK	
24V+		04	CIII_TB_DO	09		RD	
24V+				19		RD	
24V+				29]	RD	
24V+				39]	RD	

10.8CIII RELAY 01: Buffer Tank Pump



SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
CIII_DO_01	CIII_RELAY_01	A1	CIII_TB_DO	01	24	RD	Activation of the pump
24V-		A2	CIII_PS_CP	28	20	BK	for the buffer tank
CIII_RL_BT_IN		11	CIII_CP	123	24	YL	
CIII_RL_BT_OUT		14		127		GN	
N.C.		12					

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10.9 CIII_RELAY_02: Not Used



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_DO_02	CIII_RELAY_02	A1	CIII_TB_DO	03		BK	Not used
24V-		A2	CIII_RELAY_01	A2	20	BK	
AC L		11	CIII_AC_MGTH2	02		BR	
CIII_AC_Ac_L		14	CIII_AC_OUT	02		BR	
N.C.		12					

10.10 CIII RELAY 03: Not Used



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_DO_03	CIII_RELAY_03	A1	CIII_TB_DO	05		PK	Not used
24V-		A2	CIII_RELAY_02	A2	20	BK	
AC L		11	CIII_RELAY_02	11B		BR	
CIII_AC_Bs_L		14	CIII_AC_OUT	08		BR	
N.C.		12					

10.11 CIII RELAY 04: Air compressor

CIII_RELAY_04	CIII TB DO
	CIII_RELAY_03
	CIII_AC_OUT

SIGNAL		FROM	PIN		ТО		PIN	AWG	COL	OR	NOTES
CIII_DO_04		CIII_RELAY_04	A1		CIII_TB_DO		07		BF	2	Air compressor
24V-			A2		CIII_RELAY_03		A2	20	В	K	activation
AC L			11				11B		BF	2	
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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_AC_Comp_L		14	CIII_AC_OUT	14		BR	
N.C.		12					

10.12 CIII_RELAY_05: Cooling Valve



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_DO_05	CIII_RELAY_05	A1	CIII_TB_DO	11		WH	Cooling valve
24V-		A2	CIII_RELAY_04	A2	20	BK	activation
ACL		11	CIII_RELAY_04	11B		BR	
CIII_AC_CV_L		14	CIII_AC_OUT	20		BR	
N.C.		12					

10.13 CIII RELAY 06: Heater



SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
CIII_DO_06	CIII_RELAY_06	A1	CIII_TB_DO	13		GN	Heater activation
24V-		A2	CIII_RELAY_05	A2	20	BK	
ACL		11	CIII_RELAY_05	11B		BR	
CIII_AC_Heat_L		14	CIII_AC_OUT	26		BR	
N.C.		12					

10.14 CIII RELAY 07: Liquid Level Pulse



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SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
CIII_DO_07	CIII_RELAY_07	A1	CIII_TB_DO	15		GY	Pulse to measure
24V-		A2	CIII_RELAY_06	A2	20	BK	liquid level
24V+		11	CIII_PS_CP	08		RD	
CIII_MV_L1+		14	CIII_CP	11	24	RD	
CIII_MV_L1+				19		RD	
N.C.		12					

10.15 CIII RELAY 08: Safety Pressure Valve



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_DO_08	CIII_RELAY_08	A1	CIII_TB_DO	17		YL	Safety pressure
24V-		A2	CIII_RELAY_07	A2	20	BK	regulation valve
AC L		11	CIII_RELAY_06	11B		BR	activation
CIII_AC_Safe_L		14	CIII_AC_OUT	32		BR	
N.C.		12					

10.16 CIII RELAY 09: Acid pump



SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
CIII_DO_09	CIII_RELAY_09	A1	CIII_TB_DO	21		BL	pH Acid pump
24V-		A2	CIII_RELAY_08	A2	20	BK	activation
CIII_RL_Ac+		11	CIII_CP	131	24	YL	
CIII_RL_Ac-		14]	135	24	GN]
		12					1

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10.17 CIII_RELAY_10: Base pump



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_DO_10	CIII_RELAY_10	A1	CIII_TB_IO_DO	23		PR	pH Base pump
24V-		A2	CIII_RELAY_09	A2	20	BK	activation
CIII_RL_Bs+		11	CIII_CP	139	24	YL	
CIII_RL_Bs-		14		143	24	GN	
		12					

10.18 CIII AC IN: Input 220 VAC power

External AC Power input connector.

	CIII	AC_IN	▶ 			CIII_	-16		
					•	CI	II_AC_GN	D	
	SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES	
AC L		CIII_AC_IN	2	CIII_AC_MGTH6	1	20	BR		
AC N			4		3		BL		
AC GND			6	CIII_AC_GND	1		YL/GN		

10.19 CIII AC MGTH6: Over current protection at 6 A

Magnetothermic, over current protection at 6 A.

CIII AC MGTH6	►	CIII AC DIFF

SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
AC L	CIII_AC_MGTH6	2	CIII_AC_DIFF	1	20	BR	
AC N		4		3		BL	

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<u>10.20 CIII_AC_DIFF: Current leaks protector</u>

Current leaks protector.

	▶	
CIII_AC_DIFF		CIII_AC_FIL1

SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
AC L	CIII_AC_DIFF	2	CIII_AC_FILT	1	20	BR	
AC N		4		3		BL	

10.21 CIII AC FILT: AC Filter

AC filter.



SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
GND	CIII_AC_FILT	2	CIII_AC_GND	10	20	YL/GN	
AC L		4	CIII_AC_CP	1		BR	
				5		BR	
				9		BR	
				13		BR	
AC N		5		3		BL	
				7		BL	
				11		BL	
				15		BL	

10.22 CIII AC CP: AC Connection Panel

AC connection panel to distribute AC into the rack.



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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
AC L	CIII_AC_CP	2	CIII_AC_OUT	38		BR	
AC N		4		40		BL	
AC L		6	CIII_UPS	1		BR	
AC N		8		3		BL	
AC L		10	CIII_PS_SRC	3		BR	
AC N		12		2		BL	
AC L		14	CIII_MGTH2	1		BR	
AC N		16		3		BL	

10.23 CIII AC MGTH2: Over current protection at 2 A

Magnetothermic, over current protection at 2 A.

CIII_AC_MGTH2		CIII_AC_OUT
	•	CIII_RELAY

SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
ACL	CIII_AC_MGTH2	2	CIII_RELAY_02	11		BR	
AC N		4	CIII_AC_OUT	04		BL	
AC N				10		BL	
AC N				16		BL	
AC N				22		BL	
AC N				28		BL	
AC N				34		BL	

10.24 CIII AC OUT: 220 VAC Out Connection Panel

AC connector to provide relay commuted power to external devices.



SIGNAL		FROM	PIN		TO		PIN	AW	G	COL	_OR	NOTES
AC L		CIII_AC_OUT	01		Not used			2)	BR		Not used
AC N			03							BL		
AC GND			05							YL/GN		
AC L			07		Not used					BR		Not used
AC N			09							BL		
AC GND			11							YL/GN		
ACL			13		CIII_AC_Comp					BR		Compressor activation
AC N			15							BL		
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SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
AC GND		17				YL/GN	
ACL		19	CIII_AC_CV			BR	Cooling valve
AC N		21				BL	, ,
AC GND		23				YL/GN	
ACL		25	CIII_AC_Heat			BR	Heater activation
AC N		27				BL	
AC GND		29				YL/GN	
ACL		31	CIII_AC_Safe			BR	Safety pressure valve
AC N		33				BL	activation
AC GND		35				YL/GN	
ACL		37	CIII_AC_FAN	01		BR	Rack Fans
AC N		39	1	02		BL	
AC GND		41	1	03		YL/GN	
ACL		02	CIII_RELAY_02	14		BR	
ACL		08	CIII_RELAY_03	14		BR	
ACL		14	CIII_RELAY_04	14		BR	
ACL		20	CIII_RELAY_05	14		BR	
ACL		26	CIII_RELAY_06	14		BR	
ACL		32	CIII_RELAY_08	14		BR	
AC N		04	CIII_AC_MGTH2	04		BL	
AC N		10				BL	
AC N		16				BL	
AC N		22				BL	
AC N		28	1			BL	
AC N		34	1			BL	
GND		06	CIII_AC_GND	07		YL/GN	
		12	1	11		YL/GN	
		18	1	12		YL/GN	
		24	1	13		YL/GN	
		30	1	14		YL/GN	
		36]	15		YL/GN	
		42		09		YL/GN	
AC L		38	CIII_AC_CP	02		BR	
AC N		40		04		BL	

10.25 CIII AC UPS: Uninterrupted Power Supply

Uninterrupted Power Supply to provide continuous power to the PLC.



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
ACL	CIII_AC_UPS	4	CIII_PLC_CPS	5	20	BR	
GND		5		7		GN/YL	
AC N		6		6		BL	
AC N		1	CIII_AC_CP	4		BR	
ACL		3		2		BL	
GND		2	CIII_AC_GND	4]	GN/YL	

10.26 CIII AC GND: Metallic Strip to Distribute Ground

GND strip bar to distribute ground into the rack.

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SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
GND	CIII_AC_GND	01	CIII_AC_IN	06	20	YL/GN	
		02	CIII_AC_UPS	02			
		03	CIII_PS_SRC	01			
		07	CIII_AC_OUT	04			
		09		40			
		11		10			
		12		16			
		13		22			
		14		28			
		15		34			
		08	CIII_PLC_CPS	07			
		10	CIII_AC_FILT	02			

10.27 CIII ETHER: Ethernet Connector

Ethernet connector to provide network connection to the PLC.

CIII_ETHER	-	CIII_PLC_NOE

Co	onnector name:	Туре:		Features:						
	CIII_ETHER	RJ45								
	Connectors pin out									
Pin Num	Signal	Signal type	Circuit Class	Remarks	Description					
1	Ethernet TX+	Ethernet	RF	IEEE 802.3 I	Ethernet channel TX					
2	Ethernet RX Shield			10-BASE-T Ethernet/						
3	Ethernet RX+	Ethernet	RF	IEEE 802.3 u	Ethernet channel RX					
4	Ethernet RX-	Ethernet	RF	100-BASE-Tx Ethernet.	Ethernet channel RX					
5	Ethernet TX-	Ethernet	RF	Automatic sensing	Ethernet channel TX					
6	Ethernet TX Shield									

10.28 CIII CP: External Signals Connection Panel

The following table provides the connection from the CIII_RACK output connector CIII_CP to the external sensors / actuators related to CII.

It is assumed that the plant (under UAB's responsibility) shall provide cables/connectors properly labeled with the mnemonics identified in the TO column of this table. For clarity sake, these mnemonics coincide with the I/O signal denominations defined in **8.3.1.1**.

SIGNAL	FROM	PIN	TO	PIN	AWG	COLO	OR NOTES
CIII_AI_01+	CIII_CP	1	CIII_MV_DObot		24		DO sensor bottom
CIII_AI_01-		5					
CIII_AI_02+		9	CIII_MV_DOtop				DO sensor top
CIII_AI_02-		13					
CIII_AI_03+		17	CIII_MV_NH4				NH4 Analyzer
CIII_AI_03-		21					
CIII_AI_04+		25	CIII_MV_NO3				NO3 Analyzer
CIII_AI_04-		29					
CIII_AI_05+		33	CIII_MV_P				Pressure sensor
CIII_AI_05-		37					
CIII_AI_06+		41	CIII_MV_PHb				pH sensor bottom
CIII_AI_06-		45					
CIII_AI_07+		49	CIII_MV_PHt				pH sensor top
CIII_AI_07-		53					
-	-			-	-	-	-
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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_AI_08+		57	Not used				
CIII_AI_08-		61					
CIII_AI_09+		65	CIII_MV_Tb				Temperature sensor
CIII_AI_09-		69					bottom
CIII_AI_10+		13	CIII_IVIV_IT				Temperature sensor
		01	Not usod				ιυμ
		01 85	NUL USEU				
		80	Not used				
CIII_AL_12-		93	Not used				
CIII AI 13+		97	Not used				
CIII AI 13-		101					
CIII AI 14+		105	Not used				
CIII_AI_14-		109					
CIII_AI_15+		113	Not used				
CIII_AI_15-		117					
CIII_AI_16+		121	Not used				
CIII_AI_16-		125					
CIII_AO_01+		129	CIII_FC_CO2				CO2 Flow controller
CIII_AO_01-		133					
		13/	CIII_FC_N2				N2 Flow controller
		141					02 Elow controllor
		140					OZ FIOW CONTROLLED
CIII AO 04+		153	Not used				
		157	Hot used				
CIII AO 05+		161	CIII PM Ac				Acid pump
24V-		165					· · F · F
CIII_AO_06+		169	CIII_PM_Bs				Base pump
24V-		173					
CIII_AO_07+		177	CIII_PM_FI				Liquid input pump
24V-		181					
CIII_AO_08+		185	CIII_PM_L				Liquid output pump
24V-		189					
24V+		193	CIII_CAL_NH4			-	NH4 Analyzer
		197					Calibration Indicator
		002	CIII_CAL_NO3				NU3 Analyzer
24\/+ (*)		000					
		010					Level sensor low
24V+ (*)		014	CIII MV 12 (High)				Level sensor high
CIII DL 04-		022					Lovor sonsor nigh
24V+		026	CIII MVI Lbt				Level of output buffer
CIII DI 05-		030					tank
24V+		034	Not used				
CIII_DI_06-		038					
24V+		042	Not used				
CIII_DI_07-		046					
24V+		050	Not used				
CIII_DI_08-		054	N1 1 1				
24V+		058	Not used				
CIII_DI_09-		062	Naturad				
		000	NOT USED				
		070	Netuced				
		074	NUL USEU				
24V+		082	Not used				
CIII DI 12-		086					
24V+		090	Not used				
CIII DI 13-		094					
24V+		098	Not used	1	1		
CIII_DI_14-		102			1		1
24V+		106	Not used				
CIII_DI_15-		110					
24V+		114	Not used				
CIII_DI_16-		118					
CIII_RL_Lbt in		122	CIII_RL_Lbt				
I		l		<u> </u>		<u> </u>	<u> </u>
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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIII_RL_Lbt out		126					
RELAY_09 in		130	CIII_PM_Ac				Activation of Acid
RELAY_09 out		134					pump
RELAY_10 in		138	CIII_PM_Bs				Activation of Base
RELAY_10 out		142					pump
CIII_DO_11		146	Not used				
24V-		150					
CIII_DO_12		154	Not used				
24V-		158					
CIII_DO_13		162	Not used				
24V-		166					
CIII_DO_14		170	Not used				
24V-		174					
CIII_DO_15		178	Not used				
24V-		182					
CIII_DO_16		186	Not used				
24V-		190					
24V+		003	CIII_CP	027			
24V+		027		035			
24V+		035		043			
24V+		043		051			
24V+		051		059			
24V+		059		067			
24V+		067		075			
24V+		075		083			
24V+		083		091			
24V+		091		099			
24V+		099		107			
24V+		107		115			
24V+		115		164			
24V+		164		172			
24V+		172		180			
24V+		180		188			
24V-		151		159			
24V-		159		16/			
24V-		167		175			
24V-		1/5		183			
24V-		183		191			
CIII_MV_L1+		011		019			

(*) Relay to generate a pulse of 100 ms to avoid electrolysis in the media when reading tank level.

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11 APPENDIX C: CIV Rack Electrical Connection Tables

<u>11.1 CIV_TB_ACI: Current Analogue Inputs Terminal Block</u></u>

CableFast Terminal Block corresponding to the PLC's CIV-PLC_IO_ACI module (card 140ACI03000 featuring 8 Analog Inputs 4-20 mA).

The basic connection schematic is:



Detailed connection table:

SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_AI_01+	CIV_TB_ACI	1	CIV_CP	4	24	WH	
CIV_AI_01-		2		8		WH/YL	
CIV AI 02+		5		12		BR/GN	
CIV AI 02-		6		16		WH/GN	
CIV AI 03+		11		20		PR	
CIV AI 03-		12		24		RD	
CIV AI 04+		15		28		BL	
CIV AI 04-		16		32		PK	
CIV_AI_05+		21		36		YL	
CIV_AI_05-		22		40		YL/BR	
CIV_AI_06+		25		44		BR	
CIV_AI_06-		26		48		GN	
CIV_AI_07+		31		52		GY/PK	
CIV_AI_07-		32		56		GY	
CIV_AI_08+		35		60		RD/BL	
CIV_AI_08-		36		64		BK	
SENSE 1		3	CIV_TB_ACI	1			
SENSE 2		7		5			
SENSE 3		13		11			
SENSE 4		17		15			
SENSE 5		23		21			
SENSE 6		27		25			
SENSE 7		33		31			
SENSE 8		37		35			
N.C.		4					
		8					
		9					
		10					
		14					
		18					
		19					
		20					
		24					
		28					
		29					
		3U 24					
		34 20					
		30 20					
		37					
		40					

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<u>11.2CIV_TB_AVI: Voltage Analogue Inputs Terminal Block</u></u>

CableFast Terminal Block corresponding to the PLC's CIV_PLC_IO_AVI module (card 140AVI03000 featuring 8 Analog Inputs 0-5V / 4-20 mA).

The basic connection schematic is:



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_AI_09+	CIV_TB_AVI	3	CIV_CP	68	24	WH	Current cource
CIV_AI_09-		2		72		WH/YL	Current Source
CIV_AI_10+		5		76		BR/GN	Voltago courco
CIV_AI_10-	1	6		80		WH/GN	vollage source
CIV_AI_11+	1	11		84		PR	Voltago courco
CIV_AI_11-	1	12		88		RD	vollage source
CIV_AI_12+	1	15		92		BL	Voltago sourco
CIV_AI_12-		16		96		PK	vollage source
CIV_AI_13+		21		100		YL	Voltage source
CIV_AI_13-		22		104		YL/BR	Vollage Source
CIV_AI_14+		25		108		BR	Voltage source
CIV_AI_14-		26		112		GN	Vollago Sourco
CIV_AI_15+		31		116		GY/PK	Voltage source
CIV_AI_15-		32		120		GY	Ponago couroo
CIV_AI_16+		35		124		RD/BL	Voltage source
CIV_AI_16-		36		128		BK	
SENSE 1		3	CIV_IB_AVI	1			Current jumper
N.C.		4					
		/					
		8					
		9					
		10					
		13					
		14					
		10					
		10					
		19					
		20					
		23					
		27					
		28					
		29					
		30					
		33					
		34					
		37					
		38					
		39					
		40					

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<u>11.3CIV_TB_AVO1: Voltage Analogue o/p Terminal Block 1</u></u>

CableFast Terminal Block corresponding to the PLC's CIV_PLC_IO_AVO1 module (card 140AVO02000 featuring 4 Analog Outputs 0-5V).

The basic connection schematic is:



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_AO_01+	CIV_TB_AVO1	1	CIV_CP	132	24	PK	
CIV_AO_01-		2		136		YL	
CIV_AO_02+		11		140		GY	
CIV_AO_02-		12		144		GN	
CIV_AO_03+		21		148		PR	
CIV_AO_03-		22		152		WH	
CIV_AO_04+		31		156		BK	
CIV_AO_04-		32		160		RD	
R1		3	CIV_TB_AVO1	1			
COMMON 1		4		8			
CONTROL 1		5		3			
MASTER OVER		8		4			
R2		13		11			
COMMON 2		14		18			
CONTROL 2		15		13			
MASTER OVER		18		14			
R3		23		21			
COMMON 3		24		28			
CONTROL 3		25		23			
MASTER OVER		28		24			
R4	-	33		31			
COMMON 4	-	34		38			
CONTROL 4	-	35		33			
MASTER OVER	-	38		34			
N.C.	4	6					
REFERENCE I	4	/					
N.C.	4	9					
N.C.	4	10					
	4	10			4		
REFERENCE I	4	1/			4		
N.C.	4	19			-		
N.C.	-	20					
N.C.	-	20			-		
NC	4	27			4		
N.C.	4	29			-		
N.C.	4	30			4		
DEEEDENCE 1	4	30			-		
NC	4	30			-		
N.C.	4	39			4		
IN.C.	1	40			1		

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<u>11.4CIV_TB_AVO2: Voltage Analogue o/p Terminal Block 2</u></u>

CableFast Terminal Block corresponding to the PLC's CIV_PLC_IO_AVO2 module (card 140AVO02000 featuring 4 Analog Outputs 0-5V).

The basic connection schematic is:



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_AO_05+	CIV_TB_AVO2	1	CIV_CP	164	24	YL	
CIV_AO_05-		2		168		PK	
CIV_AO_06+		11		172		GY	
CIV_AO_06-		12		176		GN	
CIV AO 07+		21		180		PR	
CIV AO 07-		22		184		WH	
CIV_AO_08+		31		188		BK	
CIV_AO_08-		32		192		RD	
R1		3	CIV_TB_AVO2	1			
COMMON 1		4		8			
CONTROL 1		5		3			
MASTER OVER		8		4			
R2	1	13		11			
COMMON 2	1	14		18			
CONTROL 2		15		13			
MASTER OVER		18		14			
R3		23		21			
COMMON 3		24		28			
CONTROL 3		25		23			
MASTER OVER		28		24			
R4		33		31			
COMMON 4		34		38			
CONTROL 4		35		33			
MASTER OVER		38		34			
N.C.		6					
REFERENCE 1		7					
N.C.		9					
N.C.		10					
N.C.		16					
REFERENCE 1		17					
N.C.		19					
N.C.		20					
N.C.		26					
REFERENCE 1		27					
N.C.		29					
N.C.		30					
N.C.		36					
REFERENCE 1		37					
N.C.		39					
N.C.		40					

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<u>11.5CIV_TB_ACO: Current Analogue Outputs Terminal Block</u></u>

CableFast Terminal Block corresponding to the PLC's CIV_PLC_IO_ACO module (card 140ACO13000 featuring 8 Analog Outputs 4-20 mA).

The basic connection schematic is:



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_AO_09-	CIV_TB_ACO	4	CIV_CP	200	24	PK	
CIV_AO_10-		8		208		YL	
CIV_AO_11-		14		216		GY	
CIV_AO_12-		18		7		GN	
CIV_AO_13-		24		15		PR	
CIV_AO_14-		28		23		WH	
CIV_AO_15-		34		31		BK	
CIV_AO_16-		38		39		RD	
24V-		2	CIV_VC_24_CP	18	20	BK	
MONITOR 1		1					
N.C.		3					
MONITOR 2		5					
RETURN		6					
N.C.		7					
N.C.		9					
N.C.		10					
MONITOR 3		11					
RETURN		12					
N.C.		13					
N.C.		19					
N.C.		20					
MONITOR 4		15					
RETURN		16					
N.C.		17					
MONITOR 5		21					
RETURN		22					
N.C.		23					
MONITOR 6		25					
RETURN		26					
N.C.		27					
N.C.		29					
N.C.		30					
MONITOR 7		31					
RETURN		32					
N.C.		33					
MONITOR 8		35					
RETURN		36					
N.C.		37					
N.C.		39					
NC		40					

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<u>11.6CIV_TB_DIO: Digital Input/Outputs Terminal Block</u></u>

CableFast Terminal Block corresponding to the PLC's CIV_PLC_IO_DIO module (card 140DDM39000 featuring 16 Digital Input / Digital Output 0-24V).

The basic connection schematic is:

CIV_TB_DIO	 	CIV_CP
	4	CIV_PS_CP
		CIV_RELAY

SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_DO_01	CIV_TB_DIO	1	CIV_RELAY_01	A1	24	PR	
CIV_DO_02		3	CIV_RELAY_02	A1		BK	
CIV_DO_03		5	CIV_RELAY_03	A1		RD	
CIV_DO_04		7	CIV_RELAY_04	A1		BR	
CIV_DO_05		11	CIV_RELAY_05	A1		WH	
CIV_DO_06		13	CIV_RELAY_06	A1	1	BL	
CIV_DO_07		15	CIV_CP	203	1	WH/BK	
CIV_DO_08		17		211		BR	
CIV_DI_01		21		47	1	RD/BL	
CIV_DI_02		22		55		BK	
CIV_DI_03		23		63		WH/RD	
CIV_DI_04		24		71		PR	
CIV_DI_05		25		79		BR	
CIV_DI_06		26		87]	RD	
CIV_DI_07		27		95		GN	
CIV_DI_08		28		103		BL	
CIV_DI_09		31		111		WH/BL	
CIV_DI_10		32		119		PK/BR	
CIV_DI_11		33		127		BR/BL	
CIV_DI_12		34		135		PK/GY	
CIV_DI_13		35		143		WH	
CIV_DI_14		36		151		PK	
CIV_DI_15		37		159		WH/GN	
CIV_DI_16		38		167		BR/GN	
24V-		9	CIV_PS_CP	20	20	BK	Group A supply
24V+		10		06		RD	
24V-		19		22		BK	Group B supply
24V+		20		08		RD	
24V-		29		16		BK	
24V-		39		30		BK	
N.C.		2					
N.C.		2					
N.C.		4					
N.C.		6					
N.C.		8			ļ		
N.C.		12]		
N.C.		14					
N.C.		16					
N.C.		18					
N.C.		30]		
N.C.		40]		

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<u>11.7CIV_PS_SRC: Power Supply</u>

Basic connection schematic:



Detailed connection table:

SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
GND	CIV_PS_SRC	1	CIV_AC_GND	3	20	YL/GN	
AC N		2	CIV_AC_CP	8		BL	
AC L		3		2		BR	
24V+		4	CIV_PS_CP	1		RD	
24V-		5		15		BK	
24V+		7		13		RD	
24V-		8		29		BK	

11.8CIV PS CP: Power Supply Connection Panel

Basic connection schematic



Detailed connection table:

TN

	SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
24V+	ł	CIV_PS_CP	1	CIV_PS_SRC	4	20	RD	
24V+	ł		13		7		RD	
24V-			15		5		BK	
24V-			29		8		BK	
24V+	+		3	CIV_PS_CP	1		RD	
24V+	ł		5		3		RD	
24V+	ł		7		5		RD	
24V+	ł		9		7		RD	
24V+	ł		11		9		RD	
24V+	ł		13		11		RD	
24V-			17		15		BK	
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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
24V-		19		17		BK	
24V-		21	1	19		BK	
24V-		23	1	21		BK	
24V-		25	1	23		BK	
24V-		27	1	25		BK	
24V-		16	CIV_TB_ACO	2		BK	
24V+		6	CIV_TB_DIO	10		RD	
24V+		8		20		RD	
24V-		18		9		BK	
24V-		20		19		BK	
24V-		22		29		BK	
24V-		24		39		BK	
24V+		10	CIV_CP	003		RD	
24V+				011		RD	
24V+				019		RD	
24V+				027		RD	
24V+				035		RD	
24V+				043		RD	
24V+				051		RD	
24V+				059		RD	
24V+		12		067		RD	
24V+				075		RD	
24V+				083		RD	
24V+				091		RD	
24V+				099		RD	
24V+				107		RD	
24V+				115		RD	
24V+				123		RD	
24V+		14		131		RD	
24V+				139		RD	
24V+				147		RD	
24V+				155		RD	
24V+				163		RD	
24V+				196		RD	
24V+				204		RD	
24V+		0/		212		RD	
24V-		26		215		BK	DO_07
24V-		28		207		BK	DO_08
24V-	4	30	CIV_RELAY_01	A2		BK	
24V-	4		CIV_RELAY_02	A2		BK	
24V-	4		CIV_RELAY_03	A2		BK	
24V-	-		CIV_RELAY_04	A2		BK	
24V-	4		CIV_RELAY_05	A2		BK	
	-	2	CIV_RELAY_06	A2		ВК	
NC	4	2					
NC		4		1		1	1

<u>11.9CIV RELAY 01: Liquid input pump 1</u>

Relay to switch 24VC to activate liquid input pump1.





SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_DO_01	CIV_RELAY_01	A1	CIV_TB_DIO	1	24		
24V-		A2	CIV_PS_CP	28	20	BK	
CIV_RL_LI1_IN		11	CIV_CP	175		BK	
CIV_RL_LI1_OUT		14		171		WH	1
N.C.		12					

<u>11.10 CIV_RELAY_02: Liquid input pump 2</u>

Relay to switch 24Vdc to activate liquid input pump2.



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_DO_02	CIV_RELAY_02	A1	CIV_TB_DIO	3	24		
24V-		A2	CIV_RELAY_01	A2	20	BK	Activation of the liquid
CIV_RL_LI2_IN		11	CIV_CP	183		PR	input pump 2
CIV_RL_LI2_OUT		14		179		PK	
N.C.		12					

11.11 CIV RELAY 03: Biomass aeration valve

Relay to switch 220 VAC to activate biomass sensor cleaning valve.



SIGN	AL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES	
CIV_DO_03		CIV_RELAY_03	A1	CIV_TB_DIO	5	24			
24V-			A2	CIV_RELAY_02	A2	20	BK	Activation of electro-valve	
AC L			11	CIV_AC_MGTH2	2		BR	for cleaning the biomass	
CIV_RL_Cx	L		14	CIV_AC_OUT	2		BR	sensor	
N.C.			12						
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<u>11.12</u> CIV_RELAY_04: Safety pressure valve

Relay to switch 220 VAC to activate pressure safety valve.



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_DO_04	CIV_RELAY_04	A1	CIV_TB_DIO	7	24		
24V-		A2	CIV_RELAY_03	A2	20	BK	Activation of the pressure
AC L		11		11		BR	safety valve
CIV_RL_Fg_L		14	CIV_AC_OUT	8		BR	
N.C.		12					

11.13 CIV RELAY 05: Not used

Relay not used.



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_DO_05	CIV_RELAY_05	A1	CIV_TB_DIO	11	24		
24V-		A2	CIV_RELAY_04	A2	20	BK	
Not used		11	CIV_CP	191		RD	
Not used		14		187		RD/BL	
N.C.		12					

11.14 CIV RELAY 06: Not used

Relay not used.

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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_DO_06	CIV_RELAY_06	A1	CIV_TB_DIO	13	24		
24V-		A2	CIV_RELAY_05	A2	20	BK	Activation of the liquid input
Not used		11	CIV_CP	199		WH/GN	pump 2
Not used		14		195		GY/PK	
N.C.		12					

11.15 CIV AC IN: Input 220 VAC power

External AC Power input connector.



SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
AC L	CIV_AC_IN	2	CIV_AC_MGTH6	1	20	BR	
AC N		4		3		BL	
AC GND		6	CIV_AC_GND	1		YL/GN	

<u>11.16</u> CIV AC MGTH6: Over current protection at 6 A

Magnetothermic, over current protection at 6 A.

CIV_AC_MGTH6	}►	CIV_AC_DIFF
--------------	----	-------------

SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
AC L	CIV_AC_MGTH6	2	CIV_AC_DIFF	1	20	BR	
AC N		4		3		BL	

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<u>11.17</u> CIV_AC_DIFF: Current leaks protector

Current leaks protector.

CIV_AC_DIFF	→	CIV_AC_FILT

SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
AC L	CIV_AC_DIFF	2	CIV_AC_FILT	1	20	BR	
AC N		4		3		BL	

11.18 CIV AC FILT: AC Filter

AC filter.



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
GND	CIV_AC_FILT	2	CIV_AC_GND	2	20	YL/GN	
AC L		4	CIV_AC_CP	1		BR	
				5		BR	
				9		BR	
				13		BR	
AC N		5		3		BL	
				7		BL	
				11		BL	
				15]	BL	

<u>11.19</u> CIV AC CP: AC Connection Panel

AC connection panel to distribute AC into the rack.



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SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
ACL	CIV_AC_CP	2	CIV_AC_OUT	14		BR	
AC N		4		16		BL	
AC L		6	CIV_UPS	1		BR	
AC N		8		3		BL	
AC L		10	CIV_PS_SRC	3		BR	
AC N		12		2		BL	
AC L		14	CIV_MGTH2	1		BR	
AC N		16		3		BL	

11.20 CIV AC MGTH2: Over current protection at 2 A

Magnetothermic, over current protection at 2 A.



SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
ACL	CIV_AC_MGTH2	2	CIV_RELAY_03	11		BR	
			CIV_RELAY_04	11		BR	
AC N		4	CIV_AC_OUT	4		BL	
				10		BL	

11.21 CIV AC OUT: 220 VAC Out Connection Panel

AC connector to provide relay commuted power to external devices.



SIGNAL	FROM	PIN		TO		PIN	AWG	COL	OR	NOTES
AC L	CIV_AC_OUT	1		CIV_AC_Cx			20	BR		Cleaning biomass
AC N		3						BL		sensor
AC GND		5						YL/GN		
AC L		7		CIV_AC_Fg				BR		Pressure valve
AC N		9						BL		activation
AC GND		11						YL/GN		
AC L		13		CIV_FAN				BR		Rack Fans
AC N		15						BL		
AC GND		17						YL/GN		
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SIGNAL	FROM	PIN	ТО	PIN	AWG	COLOR	NOTES
ACL		2	CIV_RELAY_03	14		BR	
ACL		8	CIV_RELAY_04	14		BR	
AC N		4	CIV_AC_MGTH2	6		BL	
AC N		10				BL	
GND		6	CIV_AC_GND	6		YL/GN	
		12		7		YL/GN	
		18		8		YL/GN	
AC L		14	CIV_AC_CP	2		BR	
AC N		16		4		BL	

11.22 CIV AC UPS: Uninterrupted Power Supply

Uninterrupted Power Supply to provide continuous power to the PLC.

CIV_UPS	CIV_AC_CP
	CIV_AC_GND

SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
AC L	CIV_AC_UPS	4	CIV_PLC_CPS	5	20	BR	
GND		5		7		GN/YL	
AC N		6		6		BL	
AC N		1	CIV_AC_CP	4		BR	
ACL		3		2		BL	
GND		2	CIV_AC_GND	4		GN/YL	

11.23 CIV AC GND: Metallic Strip to Distribute Ground

GND strip bar to distribute ground into the rack.

SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
GND	CIV_AC_GND	1	CIV_AC_IN	6	20	YL/GN	
		2	CIV_AC_FILT	2			
		3	CIV_PS_SRC	1			
		4	CIV_AC_UPS	2			
		5	CIV_PLC_CPS	7			
		6	CIV_AC_OUT	6			
		7		12			
		8		18			

11.24 CIV ETHER: Ethernet Connector

Ethernet connector to provide network connection to the PLC.

CIV_ETHER

CIV_PLC_NOE

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Co	onnector name:	Туре:		Features:							
(CIV_ETHER_1	RJ45									
	Connectors pin out										
Pin	Signal	Signal type	Circuit C	lass	Remarks	Description					
Num											
1	Ethernet TX+	Ethernet	RF		IEEE 802.3 I	Ethernet channel TX					
2	Ethernet RX Shield				10-BASE-T Ethernet/						
3	Ethernet RX+	Ethernet	RF		IEEE 802.3 u	Ethernet channel RX					
4	Ethernet RX-	Ethernet	RF		100-BASE-Tx Ethernet.	Ethernet channel RX					
5	Ethernet TX-	Ethernet	RF		Automatic sensing	Ethernet channel TX					
6	Ethernet TX Shield										

11.25 CIV CP: External Signals Connection Panel

The following table provides the connection from the CIV_RACK output connector CIV_CP to the external sensors / actuators related to CIV.

It is assumed that the plant (under UAB's responsibility) shall provide cables/connectors properly labeled with the mnemonics identified in the TO column of this table. For clarity sake, these mnemonics coincide with the I/O signal denominations defined in **8.3.1.1**.

SIGNAL	FROM	PIN	TO	PIN	AWG	COLO	R NOTES
CIV_AI_01+	CIV_CP	001	CIV_MV_CxAbs		24		Biomass sensor
CIV_AI_01-		005					
CIV_AI_02+		009	CIV_MV_M1				Scale 1
CIV_AI_02-		013					
CIV_AI_03+]	017	CIV_MV_M2				Scale 2
CIV_AI_03-		021					
CIV_AI_04+		025	CIV_MV_P				Pressure sensor
CIV_AI_04-		029					
CIV_AI_05+		033	CIV_MV_pH				pH sensor
CIV_AI_05-		037					
CIV_AI_06+		041	CIV_MV_T				Temperature sensor
CIV_AI_06-		045					
CIV_AI_07+		049	CIV_MGO_O2				O2 gas sensor
CIV_AI_07-		053					
CIV_AI_08+		057	CIV_MGO_CO2				CO2 gas sensor
CIV_AI_08-		061					
CIV_AI_09+		065	CIV_MV_DO				Dissolved Oxygen
CIV_AI_09-		069					sensor
CIV_AI_10		073	Not used				
CIV_AI_10-		077					
CIV_AI_11		081	Not used				
CIV_AI_11-		085					
CIV_AI_12		089	Not used				
CIV_AI_12-		093					
CIV_AI_13		097	CIV_MGI_FrGas				Flowmeter air input
CIV_AI_13-		101					
CIV_AI_14		105	CIV_MGO_FrGas				Flowmeter gas
CIV_AI_14-		109					output
CIV_AI_15		113	CIV_MV_FrCO2				CO ₂ flowmeter
CIV_AI_15-		117					
	4	121	CIV_MV_FrGas		ł		Flowmeter
	-	125					compartment input
CIV_AO_01+		129	CIV_SP_CO2				CO ₂ flow regulator
		133					
AUU2+	4	13/	CIV_SP_Fgi		ł		Compartment input
	4	141			ł		now regulator
AUU3+	4	145	CIV_SP_Fg0		4		Gas output now
CIV_AU_U3-		149					regulator
l					l	<u> </u>	
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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
CIV_AO_04+		153	CIV_SP_Fgex				Air input flow
CIV_AO_04-		<u>15</u> 7	5				regulator
CIV_AO_05+		161	CIV_SP_Li1				Liquid input pump1
CIV_AO_05-		165					
CIV_AO_06+	4	169	CIV_SP_Li2				Liquid input pump2
	4	1/3					Liquid output num-
		1//	CIV_SP_LU				Liquia output pump
		101	Notusod				
	-	100	Not used				-
24V+		107	CIV SP Bs				Base numn
CIV AO 09-		197					base pump
24V+		201	CIV SP Is				Light regulator
CIV AO 10-		205	011_01_00				Light rogalator
24V+		209	CIV_SP_Ac				Acid pump
CIV_AO_11-		213					
24V+		2	Not used				
CIV_AO_12-		6					
24V+		10	Not used				
CIV_AO_13-		14					
24V+	4	18	Not used				4
	4	22	NI-1 I				
	4	26	Not used				-
24V/+	4	30	Notused				
CIV AO 16-	4	34 28	NUL USEU				-
24V+	1	42	CIV CAL CO2O2				CO2/O2 sensor
CIV DI 01	1	46	010/1 _ 00202				calibration indicator
24V+		50	CIV ERR CO2O2				CO2/O2 sensor
CIV DI 02		54					error indicator
24V+		58	CIV_SCL1_CO2O2				CO2/O2 sensor
CIV_DI_03		62					scale1 indicator
24V+		66	CIV_SCL2_CO2O2				CO2/O2 sensor
CIV_DI_04		70					scale2 indicator
24V+		74	Not used				
CIV_DI_05		78					
24V+		82	Not used				
		86	Naturad				
		90	Not used				-
		94	Netucod				
	-	98	Not used				-
24V+		102	Notused				
		110	Not used				
24V+		114	Not used				
CIV DI 10		118					
24V+		122	Not used				
CIV_DI_11		126					
24V+		130	Not used				
CIV_DI_12		134					
24V+		138	Not used				
CIV_DI_13	4	142	**				
24V+	4	146	Not used				4
	4	150	N 1 1 1				
	4	154	Not used				-
	4	100	Naturad				
	4	102	INUL USED				4
	1	100		+			Enable liquid input
RELAY 01	1	17/					pump1
RELAY 02	1	178	CIV RL L12				Enable liquid input
RELAY 02	1	182					pump2
RELAY 05	1	186	Not used	1			
RELAY_05	1	190					1
RELAY_06	1	194	Not used	Ī	1		
RELAY_06		<u>198</u>					<u> </u>
CIV_DO_07		202	Not used				
		l		1	l		
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SIGNAL	FROM	PIN	TO	PIN	AWG	COLOR	NOTES
24V-		206					
CIV_DO_08		210	Not used				
24V-		214					
24V+		003	CIV_CP	011			
24V+		011		019			
24V+		019		027			
24V+		027		035			
24V+		035		043			
24V+	1	043		051			
24V+		051		059			
24V+		067		075			
24V+		075		083			
24V+		083		091			
24V+		091		099			
24V+		099		107			
24V+		107		115			
24V+		115		123			
24V+		131		139			
24V+		129		147			
24V+		147		155			
24V+		155		163			
24V+		163		196			
24V+		196		204			
24V+	1	204		212			

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12 APPENDIX D: Wire Color Codes

e

- BK Black
- BR Brown
- GN Green
- GY Grey
- PK Pink
- PR Purple
- RD Red
- WH White
- YL Yellow

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13 APPENDIX E: Parts List

ltem	Ν.	Reference	Manufacturer	Description
MEL_SUPV_CLI01	1	Dell OptiPlex GX260 P4 1.8 GHz	Dell	P4 1.8 GHz, 1 IDE disk 40 GB, 512 MB RAM, 1Floppy, 1 CD-ROM
				Monitor 17", keyboard, mouse, Windows XP Professional
MEL_SUPV_RACK	1	7801000	Rittal	Server enclosure based on Rittal flexRack 625x600x800 mm
MEL_SUPV_SERV01	1	Dell PowerEdge 2600	Dell	PC Server Rack mounted, Xeon 2.0 GHz. 1GB RAM, 2 SCSI disks
		5		36GB raid 3, 1 Floppy, 1 CD-ROM, 1 Tape, MS Windows 2000 Server,
				Monitor 17", keyboard, mouse.
MEL SWITCH 01	2	3Com Super Stack 3	3Com	16 x 10/100 Mbps Standard RJ45 Ethernet ports
	1	7820600	Rittal	Top Enclosure System TS 8 with glass frontal door 600x1800x600 mm
				+ mounting board
CIV RACK	1	7820600	Rittal	Top Enclosure System TS 8 with glass frontal door 600x1800x600 mm
				+ mounting board
CIII PLC	1	140XTS01000	Schneider	10 slots back plane
	1	140CPS11420	Schneider	Summable Power supply 11 A
	1	140NOF77101	Schneider	Ethernet processor 10/100 TCP/IP
	1	140CPI/43412A	Schneider	CPU 2 MB RAM/896 K CONCEPT
	1	1/00018/112/1	Schneider	
	1	14000084300	Schneider	ISOLATED 16 DIGITAL OUTPLITS 1, 60VCC MODULE
	1	14000004300	Schneider	
	1	140ACO0200	Schnoidor	
	1	140ACI04000	Schneider	
	1	140AC104000	Schneider	10 CURRENT ANALOG INPUTS MODULE
CIV_PLC	1	140ATS01000	Schneider	IU SIUIS DALK PIdHE
		140CPS11420	Schneider	
		140NOE//101	Schneider	Ethernet processor 10/100 TCP/IP
	1	140CPU43412A	Schneider	CPU 2 MB RAM/896 K CONCEPT
	1	140ACI03000	Schneider	8 ANALOG CURRENT INPUTS MODULE
	1	140AVI03000	Schneider	8 ANALOG VOLTAGE INPUTS MODULE
	1	140AVO02000	Schneider	4 ANALOG VOLTAGE OUTPUTS MODULE
	1	140ACO13000	Schneider	8 ANALOG CURRENT OUTPUTS MODULE
	1	140DDM39000	Schneider	16 DIGITAL INPUTS 8 OUTPUTS MODULE
CIII_TB	6	140XTS00206	Schneider	CableFast cable with Quantum connector
	6	140CFA04000	Schneider	CableFast connection blocks
CIV_TB	5	140XTS00206	Schneider	CableFast cable with Quantum connector
	5	140CFA04000	Schneider	CableFast connection blocks
CIII CP	96	ZFKK 1.5-MSTBV-5.08	Phoenix-Contact	Double density terminal block (24-14 AWG, 12 A, 250 V)
	48	MVSTBR 2.5/2 ST / 17 92 01 6	Phoenix-Contact	Two pin pluggable connectors
CIV CP	108	7FKK 1.5-MSTBV-5.08	Phoenix-Contact	Double density terminal block (24-14 AWG, 12 A, 250 V)
011_01	54	MVSTBR 2 5/2 ST / 17 92 01 6	Phoenix-Contact	Two pin pluggable connectors
CIII PS SRC	1	ABI 7RE2405	Schneider	Commuted Power Supply 5 A
CIV PS SRC	1	ABL7RE2405	Schneider	Commuted Power Supply 5 A
	14		Dhooniy Contact	Universal terminal block with screw connection cross section: 0.14 1.5
	14	0K 1,5N	FILICENIA-CUNILACI	mm ² width: 1.2 mm, color: gray
	15		Dhooniy Contact	Universal terminal block with screw connection, cross section: 0.14, 1.5
CIV_PS_CP	15	UK I,3N	Phoenix-Coniaci	Universal terminal block with sciew connection, closs section: 0.14 - 1.5
	0		Dhaaniy Cantaat	I IIII'r, Wiulii. 4.2 IIIII, cului. yidy
CIII_AC_CP	8	UK 3N	Phoenix-Contact	Universal terminal block with screw connection, cross section: 0.2 - 2.5
	0		Dhaaniy Cantaat	IIIII'', AWG: 28 - 12, WIUII: 5.2 IIIII, COIOI: YIdy
UV_AC_CP	ö	UN 3N	Privenix-Contact	Universal terminal block with screw connection, cross section: 0.2 - 2.5
	01		Dhaaniy Carta I	Initin', AWG: 20 - 12, WIUIT 5.2 MM, COIOT GIAY
CIII_AC_OUT	21	UK 3N	Phoenix-Contact	Universal terminal block with screw connection, cross section: U.2 - 2.5
	0			mm², AWG: 28 - 12, Width: 5.2 mm, color: gray
CIV_AC_OUT	9	UK 3N	Phoenix-Contact	Universal terminal block with screw connection, cross section: 0.2 - 2.5
	_			mm ² , AWG: 28 - 12, width: 5.2 mm, color: gray
CIII_AC_IN	3	UK 3N	Phoenix-Contact	Universal terminal block with screw connection, cross section: 0.2 - 2.5
				mm ² , AWG: 28 - 12, width: 5.2 mm, color: gray
CIV_AC_IN	3	UK 3N	Phoenix-Contact	Universal terminal block with screw connection, cross section: 0.2 - 2.5
	<u> </u>		1	mm ² , AWG: 28 - 12, width: 5.2 mm, color: gray
CIII_AC_DIFF	1	CD748M	Hager	Differential current break at 30 mA
CIV_AC_DIFF	1	CD748M	Hager	Differential current break at 30 mA
CIII_AC_MGTH6	1	C60N/C6	Merlin Gerin	Magnetothermic 6 Amp
CIV_AC_MGTH6	1	C60N/C6	Merlin Gerin	Magnetothermic 6 Amp
CIII_AC_FILT	1	YK06T1	Yunpen	Standard AC input filter
CIV_AC_FILT	1	YK06T1	Yunpen	Standard AC input filter
CIII AC UPS	1	POWERSTACK 250 VA	APC	Uninterrupted Power Supply, 250 VA. 165 Watts, 230 Vin/Vout 50/60 Hz
CIV AC UPS	1	POWERSTACK 250 VA	APC	Uninterrupted Power Supply, 250 VA, 165 Watts, 230 Vin/Vout 50/60 Hz
	<u>. '</u>			

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ltem	Ν.	Reference	Manufacturer	Description
CIII_AC_MGTH2	1	C60N/C2	Merlin Gerin	Magnetothermic 2 Amp
CIV_AC_MGTH2	1	C60N/C2	Merlin Gerin	Magnetothermic 2 Amp
CIII_AC_GND	1	7113.000	Rittal	Ground metal strip
CIV_AC_GND	1	7113.000	Rittal	Ground metal strip
CIII_RELAY	10	EMG 10-REL/KSR-G 24	Phoenix-Contact	Relay module, with soldered-in miniature switching relay, contact
				(AgCdO): medium to large loads, 1 PDT, input voltage 24 V DC
CIV_RELAY	6	EMG 10-REL/KSR-G 24	Phoenix-Contact	Relay module, with soldered-in miniature switching relay, contact
				(AgCdO): medium to large loads, 1 PDT, input voltage 24 V DC
CIII_ETHER	1	27898-31	Simon	DIN guide adapter
	1	75542	Simon	Lucent & ATT modular RJ-45 Cat-5 connector.
CIV_ETHER	1	27898-31	Simon	DIN guide adapter
	1	75542	Simon	Lucent & ATT modular RJ-45 Cat-5 connector.
HMI	1	XBTF034610	Schneider	TER. TFT C 10 Touch-screen PENTIUM ETHERNET
Supervision SW	1	iFix 3.0 / Blind server	Intellution	SCADA blind server
	1	iFix 3.0 / Development client	Intellution	SCADA development client
PLC programming	1	372SPU47101V25	Schneider	Concept 2.6
HMI programming	1	XBTL1003S	Schneider	KIT SOFT CD PROT -S- CABLES ESP

(*) Marked elements are parts of CIII and CIV racks.

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14 APPENDIX F: Expansion capabilites

<u>14.1 CIII Rack expansion capabilities</u>

The Compartment III rack allows the following expansion capabilities:

• Available signals (initially not used):

Number	Туре	Electrical Range	Location
6	Analog Inputs	4-20 mA	Al 11 – Al 16
1	Analog Output	0 – 5 V	AO 04
11	Digital Inputs	N/A	DI 05 – DI 16
6	Digital Outputs	0 – 24 V	DO 11 – DO 16

- 2 Available relays: RELAY_01 and RELAY_02
- 2 free slot in the PLC back plane
- Space in the mounting board to allocate a second back plane of 6 slots.
- Space in the rack to mount a secondary mounting board placed in front of the current.

14.2 CIV Rack expansion capabilities

The Compartment IV rack allows the following expansion capabilities:

• Available signals (initially not used):

Number	Туре	Electrical Range	Location
3	Analog Inputs	4-20 mA	Al 10 – Al 12
1	Analog Output	0 – 5 V	AO 08
12	Digital Inputs	N/A	DI 05 – DI 16
5	Digital Outputs	0 – 24 V	DO 05 – DO 08

- 2 Available relays: RELAY_05 and RELAY_06
- 1 free slot in the PLC back plane
- Space in the mounting board to allocate a second back plane of 6 slots.
- Space in the rack to mount a secondary mounting board placed in front of the current.

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15 APPENDIX G: RBT Compliance

Following considerations have been taken into account to be compliant with the Spanish *Reglamento Electrotécnico de Baja Tensión, RBT* (Low Voltage Equipments Regulation).

The Melissa Control System Demonstrator racks can be classified as Receivers. Therefore RBT's instruction MI BT 031 for Receiver General Prescriptions is applicable. This instruction has references to instructions MI BT 017, MI BT 020 and MI BT 021.

MI BT 031

- The system has been designed according to the location and environmental conditions in the UAB's Pilot Plant, according to the norm.
- The classification of the racks is Class I: System is provided with a ground connection to the installation and metallic parts are connected to the ground.
- Isolation has been successfully tested to 1500 V during 1 minute.
- Utilization conditions are referenced into MI BT 017 (indicated above).
- System has been labeled and detailed design documentation is provided.

MI BT 017

- Sections of conductors are dimensioned according to the regulations.
- AC line has been divided into two separated sections, the AC input section and the AC output section. A bipolar switch separates them. Power to the PLC is provided through an UPS connected to the AC input line.
- System can be switched off by an unipolar switch at the input.
- Measures to protect direct or indirect contacts are Class B: Ground elements are connected to installation ground. System is switched off by default intensity (MI BT 021).

MI BT 020

- Installation is protected over current by a magnetothermic of 6 Amp at AC input (before Differential) and a magnetothermic of 2 Amp at AC output (before AC output connectors).
- Differential at 50 mA is located at system AC input (unipolar switch) to interrupt power in case of current leak.

MI BT 021

• Measures to protect direct or indirect contacts are Class B: Ground elements are connected to installation ground. System is switched off by default intensity.

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MELISSA

Contract Number: ESTEC/CONTRACT: 15671/01/NL/ND

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Control System Demonstrator Software Design Document

Version: 1

Issue: 1



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1	0	23 Feb '04	First version for ESA review
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1 SCOPE

This document describes de design of the software that will be implemented to test the Control System Demonstrator hardware, designed based on the architecture proposed in [A4] and built as described in [R7], for the MELISSA Pilot Plant placed at UAB premises, and in particular, to upgrade current compartment III and IV control system.

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

- [A1] MELISSA. Adaptation for Space, Phase 1. Statement of Work.TOS-MCT/2000/2977/ln/CL. Issue 5. April 2001.
- [A2] MELISSA. Adaptation for Space-Phase 1. Proposal issued by NTE. MEL-0000-OF-001-NTE. Issue 2. October 2001.
- [A3] Memorandum of Understanding between the UAB and NTE S.A. MEL-0000-SP-007-NTE. Version 1. Issue 0. 21 January 2002.
- [A4] MELISSA Control System Architecture and Trade-off. TN 72.3. Version 1. Issue 0. December 2002.

2.2 Reference Documents

- [R1] Definition of the control requirements for the MELISSA Loop. TN 72.2, v.1.2, November 2002 (MEL-3100-SP-010-NTE).
- [R2] Photoheterotrophic Compartment Set-up. TN 37.6. UAB, February 1998.
- [R3] Nitrifying Compartment Studies. TN 25.310. UAB, September 1996.
- [R4] Set-up of the Photosynthetic Pilot Reactor. TN. 37.2. UAB, April 1998.
- [R5] Spirulina Controller. TN 72.3.1, v. 1.0, ADERSA, March 2003.
- [R6] Nitrite Controller. TN 72.3.2, v. 1.1, ADERSA, October 2003.
- [**R7**] Control System Demonstrator Hardware Design Document. TN 72.4 Volume IIa, v.1.1, July 2004 (MEL-3320-RP-020-NTE).

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3 ACRONYMS LIST

DO	Dissolved Oxygen
FGB	Function Block Diagram
HDD	Hardware Design Document
HMI	Human Machine Interface
PID	Proportional, Integration, Derivative
PLC	Programmable Logic Controller
SCADA	Supervisory Control And Data Acquisition
SDD	Software Design Document
TC	Test Case
TP	Test Procedure
UAB	Universitat Autònoma de Barcelona

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4 INTRODUCTION

This document describes the software design of the Control System demonstrator to be installed at the MELISSA Pilot Plant (UAB's premises).

This demonstrator has been designed as to permit the verification of some key aspects of the new MELISSA Control System Architecture described in [A4]. The aspects to be verified as previously agreed with ESA, are the following:

- In-plant verification of the Control law for the *Spirulina* compartment (variables, loops etc.) with the new control HW.
- In-plant verification of the Control law for the Nitrifying compartment. (Variables, loops etc.) with the new control HW.
- Non-nominal tests to verify alarm management

These verification objectives are to be developed in a specific Test Plan and Procedure that NTE will produce in co-ordination with the UAB (E) and SHERPA (F).

Based on these verification objectives NTE proposed for implementation the Control System demonstrator for compartments CIII and CIV shown in Figure 1.

4.1 SW Configuration

The Control System Demonstrator presents the following SW configuration:

- Local Control SW, consisting of PLC programs implemented using Concept 2.6 SW (by Schneider), running over Schneider's Modicon Quantum PLCs.
- Master Control SW, implemented using the iFix 3.0 Supervision SW (by Intellution) and running in the Supervision Server platform (Dell's PowerEdge).
- Dedicated Supervision (SCADA) SW, implemented using iFix 3.0 Supervision SW (by Intellution) and running in both, the Supervision Server platform and the Supervision Client platform (Dell's OptiPlex).
- Human Machine Interface (HMI), implemented using the Magelis XBT-L1000 design SW (by Schneider) and running over the HMI touch-screen (Schneider Magelis XBT-F034610).
- Supervision Server running Microsoft® Windows 2000 SP4
- Supervision Client running Microsoft® Windows XP SP1

The purchased SW and corresponding suppliers used in the Control System Demonstrator is summarised in the following list follows:

- Concept 2.6 by Schneider
- IFix 3.0 by Intellution
- XBT-L1000 by Schneider
- Windows 2000 SP4 by Microsoft®
- Windows XP SP1 Microsoft ®

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4.2 Document organisation

Chapter 5 defines the Local Control SW implemented on the Quantum PLCs for CIII and CIV, respectively. Sections headed with a label (ex. CIII_PLCSW_pH) describe the SW design item that can be traced to the implementation. Each SW item is explained with the following subsections:

- A textual description of the SW item's function
- The list and description of the variables involved
- A logical block diagram showing the interrelation and processes between i/p and o/p for that SW item as defined in the SW item's function description
- Description of the associated alarms, triggering conditions and actions
- Description of the operational modes

Chapter 6 contains the description of the HMI SW running on the HMI touch-screen device and the various displays which build up this software element.

Chapter 7 covers the design of the Master Control SW running on the Supervision Server, which mainly consists on the adaptation of the control laws provided by SHERPA for CIII and CIV, respectively, to the iFix programming environment.

Chapter 8 shows the design of the supervision (SCADA) screens running on the supervision platforms. It first explain the screen layout and then details the Main Display and the various displays associated to CIII and CIV respectively. The Supervision Database is also described.

Finally, chapter 9 describes the network configuration providing the set of IP addresses.

Appendix A contains specific naming conventions for the internal variables used in calculations or to exchange data between PLCs and Supervision.

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Figure 1. Control System Demonstrator

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5 LOCAL CONTROL

Low level control is implemented as a set of loops running in a Quantum PLC.

Each compartment has its own PLC. Therefore a PLC program is developed for each PLC/Compartment. Each program is divided into sections. Each section is dedicated to perform a specific control and/or measurement function.

The design of the PLC programs enforces the flexibility of modification of calibration, PID and scaling parameters from the supervision.

5.1 Target Platform

PLC programs will be developed for the Schneider Quantum PLC using the Concept 2.6 software.

Sections are coded using the IEC standard language FBD (Function Block Diagram).

5.1.1 Memory Allocation

Each system will allocate memory to store system data and control data. System data is the data that allows system status monitoring, and control data is the information regarding each input / output module in the PLC to be shared with the Supervision.

In Quantum PLC the I/O memory addresses are formed as follows:

Group	Туре
0x	Digital inputs
1x	Digital Outputs
3x	Analogue Inputs
4x	Analogue Outputs

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5.2 CIII_PLC_SW: PLC Software for the Compartment III

This compartment is based on a Nitrifying reactor. The inputs are the liquid output of the compartment II and gas outputs from other compartments via a Buffer Tank. Its main function is to transform Ammonia to Nitrates producing Nitrate in the liquid phase and CO2 in the gas phase.

Following control actions are implemented:

- Regulation of Temperature
- Regulation of pH
- Regulation of DO
- Regulation of Level
- Regulation of Pressure
- Regulation of Nitrates

5.2.1 CIII PLC Configuration

Back plane modules distribution

140CPS11 420	140CPU4 3412A	140NOE7 7101	140ACI04 000	140AVO0 2000	140ACO0 2000	140DDI8 4100	140DDO8 4300	(Free)	(Free)
Backplane Power Supply module	CPU module	Ethernet module	16 Analogue input 4-20 mA	4 Analogue input 0-5 V	4 Analogue output 4-20 mA	16 Digital Inputs 10-60 V	16 Digital Outputs 10-60 V		
1	2	3	4	5	6	7	8	9	10

CPU: Quantum 140CPU43412A

Communications Module: 140NOE77101

PLC I/O Memory map is configured as follows:

Module	Start Address	End Address
140ACI04000	300100	300116
140AVO02000	400100	400103
140ACO02000	400104	400107
140DDI84100	100065	100080
140DDO84300	000065	080000

• First addresses of each group are reserved for system purposes.

- Variable addresses are specified in following sections.
- 140AVO02000 outputs are disabled in case of failure
- 140ACO02000 outputs are set to the minimum value in case of failure.

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5.2.2 CIII PLC Program sections

The PLC program is divided into sections, where each section corresponds to a defined function that manages an independent group of input / outputs.

Section	Description
CIII_PLCSW_Temp	Temperature regulation
CIII_PLCSW_pH	pH regulation
CIII_PLCSW_DO	DO regulation
CIII_PLCSW_Liquid	Liquid flow regulation
CIII_PLCSW_P	Pressure regulation
CIII_PLCSW_N	Nitrates regulation

A brief description of the functionality of each section:

- Temperature is measured from two probes (top and bottom of the reactor). Regulation is performed by activating a Heater or a Cooling valve.
- pH is measured from two probes (top and bottom). Regulation is performed adding CO2/Acid media or base media.
- DO is measured by two probes (top and bottom). Regulation is performed actuating over the O2 input flow. In addition, N2 can be added if DO does not decrease when no O2 is added.
- Liquid level is measured by two contacts positioned in the top of the reactor to indicate low and high level status. In case of low level output pump flow is decreased and in case of high level output pump flow is increased. Initially input and output liquid flows are equal and constant.
- Pressure is measured at top of the reactor. It is regulated actuating over a valve; in case of overpressure this valve is opened to release this excessive overpressure.
- Ammonia/Nitrates control is regulated by actuating over the input liquid flow rate.

5.2.3 CIII PLC Initial values

Following are the values that are loaded into PLC when it is restarted

Name	Description	Initial Value
CIII_CNS_CO2Kp	Additional proportional constant for CO2	5
CIII_CNS_DOBias	Disturbance variable (Feed_fw) for DO PID	0
CIII_CNS_DOKd	Derivative constant for DO PID	0.00083
CIII_CNS_DOKi	Integrative constant for DO PID	0
CIII_CNS_DOKp	Proportional constant for DO PID	1
CIII_CNS_DOramp	DO supervision set point ramp coefficient	0.016
CIII_CNS_LinA	Calibration constant parameter A	73.5294
CIII_CNS_LinB	Calibration constant parameter B	0.1765
CIII_CNS_N2Kp	Proportional constant for N2 regulation	0.5
CIII_CNS_OpModeGas	Gas control operational mode (0=Off, 1=Auto, 2=Manual)	0
CIII_CNS_OpModeL	Liquid control operational mode (0=Off, 1=Auto, 2=Manual)	0
CIII_CNS_OpModepH	pH control operational mode (0=Off, 1=Auto, 2=Manual)	0
CIII_CNS_OpModeT	Temperature control operational mode (0=Off, 1=Auto, 2=Manual)	0
CIII_CNS_pHKi	Integration constant for Acid/Base PI	0

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CIII_CNS_pHKp	Proportional constant for Acid/Base PI	8
CIII_CNS_pHMode	PH regulation mode variable (1=CO2 only, 2=CO2+Base,	2
	3=Base+Acid)	
CIII_CNS_pHramp	pH supervision set point ramp coefficient	0.005
CIII_CNS_Tramp	Temperature supervision set point ramp coefficient	0.0083
CIII_MAN_Ac	Manual acid pump set point	0
CIII_MAN_Bs	Manual base pump set point	0
CIII_MAN_CO2	Manual CO2 flow controller set point	0
CIII_MAN_EnAc	Manual enable of acid pump	0
CIII_MAN_EnBs	Manual enable of base pump	0
CIII_MAN_EnCV	Manual enable of the cooling valve	0
CIII_MAN_EnHT	Manual enable of the heater	0
CIII_MAN_EnP	Manual enable of pressure safety valve	0
CIII_MAN_Lin	Manual liquid input pump set point	0
CIII_MAN_LO	Manual liquid output pump set point	0
CIII_MAN_N2	Manual N2 flow controller set point	0
CIII_MAN_O2	Manual O2 flow controller set point	0
CIII_SSP_DO	DO Supervision set point	80
CIII_SSP_L1in	Level 1 liquid input supervision set point	0
CIII_SSP_P	Pressure supervision set point	80
CIII_SSP_pH	pH supervision set point	8.0
CIII_SSP_T	Temperature supervision set point	28

5.2.4 CIII_PLCSW_Temp: Temperature regulation

5.2.4.1 Function

This section regulates the temperature of the reactor. The functions of this section are:

- 1. Acquire the temperature from top and bottom sensors and calculate the average as 80% bottom and 20% top (0.2top + 0.8bot). Weights can be modified from the supervision.
- 2. On controller reset or loop mode change, the set point starts on the measured value and reaches the fixed value with a ramp of 0.5/min, this value can be modified from the supervision.
- 3. Consider a dead band of 0.1 over /0.5 under the temperature set point.
- 4. In case of over temperature activate the Cooling valve.
- 5. In case of under temperature activate Heater with a pulse action with a duration regulated by a proportional (Kp=0.7, max=1, min=0) which output (Prop) sets the pulse period and duration as follows:

a = 5 * Propb = 16 * (Prop + 1) (both values in seconds)



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5.2.4.2 Variables

Name	Description	PLC_Address	Device	Туре	Range
CIII_ALM_Tdif	Alarm of temperature difference between top and bottom	000165		bool	
CIII_ALM_Tover	Over temperature alarm	000166		bool	
CIII_ALM_Tunder	Under temperature alarm	000175		bool	
CIII_ALM_Tbot	Alarm to notify Temperature bottom sensor link error	000177		bool	
CIII_ALM_Ttop	Alarm to notify Temperature top sensor link error	000176		bool	
CIII_CNS_Tramp	Temperature supervision set point ramp coefficient	400556		real	0-100
CIII_CNS_OpMo deT	Temperature control operational mode (0=Off, 1=Auto, 2=Manual)	400567		int	1,2,3
CIII_MAN_EnCV	Manual enable of the cooling valve	000192		Bool	0-1
CIII_MAN_EnHT	Manual enable of the heater	000193		Bool	0-1
CIII_MV_Tb	Temperature at bottom	300108	Thermometer	4-20 mA	0.2-147 C°
CIII_MV_Tt	Temperature at top	300109	Thermometer	4-20 mA	0.2-147 C°
CIII_RL_CV	Open/close the cooling valve	000084	Cooling valve	0-24 V	0-1
CIII_RL_HT	Activate Heater	000085	Hot finger	0-24 V	0-1
CIII_SMV_T	Temperature scaled measure	400532		real	0.2-147 C°
CIII_SMV_Tb	Temperature at bottom scaled measure	400608		real	0-150 C°
CIII_SMV_Tt	Temperature at top scaled measure	400606		real	0-150 C°
CIII_SSP_T	Temperature supervision set point	400500		real	0-150 C°

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5.2.4.3 Block Diagram



5.2.4.4 Alarms

Alarm condition	Action
Temperature delta between top	Activate alarm CIII_ALM_TDif and stop liquid input pump.
Temperature 1.5° C over the	Activate alarm CIII_ALM_TOver and set Temperature Loop operation
set point	mode to OFF.
Temperature 1.5 C° under the	Activate alarm CIII_ALM_TUnder.
set point	
Temperature top sensor failure	Set safety value (set point) and notify failure
Temperature bottom sensor	Set safety value (set point) and notify failure
failure	

5.2.4.5 Operational Modes

Mode	Description	Action
0	Off	Set Heater and Cooling valve outputs to 0
1	Auto	Set outputs from control action
2	Manual	Manual enable/disable Heater and cooling valve

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5.2.5 CIII_PLCSW_pH: pH regulation

5.2.5.1 Function

This section controls de pH in the reactor. The regulation can be done in 3 modes:

Mode	Description	CO ₂ flow	Base pump	Acid pump
1	Only CO ₂ is used to regulate pH	Enabled	Disabled	Disabled
2	CO_2 and Base medium is used to regulate pH.	Enabled	Enabled	Disabled
3	Base and additional Acid media is used to regulate pH.	Disabled	Enabled	Enabled

- 1. Acquire the pH from top and bottom sensors and calculate the average as 90% bottom and 10% top (0.1top + 0.9bot). Weights are provided by the supervision.
- 2. On controller reset or loop mode change, the set point starts on the measured value and reaches the fixed value with a ramp of 0.3/min, this value can be modified from the supervision.
- 3. Control action is regulated by a PI with parameters Kp=8, Ki=0. Values can be modified from the Supervision. Control action is only enabled during 30 seconds every 10 minutes.
- 4. CO_2 is regulated by previous PI, with an additional Kp = 5.0. Value can be modified from the Supervision.
- 5. In case of pH over the set point actuate with acid pump if enabled or CO_2 if enabled.
- 6. In case of pH under the set point actuate with base pump if enabled.
- 7. Consider a dead band of 0.1 (set point=8.0, dead band=7.9-8.1)

Name	Description	PLC_Address	Device	Туре	Range
CIII_ALM_AcErr	Alarm to notify acid pump link error	000186		bool	
CIII_ALM_BsErr	Alarm to notify base pump link error	000185		bool	
CIII_ALM_pH	Alarm of pH deviation	000167		bool	
CIII_ALM_pHbot	Alarm to notify pH bottom sensor link error	000179		bool	
CIII_ALM_pHtop	Alarm to notify pH top sensor link error	000178		bool	
CIII_CNS_CO2Kp	Additional proportional constant for CO ₂	400522		real	0-100
CIII_CNS_OpMode pH	pH control operational mode (0=Off, 1=Auto, 2=Manual)	400564		int	0,1,2
CIII_CNS_pHMode	pH regulation mode variable (1= CO ₂ only, 2=CO2+Base, 3=Base+Acid)	400569		int	1,2,3
CIII_CNS_pHKi	Integration constant for Acid/Base PI	400510		real	0-100
CIII_CNS_pHKp	Proportional constant for Acid/Base PI	400508		real	0-100
CIII_CNS_pHramp	pH supervision set point ramp coefficient	400560		real	0-100

5.2.5.2 Variables

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Name	Description	PLC_Address	Device	Туре	Range
CIII_IND_Ac	Enable Acid pump output to regulate pH	000169		bool	
CIII_IND_Bs	Enable Base pump output to regulate pH	000170		bool	
CIII_IND_CO2	Enable CO ₂ output to regulate pH	000168		bool	
CIII_MAN_Ac	Manual acid pump set point	400570		real	0-100%
CIII_MAN_Bs	Manual base pump set point	400572		real	0-100%
CIII_MAN_CO2	Manual CO ₂ flow controller set point	400574		real	0-100%
CIII_MAN_EnAc	Manual enable of acid pump	000190		Bool	0-1
CIII_MAN_EnBs	Manual enable of base pump	000191		Bool	0-1
CIII_MV_pHb	pH at bottom	300105	pH meter	4-20 mA	3-13
CIII_MV_pHt	pH at Top	300106	pH meter	4-20 mA	1.5-11.5
CIII_RL_Ac	Relay acid pump	000066	Acid pump	0-24 V	0-1
CIII_RL_Bs	Relay base pump	000067	Base pump	0-24 V	0-1
CIII_SMV_pH	pH scaled measure	400534		real	0 - 14
CIII_SMV_Ac	Acid pump control action	400536		real	0-100%
CIII_SMV_Bs	Base pump control action	400538		real	0-100%
CIII_SMV_pHb	Scaled pH value at bottom	400610		Real	3-13
CIII_SMV_pHt	Scaled pH value at top	400592		Real	3-13
CIII_SMV_CO2	CO ₂ input flow control action	400540		real	0-100%
CIII_SP_Ac	Acid pump flow regulation	400104	Acid pump	4-20 mA	0-100%
CIII_SP_Bs	Base pump flow regulation	400105	Base pump	4-20 mA	0-100%
CIII_SP_CO2	CO ₂ input flow regulation	400100	CO ₂ flow controller	0-5 V	0-100%
CIII_SSP_pH	pH supervision set point	400504		real	0-14

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5.2.5.3 Block Diagram



5.2.5.4 Alarms

Alarm condition	Action
1 unit of pH over/under set-	Activate alarm CIII_ALM_pH.
point during 15'	
pH bottom sensor failure	Set safety value measure (nominal set point) and notify failure
pH top sensor failure	Set safety value measure (nominal set point) and notify failure
pH bottom and pH top sensor	In case both sensors failed, stop PID action (PID output=0)
failure	
Acid pump link failure	Notify failure to Supervision (CIII_ALM_AcErr)
Base pump link failure	Notify failure to Supervision (CIII_ALM_BsErr)

5.2.5.5 Operational Modes

Mode	Description	Action
0	Off	Set acid/base pumps and CO ₂ flow controller outputs to 0
1	Auto	Set outputs from control action
2	Manual	Set manual set points to acid/base pumps and flow controller

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5.2.6 CIII_PLCSW_DO: DO regulation

5.2.6.1 Function

This section controls the DO (Dissolved Oxygen) in the reactor. The functions of this section are:

- 1. Acquire the DO from top and bottom sensors and calculate the average as 50% bottom and 50% top (arithmetical mean).
- 2. Control action is regulated by a PID with constants Kp=1, Ki=0, Kd=0.00083. Values can be modified from the Supervision.
- 3. When O_2 value is completely closed and DO value is over the set point, a control action is performed opening the N_2 value, action is regulated adding a Kp=0.5 to the output of the O_2 PID.
- 4. In case of DO over the set point close O_2 valve.
- 5. In case of DO under the set point open O_2 valve.
- 6. On controller reset or loop mode change, the set point starts on the measured value and reaches the fixed value with a ramp of 1.0/min, this value can be modified from the supervision.

Name	Description	PLC_Address	Device	Туре	Range
CIII_ALM_DOTop	Alarm to notify DO top sensor link error	000180		bool	
CIII_ALM_DOBot	Alarm to notify DO bottom sensor link error	000181		bool	
CIII_ALM_DO	Alarm to notify DO is over the set point	000189		bool	
CIII_CNS_DOKp	Proportional constant for DO PID	400512		real	0-100
CIII_CNS_DOKi	Integrative constant for DO PID	400514		real	0-100
CIII_CNS_DOKd	Derivative constant for DO PID	400516		real	0-100
CIII_CNS_DOBias	Disturbance variable (Feed_fw) for DO PID	400518		real	0-100
CIII_CNS_N2Kp	Proportional constant for N ₂ regulation	400614		real	0-100
CIII_CNS_OpMode Gas	Gas control operational mode (0=Off, 1=Auto, 2=Manual)	400566		int	0,1,2
CIII_CNS_DOramp	DO supervision set point ramp coefficient	400588		real	0-100
CIII_MAN_N2	Manual N ₂ flow controller set point	400580		real	0-150%
CIII_MAN_O2	Manual O ₂ flow controller set point	400582		real	0-100%
CIII_MV_DOb	DO at bottom	300100	Oxygen analyser	4-20 mA	0-100%
CIII_MV_DOt	DO at top	300101	Oxygen analyser	4-20 mA	0-100%
CIII_SMV_DO	DO scaled measure value	400544		real	0-100%

5.2.6.2 Variables

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Name	Description	PLC_Address	Device	Туре	Range
CIII_SMV_DObot	DO at bottom scaled measure value	400604		real	0-100%
CIII_SMV_DOtop	DO at top scaled measure value	400602		real	0-100%
CIII_SMV_O2	O ₂ input flow control action	400546		real	0-100%
CIII_SMV_N2	N ₂ input flow control action	400548		real	0-150%
CIII_SP_02	O ₂ flow regulation	400102	O ₂ flow controller	0-5 V	0-100%
CIII_SP_N2	N ₂ flow regulation	400101	N ₂ flow controller	0-5 V	0-150%
CIII_SSP_DO	DO Supervision set point	400520		real	0-200%

5.2.6.3 Block Diagram



5.2.6.4 Alarms

Alarm condition	Action
In case of DO is a 10%	Activate alarm CIII_ALM_DO.
over/under the set-point	
DO top sensor failure	Set safety value (nominal set point) and notify failure
DO bottom sensor failure	Set safety value (nominal set point) and notify failure
DO top and DO bottom sensors	In case both sensors failed, stop PID action (PID output = BIAS)
failure	

5.2.6.5 Operational Modes

Mode	Description	Action
0	Off	Set N ₂ and O ₂ flow controller outputs to 0 (closed)
1	Auto	Set outputs from control action
2	Manual	Set manual set points to N ₂ and O ₂ flow controller outputs

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5.2.7 CIII_PLCSW_Liquid: Liquid flow regulation

5.2.7.1 Function

This section controls the liquid input/output and liquid level of the reactor. The functions of this section are:

- 1. Generate a pulse every 5 seconds of 120 ms to enable level sensors
- 2. Increase output pump a 25% of the input pump set point if level is high.
- 3. Decrease output pump a 25% of the input pump set point if level is low.
- 4. Hold output pump set point and low level and high level indicators while pulse is 0.
- 5. Disable liquid input pump in case Temperature difference alarm is active.
- 6. When buffer tank at output reaches high level, activate buffer tank output pump.
- 7. Calculate liquid input pump set point as Ax + B where A, B values are initially A= 73.5294 and B= 0.1765 and x is the Level 1 liquid input supervision set point. These values can be modified from the supervision.

5.2.7.2 Variables

Name	Description	PLC_Address	Device	Туре	Range
CIII_ALM_L	Alarm of high level	000171		bool	
CIII_ALM_LIErr	Alarm to notify liquid input pump link error	000187		bool	
CIII_ALM_LOErr	Alarm to notify liquid output pump link error	000188		bool	
CIII_CNS_OpMode L	Liquid flow control operational mode (0=Off, 1=Auto, 2=Manual)	400565		int	0,1,2
CIII_CNS_LinA	Input pump calibration constant parameter A	400584		real	0-100
CIII_CNS_LinB	Input pump calibration constant parameter B	400586		real	0-100
CIII_CNS_LoA	Output pump calibration constant parameter A	400598		real	0-100
CIII_CNS_LoB	Output pump calibration constant parameter B	400600		real	0-100
CIII_IND_Llow	Liquid level low indicator	000173		bool	
CIII_IND_Lhigh	Liquid level high indicator	000174		bool	
CIII_MAN_Lin	Manual liquid input pump set point	400576		real	0-100%
CIII_MAN_LO	Manual liquid output pump set point	400578		real	0-100%
CIII_MV_LHigh	Level measurement high	100083	Level sensor 2	0-24 V	0-1
CIII_MV_LLow	Level measurement low	100082	Level sensor 1	0-24 V	0-1
CIII_MVO_Lbt	Indicator of max level reached for a buffer tank	100084	Level sensor	0-24 V	0-1
CIII_RL_Lbt	Activation of the pump for the buffer tank	000065	Pump buffer tank	0-24 V	0-1

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Name	Description	PLC_Address	Device	Туре	Range
CIII_RL_Lp	Relay to have a pulse in the level sensor lecture	000071	Level sensor	0-24 V	0-1
CIII_SMV_LiFr	Liquid input flow rate	400596		real	0-10 l/h
CIII_SMV_LO	Liquid output flow control action	400550		real	0-100%
CIII_SMV_LoFr	Liquid output flow rate	400594		real	0-10 l/h
CIII_SP_Lin	Liquid input pump flow regulation	400106	Input liquid pump	4-20 mA	0-100%
CIII_SP_LO	Liquid output pump flow regulation	400107	Output liquid pump	4-20 mA	0-100%
CIII_SSP_L1Lin	Level 1 liquid input supervision set point	400524		real	0-10 l/h
CIII_SSP_L2Lin	Level 2 liquid Input supervision set point	400542		real	0-10 l/h

5.2.7.3 Block Diagram



5.2.7.4 Alarms

Alarm condition	Action
In case of level is high during 15'	Activate alarm CIII_ALM_L and disable input pump
Liquid input pump link error	Notify to Supervision (CIII_ALM_LIErr)
Liquid output pump link error	Notify to Supervision (CIII_ALM_LOErr)

5.2.7.5 Operational Modes

Mode	Description	Action
0	Off	Set liquid input/output pump outputs to 0
1	Auto	Set outputs from control action
2	Manual	Set manual set points to liquid input/output pump outputs

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5.2.8 CIII_PLCSW_P: Pressure regulation

5.2.8.1 Function

This section controls the pressure of the reactor. The functions of this section are:

- 1. Acquire pressure value
- 2. If pressure if over the set point open Pressure Safety Valve.

5.2.8.2 Variables

Name	Description	PLC_Address	Device	Туре	Range
CIII_ALM_Perr	Alarm to notify Pressure sensor link error	000182		bool	
CIII_ALM_P	Over pressure alarm	000172		bool	
CIII_CNS_OpMode Gas	Gas control operational mode (0=Off, 1=Auto, 2=Manual)	400566		int	0,1,2
CIII_MAN_EnP	Manual enable of pressure safety valve	000194		Bool	0-1
CIII_MV_P	Pressure at top of the gas phase	300104	Pressure sensor	0-20 mA	0-1000 mbar
CIII_RL_P	Activation of Pressure Safety Valve	000072	Pressure solenoid valve	0-24 V	0-1
CIII_SMV_P	Pressure scaled measure value	400552		real	0-1000 mbar
CIII_SSP_P	Pressure supervision set point	400526		real	0-1000 mbar

5.2.8.3 Block Diagram



5.2.8.4 Alarms

Alarm condition	Action
In case of over pressure during	Activate alarm CIII_ALM_P
15′	
Pressure sensor failure	Set safety value (nominal set point)

5.2.8.5 Operational Modes

Mode	Description	Action
0	Off	Set status of safety pressure valve to open
1	Auto	Set outputs from control action
2	Manual	Set manual enable status to the safety pressure valve

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5.2.9 CIII_PLCSW_N: Nitrates acquisition

5.2.9.1 Function

This section acquires the nitrate concentration in the reactor. The functions of this section are:

- 1. Acquire and scale NO3 value
- 2. Acquire and scale NH4 value

5.2.9.2 Variables

Name	Description	PLC_Address	Device	Туре	Range
CIII_ALM_NO3	Alarm to notify NO ₃ sensor link error	000183		bool	
CIII_ALM_NH4	Alarm to notify NH ₄ sensor link error	000184		bool	
CIII_IND_CaINH4	Analyser calibration indicator	100080	Ammonium analyser	0-24 V	0-1
CIII_IND_CalNO3	Nitrate calibration indicator	100081	NO ₃ analyser	0-24 V	0-1
CIII_MV_NH4	Ammonium concentration	300102	Ammonium analyser	4-20 mA	0-155.6 ppm N-NH ₄ +
CIII_MV_NO3	Nitrate concentration	300103	NO ₃ analyser	4-20 Ma	0-1000 ppm N-NO ₃ -
CIII_SMV_NH4	Ammonium concentration scaled measure	400528		real	0-200 ppm N-NH ₄ +
CIII_SMV_NO3	Nitrate concentration scaled measure	400530		real	0-1000 ppm N-NO ₃ -
CIII_SMV_NO2	Estimation of NO ₂ concentration (calculated by control law)	400612		real	mol/l

5.2.9.3 Alarms

Alarm condition	Action
NO ₃ sensor failure	Set safety value 4.2 and notify failure
NH ₄ sensor failure	Set safety value 329.0 and notify failure

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5.3 CIV_PLCSW: PLC Software for the Compartment IVa

This compartment is based on a Photosynthetic reactor. Its inputs are the liquid phase of the compartment II and the gas outputs of other compartments via a Buffer Tank. The main function of this compartment is to convert Nitrates into edible biomass and CO_2 into O_2 . Therefore the outputs are O_2 in the gas phase and edible biomass in the solid phase.

Following control actions are implemented:

- Cleaning of biomass sensor
- Regulation of liquid flow
- Regulation of gas flow
- Regulation of light intensity
- Regulation of pH

5.3.1 CIV PLC Configuration

Back plane modules distribution

140CPS1	140CPU4	140NOE7	140ACI03	140AVI03	140AVO0	140AVO0	140ACO0	140DDM	(Free)
1420	3412A	7101	000	000	2000	2000	2000	39000	
Backplan e Power Supply module	CPU module	Ethernet module	8 Analogue input 4-20 mA	8 Analogue input 0-5 V	4 Analogue output 0- 5 V	4 Analogue output 0- 5 V	4 Analogue output 0- 20/4-20 mA	16 Digital inputs / 8 Digital outputs 10-60 VCC	
1	2	3	4	5	6	7	8	9	10

CPU: Quantum 140CPU43412A

Communications Module: 140NOE77101

PLC I/O Memory map is configured as following:

Module	Start Address	End Address
140ACI03000	300100	300108
140AVI03000	300109	300117
140AVO02000	400100	400103
140AVO02000	400104	400107
140ACO02000	400108	400115
140DDM39000 / DI	100065	100080
140DDM39000 / DO	000065	000072

• First addresses of each group are reserved for system purposes.

• Variable addresses are specified in following sections.

• 140AVO02000 outputs are disabled in case of failure

• 140ACO02000 outputs are set to the minimum value in case of failure.

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5.3.2 CIV PLC Program sections

The PLC program is divided into sections, where each section corresponds to a defined function that manages an independent group of input / outputs.

Section	Description
CIV_PLCSW_Biomass	Acquisition and conditioning of biomass concentration
CIV_PLCSW_Light	Light regulation
CIV_PLCSW_Liquid	Liquid flow regulation
CIV_PLCSW_Gas	Gas flow and pressure regulation
CIV_PLCSW_pH	pH regulation
CIV_PLCSW_T	Temperature acquisition

A brief description of the functionality of each section:

- Biomass concentration acquisition is performed in light attenuation units, to provide biomass concentration in dry weight units (g/l) a conditioning of the value has to be performed. In addition the section includes biomass sensor cleaning logic.
- Light regulation is done in open loop. Control action is adjusted using a mathematical expression deduced from previous experiments.
- Liquid flow is regulated in open loop since no flow meters are available. Liquid input set point is provided from the supervision and output set point is calculated adding a 10%.
- Gas flow is fixed from the supervision. Pressure is maintained adjusting gas input/output into a predefined range. In addition a pressure safety valve opens in case of an overpressure.
- pH regulation is performed using CO₂ and additional base and acid media. Operational mode can be determined from the supervision.
- Temperature regulation is performed externally using a specialised controller. The CIV PLC only acquires the temperature value and sends it to the Supervision.
- Nitrates measurement is not implemented since it is not used at this time.

5.3.3 CIV PLC Initial values

Following are the values that are loaded into PLC when it is restarted

Name	Description	Initial Value
CIV_CNS_AcKp	Acid pump regulator proportional constant for PID	100
CIV_CNS_BsKp	Base pump regulator proportional constant for PID	100
CIV_CNS_CO2Kd	CO2 flow regulator derivative constant for PID	0.01
CIV_CNS_CO2Ki	CO2 flow regulator integration constant for PID	100
CIV_CNS_CO2Kp	CO2 flow regulator proportional constant for PID	5
CIV_CNS_ConvV	Density factor to translate Kg to liters	1
CIV_CNS_DW	Dry Weight conversion factor	1
CIV_CNS_Li1FrA	Parameter A for liquid input pump 1 set-point calculation	18.315
CIV_CNS_Li1FrB	Parameter B for liquid input pump 1 set-point calculation	11.0989
CIV_CNS_Li2FrA	Parameter A for liquid input pump 2 set-point calculation	16.103
CIV_CNS_Li2FrB	Parameter B for liquid input pump 2 set-point calculation	0.8534
CIV_CNS_LoFrA	Parameter A for liquid output pump set-point calculation	15
CIV_CNS_LoFrB	Parameter B for liquid output pump set-point calculation	1
CIV_CNS_MaxPress	Maximum allowed pressure in the reactor	1.1

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Name	Description	Initial Value
CIV_CNS_MinV	Minimum volume to switch liquid input tank	10
CIV_CNS_OffsetCO2	Offset to provided a constant flux of CO2 to the reactor	0
CIV_CNS_OpModeBP	Biomass Production control mode (0=Off, 1=Auto, 2=Manual)	0
CIV_CNS_OpModeGas	Gas control mode (0=Off, 1=Auto, 2=Manual)	0
CIV_CNS_OpModepH	pH control mode ((0=Off, 1=Auto, 2=Manual)	0
CIV_CNS_PHMODE	PH regulation mode parameter (1=CO2 only, 2=CO2+Base, 3=Base+Acid)	1
CIV_MAN_Ac	Manual Acid Pump set point	0
CIV_MAN_Bs	Manual Base Pump set point	0
CIV_MAN_EnCx	Manual enable of biomass sensor aeration valve	0
CIV_MAN_EnLi1	Manual enable of Liquid input Pump 1	0
CIV_MAN_EnLi2	Manual enable of Liquid input Pump 2	0
CIV_MAN_EnLO	Manual enable of Liquid output Pump	0
CIV_MAN_EnSafety	Manual enable of pressure safety valve	1
CIV_MAN_FrCO2	Manual CO2 flow regulation set point	0
CIV_MAN_Li1	Manual Liquid Pump input1 set point	0
CIV_MAN_Li2	Manual Liquid Pump input2 set point	0
CIV_MAN_LO	Manual Liquid Pump output set point	0
CIV_MAN_Ls	Manual regulator of light supply set point	0
CIV_SSP_Fgex	Gas flow external input supervision set point	0
CIV_SSP_Fgi	Gas flow at input regulation supervision set point	0
CIV_SSP_Fgo	Gas flow at output regulation supervision set point	0
CIV_SSP_L1BP	Level 1 Biomass production set point	0
CIV_SSP_L1LiFr	Level 1 Liquid input flow rate set-point	0
CIV_SSP_Light	Light supervision set-point	0
CIV_SSP_NomPress	Nominal pressure in the reactor set-point	0.01
CIV_SSP_pH	pH set-point fixed by the supervision	9.5
CIV_SSP_T	Temperature set-point fixed by the supervision	36

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5.3.4 CIV_PLCSW_Biomass: Biomass measurement

5.3.4.1 Function

The functions of this section are:

- 3. Acquire the Biomass concentration and translate the input value in light attenuation units to dry weight units.
- 4. Clean the Biomass sensor generating a pulse every 5 minutes during 5 seconds to open the compressor valve.
- 5. Maintain the Biomass input value held since the valve is opened to 5 seconds after the valve is closed to avoid disturbances while the sensor is being cleaned.
- 6. Calculate actual Biomass Production = liquid input flow * biomass concentration(dw)
- 7. Biomass sensor range provided by Supervision (configurable).



5.3.4.2 Variables

Name	Description	PLC_Address	Device	Туре	Range
CIV_ALM_CxErr	Alarm to notify biomass sensor link error	000171		Bool	
CIV_CNS_DW	Dry weight conversion factor	400542		Real	
CIV_CNS_OpModeBP	Biomass Production control mode (0=Off, 1=Auto,	400566		int	0,1,2
CIV_MAN_EnCx	Manual activation value of biomass sensor aeration valve	100165		Bool	
CIV_MV_CxAbs	Biomass measurement in absorvance units	300100	Biomass sensor	4-20 mA	Configurable (Abs.U)
CIV_RL_Cx	Aeration of biomass sensor for cleaning	000067	Electrovalve	0-24 V	0 – 1 (=cleaning)
CIV_SMV_BP	Biomass production	400584		Real	0 – 5 g/h
CIV_SMV_CxDW	Biomass concentration in dry weight units (gr/l)	400200		Real	Configurable (gr/l)
CIV_SSP_L1BP	Level 1 Biomass production set point	400554		Real	0 – 10 g/h
CIV_SSP_L2BP	Level 2 Biomass production set-point	400564		Real	0 – 10 g/h
CIV_CNS_CxAbsMin	Configurable max range of biomass sensor	400588		Real	0 Abs. u.
CIV_CNS_CxAbsMax	Configurable min range of biomass sensor	400590		Real	2 Abs. u.

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5.3.4.3 Block Diagram



5.3.4.4 Alarms

Alarm condition	Action
Biomass sensor failure	Set safety value (1.0) and notify failure.

5.3.4.5 Operational modes

Mode	Description	Action
0	Off	Close aeration valve
1	Auto	Perform control action
2	Manual	Set manual value to aeration valve status.

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5.3.5 CIV_PLCSW_Liquid: Liquid flow regulation

5.3.5.1 Function

This section regulates the input/output liquid flow. Flow rate set-point is provided by the supervision. Liquid input media is provided from two buffer tanks with a pump for each one being only one active at a time. A balance measures the weight of each tank and this allows the system to detect when a tank is empty. Output flow rate is regulated maintaining the output pump a 10% over the input flow rate. When active buffer is under a defined volume (tank is empty), the alternative pump is activated (if its corresponding tank is not empty). This volume value is fixed from the supervision. If both tanks are under the minimum volume input and output pumps are stopped.

The functions of this section are:

- 1. Acquisition and conditioning of the inlet media tanks weight translating weight units into volume units. The Supervision fixes the conversion factor.
- 2. Control the active inlet pump according to the medium tank remaining volume. The value for switching is fixed by the Supervision.
- 3. Calculate output pump flow rate as the 10% over the input flow rate. Output pump setpoint is calculated using the expression Ax + B with the parameters (LoFrA, LoFrB) provided by the Supervision.
- 4. When the two input tanks are empty, an alarm is generated and output pump is stopped.
- 5. Calculate set-point of input pumps using the expression y=Ax + B (x = flow, y = %actuation) with the parameters fixed by the supervision (Li1FrA, Li1FrB, Li2FrA, Li2FrB).



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5.3.5.2 Variables

Name	Description	PLC_Addres	Device	Туре	Range
CIV_ALM_LiEmpty	Alarm liquid input tanks empty	000165		Bool	0 – 1 (=active)
CIV_ALM_V1Err	Alarm to notify scale1 sensor link	000172		Bool	
	error				
CIV_ALM_V2Err	Alarm to notify scale2 sensor link error	000173		Bool	
CIV_CNS_ConvV	Density factor to translate Kg to litres	400518		Real	
CIV_CNS_Li1FrA	Parameter A for liquid input pump 1 set-point calculation	400512		Real	
CIV_CNS_Li1FrB	Parameter B for liquid input pump 1 set-point calculation	400514		Real	
CIV_CNS_Li2FrA	Parameter A for liquid input pump 2 set-point calculation	400538		Real	
CIV_CNS_Li2FrB	Parameter B for liquid input pump 2 set-point calculation	400540		Real	
CIV_CNS_LoFrA	Parameter A for liquid output pump set-point calculation	400510		Real	
CIV_CNS_LoFrB	Parameter B for liquid output pump set-point calculation	400512		Real	
CIV_CNS_MinV	Minimum volume to switch liquid input tank	400500		Real	
CIV_CNS_OpMode BP	Biomass Production control mode (0=Off, 1=Auto, 2=Manual)	400566		int	0,1,2
CIV_MAN_Li1	Manual Liquid Pump input1 set point	400570		Real	0 – 100 %
CIV_MAN_Li2	Manual Liquid Pump input2 set point	400572		Real	0 – 100 %
CIV_MAN_LO	Manual Liquid Pump output set point	400574		Real	0 – 100 %
CIV_MAN_EnLi1	Manual enable of Liquid input Pump 1	100166		Bool	0 – 1 (=active)
CIV_MAN_EnLi2	Manual enable of Liquid input Pump 2	100167		Bool	0 – 1 (=active)
CIV_MAN_EnLO	Manual enable of Liquid output Pump	100168		Bool	0 – 1 (=active)
CIV_MLI_M1	Mass measurement to determine input flow	300101	Scale1	4-20 mA	0 – 150 kg
CIV_MLI_M2	Mass measurement to determine input flow	300102	Scale2	4-20 mA	0 – 150 kg
CIV_RL_Li1	Liquid Pump input1 on	000065	Liquid input pump1	0-24 V	0 – 1 (=active)
CIV_RL_Li2	Liquid Pump input2 on	000066	Liquid input pump2	0-24 V	0 – 1 (=active)
CIV_SMLI_V1	Volume liquid input buffer tank1	400202		Real	0 – 150 l
CIV_SMLI_V2	Volume liquid input buffer tank2	400204		Real	0 – 150 l
CIV_SMV_Li1	Liquid Pump input1 set point in %	400222		real	0 – 100 %
CIV_SMV_Li2	Liquid Pump input2 set point in %	400224		real	0 – 100 %
CIV_SMV_LiFr	Liquid input flow rate	400586		real	0 – 100 %
CIV_SMV_LO	Liquid Pump output set point in %	400226		real	0 – 100 %
CIV_SMV_LoFr	Computed liquid output flow rate	400238		Real	
CIV_SP_Li1	Liquid Pump input1 set point	400104	Liquid input pump1	0-5 V	0 – 100 %
CIV_SP_Li2	Liquid Pump input1 set point	400105	Liquid input pump2	0-5 V	0 – 100 %
CIV_SP_LO	Liquid Pump output set point	400106	Liquid output pump	0-5 V	0 – 100 %
CIV_SSP_L1LiFr	Level 1 Liquid input flow rate set-point	400508		Real	0 – 10 l/h
CIV_SSP L2LiFr	Level 2 Liquid input flow rate set point	400556	Ī	Real	0 – 10 l/h

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5.3.5.3 Block Diagram



5.3.5.4 Alarms

Alarm condition	Action
Tank1 and Tank2 empty	Notify alarm to Supervision (CIV_RL_Li1, CIV_RL_Li2) and stop output pump.
Scale1 sensor failure	Set safety value and notify failure.
Scale2 sensor failure	Set safety value and notify failure.
Temperature alarm on	Stop input pumps.

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5.3.5.5 Operational modes

Mode	Description	Action
0	Off	Disable input/output pumps
1	Auto	Perform control action
2	Manual	Set manual enable/disable and set points to input/output pumps

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5.3.6 CIV_PLCSW_Light: Light regulation

5.3.6.1 Function

This section performs conditioning of light regulation set point received from the Supervision. The functions of this section are:

- 1. Amplify input set point from 0-1 to 0-100
- 2. Smooth a set point change step into a ramp in 15 seconds. The ramp is calculated to perform full change in 15".
- 3. In case of temperature alarm set a safety value (10%) to light regulator.



5.3.6.2 Variables

Name	Description	PLC_Address	Device	Туре	Range
CIV_ALM_LsErr	Alarm to notify light supply link	000182		Bool	
	error				
CIV_MAN_Ls	Manual regulator of light supply	400576		Real	0 – 100 %
	set point				
CIV_SMV_Ls	Regulator of light supply actuation	400236		Real	0 – 100 %
	in %				
CIV_SP_Ls	Regulator of light supply	400109	Light	4-20 mA	0 – 100 %
			regulator		
CIV_SSP_Light	Light Supervision set-point	400520		Real	0 – 1
CIV_SSP_LightWm	Light set-point (w/m2)	400558		Real	0-500 w/m2
CIV_CNS_OpModeBP	Biomass Production control mode	400566		int	0,1,2
	(0=Off, 1=Auto, 2=Manual)				

5.3.6.3 Block Diagram



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5.3.6.4 Alarms

Alarm condition	Action		
Temperature alarm on	Set safety value to light regulator (10%).		
Light supply link error	Notify error to supervision		

5.3.6.5 Operational modes

Mode	Description	Action
0	Off	Set light supply output to 0
1	Auto	Perform control action
2	Manual	Set manual set point to light supply output

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5.3.7 CIV_PLCSW_Gas: Gas flow regulation

5.3.7.1 Function

This section controls the gas loop. The functions of this section are:

- 1. Acquire the current pressure value.
- 2. If pressure < NomPress increment a 10% input gas flow and activates the under pressure indicator. When pressure is again in a nominal value (inside dead band), stop incrementing supervision value. If pressure > NomPress, increment a 10% output gas flow and activates the over pressure indicator. Again, when pressure return to a nominal value (inside dead band), stop the incrementing the supervision value. NomPress is the nominal pressure specified by the Supervision. A dead band of +/-1% is considered.
- 3. Open pressure safety valve in case pressure reaches MaxPress. MaxPress is specified by the Supervision. Close it when pressure reaches the set point.
- 4. Allow manual setting of gas flow input and gas flow output (stop controlling action).
- 5. Acquire gas flow rate at compartment input.
- 6. Acquire gas flow rate at output
- 7. Acquire gas flow rate at external input.
- 8. Acquire CO_2 flow rate.
- 9. Acquire % DO saturation
- 10. Acquire CO_2 at output
- 11. Acquire O₂ at output
- 12. Allow to edit CO₂/O₂ sensor scales (scale1 and scale2)

NOTE: CO₂ flow regulation is performed in the CIV_PLCSW_pH section since is used to regulate pH.



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5.3.7.2 Variables

Name	Description	Address	Device	Туре	Range
CIV_ALM_CO2Err	Alarm to notify O ₂ sensor link error	000177		Bool	
CIV_ALM_Gas	Alarm notification for overpressure	000167		Bool	
CIV_ALM_Perr	Alarm to notify pressure sensor link error	000174		Bool	
CIV_ALM_O2Err	Alarm to notify O ₂ sensor link error	000176		Bool	
CIV_ALM_DOErr	Alarm to notify DO sensor link error	000178		Bool	
CIV_CNS_MaxPress	Maximum allowed pressure in the reactor	400524		Real	
CIV_CNS_OpModeGas	Gas control mode (0=Off, 1=Auto, 2=Manual)	400568		int	0,1,2
CIV_IND_CalCO2O2	Calibration indicator of CO ₂ /O ₂ sensor.	100065	CO ₂ /O ₂ sensor	0-24 V	0-1 (=Calibr.)
CIV_IND_ErrCO2O2	Error Indicator of CO ₂ /O ₂ sensor.	100066	CO ₂ /O ₂ sensor	0-24 V	0 (=Error) 1 (=OK)
CIV_IND_Scale1CO2O 2	CO ₂ /O ₂ sensor scale	100067	CO ₂ /O ₂ sensor	0-24 V	0 (= scale 1) 1 <u>(</u> = scale 2)
CIV_IND_Scale2CO2O 2	CO ₂ /O ₂ sensor scale	100068	CO ₂ /O ₂ sensor	0-24 V	0 (= scale 1) 1 (= scale 2)
CIV_IND_OverPress	Over pressure indicator	000168		Bool	
CIV_IND_UnderPress	Under pressure indicator	000169		Bool	
CIV_MAN_EnSafety	Manual enable of pressure safety valve	100169		Bool	0 – 1 (=active)
CIV_MGI_FrGas	Gas flow at external input	300113	Flowmeter	0-5 V	0 – 30 nLm
CIV_MGO_CO2	CO ₂ measurement at gas output	300107	CO ₂ sensor	4-20 mA	Configurable %
CIV_MGO_FrGas	Gas flow at output	300114	Flowmeter	0-5 V	0 – 30 nLm
CIV_MGO_O2	O2 measurement sensor input	300106	O ₂ sensor	4-20 mA	Configurable %
CIV_MV_DO	Percent of DO saturation in the reactor	300109	DO sensor	4-20 mA	Configurable %
CIV_MV_FrCO2	CO ₂ flow measurement	300115	Flowmeter	0-5 V	0 – 5 nLm
CIV_MV_FrGas	Gas flow at compartment input	300116	Flowmeter	0-5 V	0 – 30 nLm*
CIV_MV_P	Pressure measurement	300103	Pressure sensor	4-20 mA	0 – 1.5 bar
CIV_RL_Safety	Pressure safety valve activation	000068	Pressure valve	0-24 V	0 – 1 (=close)
CIV_SMGI_FrGas	Gas flow at external input scaled value	400208		real	0 – 30 nLm
CIV_SMGO_CO2	CO ₂ at output measurement scaled value	400218		real	Configurable %
CIV_SMGO_FrGas	Gas flow at output scaled value	400214		real	0 – 30 nLm

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Name	Description	Address	Device	Туре	Range
CIV_SMGO_02	O ₂ measure scaled value	400216		real	Configurable %
CIV_SMV_DO	Percent of DO saturation in the reactor scaled value	400206		real	Configurable %
CIV_SMV_FrCO2	CO ₂ at input measure scaled value	400210		Real	
CIV_SMV_FrGas	Gas flow at compartment input scaled value	400212		real	0 – 30 nLm*
CIV_SMV_P	Pressure measurement scaled value	400220		real	0 – 1.5 bar
CIV_SP_Fgex	Gas flow external input regulation	400103	Flow regulator	0-5 V	0 – 30 nLm
CIV_SP_Fgi	Gas flow at input regulation	400101	Flow regulator	0-5 V	0 – 30 nLm
CIV_SP_Fgo	Gas flow at output regulation	400102	Flow regulator	0-5 V	0 – 30 nLm
CIV_SSP_Fgex	Gas flow external input supervision set point	400532		Real	0 – 30 nLm
CIV_SSP_Fgi	Gas flow at input regulation supervision set point	400526		Real	0 – 30 nLm
CIV_SSP_Fgo	Gas flow at output regulation supervision set point	400528		Real	0 – 30 nLm
CIV_SSP_NomPress	Nominal pressure in the reactor	400522		Real	
CIV_CNS_DOMax	Configurable DO range max	400592		Real	400.0 %
CIV_CNS_DOMin	Configurable DO range min	400594		Real	0.0 %
CIV_CNS_CO2Max	Configurable CO2 range max	400596		Real	10 ppm
CIV_CNS_CO2Min	Configurable CO ₂ range min	400598		Real	0 ppm
CIV_CNS_O2Max	Configurable O ₂ range max	400600		Real	10 ppm
CIV_CNS_O2Min	Configurable O ₂ range min	400602		Real	0 ppm
CIV_CNS_CO2E2Max	Configurable Scale2 CO ₂ range max	400604		Real	20 ppm
CV_CNS_CO2E2Min	Configurable Scale2 CO ₂ range min	400606		Real	0 ppm
CIV_CNS_02E2Max	Configurable Scale2 O ₂ range max	400608		Real	25 ppm
CV_CNS_O2E2Min	Configurable Scale2 O ₂ range min	400610		Real	0 ppm

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5.3.7.3 Block Diagram

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5.3.7.4 Alarms

Alarm condition	Action
Over pressure during 5	Notify alarm to supervision (CIV_ALM_Gas)
seconds	
Pressure sensor failure	Set safety value (nominal set point) and notify failure
CO ₂ sensor failure	Set safety value (0.0) and notify failure
O ₂ sensor failure	Set safety value (0.0) and notify failure
DO sensor failure	Set safety value (0.0) and notify failure
No Gas alarm	Stop liquid input pump, set light to 10% and notify failure
	(CIV_ALM_NoGas)

5.3.7.5 Operational modes

Mode	Description	Action
0	Off	Set gas input/output to 0
1	Auto	Perform control action
2	Manual	Set supervision set points directly to gas input/outputs and manual
		enable/disable of the pressure safety valve.

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5.3.8 CIV_PLCSW_pH: pH regulation

5.3.8.1 Function

This section controls de pH in the reactor. The regulation can be done in 3 modes:

Mode	Description	CO2 flow rate	Base pump	Acid pump
1	Only CO2 is used to regulate pH	Enabled	Disabled	Disabled
2	CO2 is fixed and a base medium is	Enabled	Enabled	Disabled
	used to regulate pH.			
3	CO2 is fixed and a base and	Disabled	Enabled	Enabled
	additional acid medium is used to			
	regulate pH.			

Disabled : Control Action = 0% Enabled: Control action regulated.

The functions of this section are:

- 1. Acquire the pH value.
- 2. If Base Pump is enabled, in case deviation to the set point is <- 0.15 units activate Base Pump and Base On indicator.
- 3. If Acid Pump is enabled, in case deviation to the set point is > 0.15 units activate Acid Pump and Acid On indicator.
- 4. Acid and Base pumps control
- 5. If CO2 regulation is enabled, regulate CO2 input flow to control the pH using a PID (Mode 1) (Kp=5, Ki=1000, D=0, with PID output ranged 0-100%). Values can be modified from the Supervision.
- 6. Maintain a fix CO2 input flow rate (BIAS) value provided by the Supervision.

Name	Description	PLC_Add	Device	Туре	Range
CIV_ALM_AcErr	Alarm to notify acid pump link error	000180		Bool	
CIV_ALM_BsErr	Alarm to notify base pump link error	000181		Bool	
CIV_ALM_pH	Alarm to notify problems in pH regulation	000166		Bool	
CIV_ALM_pHErr	Alarm to notify pH sensor link error	000175		Bool	
CIV_CNS_AcKp	Acid pump regulator proportional constant	400544		Real	
CIV_CNS_BsKp	Base pump regulator proportional constant	400546		Real	
CIV_CNS_CO2Kd	CO2 flow regulator derivative constant for PID	400552		Real	
CIV_CNS_CO2Kp	CO2 flow regulator proportional constant for PID	400548		Real	
CIV_CNS_CO2Ki	CO2 flow regulator integration constant for PID	400550		Real	

5.3.8.2 Variables

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Name	Description	PLC_Add	Device	Туре	Range
CIV_CNS_OffsetCO 2	Offset to provided a constant flux of CO2 to the reactor	400536		Real	
CIV_CNS_OpModep H	pH control mode ((0=Off, 1=Auto, 2=Manual)	400567		int	0,1,2
CIV_CNS_pHMODE	pH regulation mode parameter (1=CO2 only, 2=CO2+Base, 3=Base+Acid)	400560		Real	1,2,3
CIV_IND_Ac	Enable addition of Acid for pH regulation	000203		Bool	
CIV_IND_Bs	Enable addition of Base for pH regulation	000204		Bool	
CIV_IND_CO2	Enable addition of CO2 for pH regulation	000202		Bool	
CIV_MAN_Ac	Manual Acid Pump set point	400580		Real	0 – 100 %
CIV_MAN_Bs	Manual Base Pump set point	400578		Real	0 – 100 %
CIV_MAN_FrCO2	Manual CO2 flow regulation set point	400582		Real	0 – 5 nLm
CIV_MV_pH	pH measurement	300104	pH sensor	4-20 mA	0 – 14
CIV_SMV_Ac	Additional Acid source actuation in %	400234		Real	0 – 100 %
CIV_SMV_Bs	Additional Base source actuation in %	400232		Real	0 – 100 %
CIV_SMV_CacCO2	Control action to regulate CO2 input	400240		Real	0 – 5 nLm
CIV_SMV_pH	Scaled pH measurement	400230		Real	
CIV_SP_Ac	Additional Acid source for pH regulation	400110	Acid pump	4-20 mA	0-100%
CIV_SP_Bs	Additional Base source for pH regulation	400108	Base pump	4-20 mA	0 – 100 %
CIV_SP_FrCO2	CO2 flow regulation	400100	CO2 flow regulator	0-5 V	0 – 5 nLm
CIV_SSP_pH	pH set-point fixed by the supervision	400534		Real	

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5.3.8.3 Block Diagram



NOTE: PID output calculation is performed as follows (from Concept documentation):

dt: Time differential between the current cycle and the previous cycle TI: Reset time TD: Retaining time YP = GAIN * ERR

$$\begin{split} YI(new) &= YI(old) + GAIN * (dt/TI) * (ERR(new) + ERR(old))/2 \\ YD(new) &= YD(old) + TD*GAIN * (ERR(new)-ERR(old))/dt \end{split}$$

Y = YP + YI + YD

5.3.8.4 Alarms

Alarm condition	Action
pH out of the set point during 15'	Notify alarm to supervision (CIV_ALM_pH)
pH sensor failure	Set safety value (nominal set point) and notify failure. Disable PID action (PID output = 0).
Base pump link error	Notify error to supervision
Acid pump link error	Notify error to supervision

5.3.8.5 Operational modes

Mode	Description	Action
0	Off	Set acid/base pumps and CO2 flow controller outputs to 0
1	Auto	Perform control action
2	Manual	Set manual set points to acid/base pumps and CO2 flow controller.

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5.3.9 CIV_PLCSW_T: Temperature acquisition

5.3.9.1 Function

Acquire and scale temperature sensor value.

5.3.9.2 Variables

Name	Description	PLC_Address	Device	Туре	Range
CIV_ALM_T	Alarm to notify over temperature	000170		Bool	
CIV_ALM_TErr	Alarm to notify Temperature sensor link error	000179		Bool	
CIV_MV_T	Temperature measurement	300105	Temperature sensor	4-20 Ma	0 – 150 ° C
CIV_SMV_T	Scaled Temperature value	400228		Real	0 – 150 ° C
CIV_SSP_T	Temperature set-point fixed by the supervision	400562		Real	0-100 ° C

5.3.9.3 Block Diagram



5.3.9.4 Alarms

Alarm condition	Action
Temperature 5° over the set point	Notify alarm and Set light set point to a safety value (10%)
Temperature sensor failure	Set a safety value (temperature set point) and notify error.

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6 HMI

6.1 Target Platform

HMI is implemented by means of a Magelis display (Schneider Electric, model XBT-F34X). From this graphical touch-screen basic supervision functions can be performed over the local controllers.

6.2 Main HMI Display

6.2.1 MEL_HMI_Main: Main Display

In this display principal values of all compartments can be monitored. The display shall visualise following values:

Name	Description	PLC_Address
CIII_SMV_NO2	Estimation of NO2 concentration (calculated by control law)	400562
CIII_SMV_DO	DO scaled measure value	400544
CIII_SMV_LiFr	Liquid input flow rate	400596
CIII_SMV_LoFr	Liquid output flow rate	400594
CIV_SMGO_02	O2 at output measure scaled value	400216
CIV_SMV_LiFr	Liquid input flow rate	400586
CIV_SMV_LoFr	Liquid output flow rate	400238
CIV_SMV_BP	Biomass production	400584

6.2.1.1 Navigation

- CIII_HMI_Main

- CIV_HMI_Main

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6.3 CIII HMI Displays

6.3.1 CIII_HMI_Main: CIII Main display

Main display for the Compartment III which shall visualize following values:

Name	Description	PLC_Address
CIII_SMV_NO2	Estimation of NO2 concentration (calculated by control law)	400562
CIII_SMV_NO3	Nitrate concentration scaled measure	400530
CIII_SMV_NH4	Ammonium concentration scaled measure	400528
CIII_SMV_pH	pH scaled measure	400534
CIII_SMV_T	Temperature scaled measure	400532
CIII_SMV_DO	DO scaled measure value	400544
CIII_SMV_P	Pressure scaled measure value	400552
CIII_SSP_L2LiFr	Level 2 liquid Input supervision set point	400542
CIII_SMV_LiFr	Liquid input flow rate	400596
CIII_SMV_LoFr	Liquid output flow rate	400594

6.3.1.1 Navigation

- CIII_HMI_Temp
- CIII_HMI_pH
- CIII_HMI_Liquid
- CIII_HMI_Gas
- CIII_HMI_Main

6.3.2 CIII_HMI_Temp: Temperature regulation display

Display to visualize Temperature measure, and fix Temperature set point. Following values shall be visualized:

Name	Description	PLC_Address
CIII_SMV_T	Temperature scaled measure	400532
CIII_SMV_Tb	Temperature at bottom scaled measure	400608
CIII_SMV_Tt	Temperature at top scaled measure	400606
CIII_SSP_T	Temperature supervision set point	400500

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Name	Description	PLC_Address
CIII_RL_CV	Open/close the cooling valve	000084
CIII_RL_HT	Activate Heater	000085
CIII_CNS_OpModeT	Temperature control operational mode (0=Off, 1=Auto, 2=Manual)	400567

6.3.2.1 Navigation

- CIII_HMI_Temp
- CIII_HMI_pH
- CIII_HMI_Liquid
- CIII_HMI_Gas
- CIII_HMI_Main

6.3.3 CIII_HMI_pH: pH regulation display

Display to visualize pH measure, change pH control mode, and fix pH set point. Following values shall be visualized:

Name	Description	PLC_Address
CIII_SSP_pH	pH supervision set point	400504
CIII_SMV_pH	pH scaled measure	400534
CIII_SMV_PHb	Scaled pH value at bottom	400590
CIII_SMV_PHt	Scaled pH value at top	400592
CIII_SMV_Ac	Acid pump control action	400536
CIII_SMV_Bs	Base pump control action	400538
CIII_SMV_CO2	CO2 input flow control action	400540
CIII_RL_Ac	Relay acid pump	000081
CIII_RL_Bs	Relay base pump	000082
CIII_CNS_pHMode	PH regulation mode variable (1=CO2 only, 2=CO2+Base, 3=Base+Acid)	400554
CIII_CNS_OpModepH	pH control operational mode (0=Off, 1=Auto, 2=Manual)	400564

6.3.3.1 Navigation

- CIII_HMI_Temp
- CIII_HMI_pH
- CIII_HMI_Liquid
- CIII_HMI_Gas

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6.3.4 CIII_HMI_Liquid: Liquid flow regulation display

Display to visualize level, and input/output liquid flow rates and change input flow set-point. Following values shall be visualized:

Name	Description	PLC_Address
CIII_SSP_L1Lin	Level 1 liquid input supervision set point	400524
CIII_SSP_L2Lin	Level 2 Liquid input supervision set point	400542
CIII_SMV_LO	Liquid output flow control action	400550
CIII_SMV_LiFr	Liquid input flow rate	400596
CIII_SMV_NO3	Nitrate concentration scaled measure	400530
CIII_SMV_NH4	Amonium concentration scaled measure	400528
CIII_SMV_NO2	Estimation of NO2 concentration (calculated by control law)	400562
CIII_IND_Llow	Liquid level low indicator	000173
CIII_IND_Lhigh	Liquid level high indicator	000174
CIII_CNS_OpModeL	Liquid control operational mode (0=Off, 1=Auto, 2=Manual)	400565
CIII_SMV_LI	Liquid Input pump control action	400616

6.3.4.1 Navigation

- CIII_HMI_Temp
- CIII_HMI_pH
- CIII_HMI_Liquid
- CIII_HMI_Gas
- CIII_HMI_Main

6.3.5 CIII_HMI_Gas: Gas flows regulation display

Display to visualize DO, pressure measures, O2, N2 input flow rates and change DO set point. Following values shall be visualized:

Name	Description	PLC_Address
CIII_SSP_DO	DO Supervision set point	400520
CIII_SSP_P	Pressure supervision set point	400526
CIII_SMV_DO	DO scaled measure value	400544
CIII_SMV_DObot	DO at bottom scaled measure value	400604

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Name	Description	PLC_Address
CIII_SMV_DOtop	DO at top scaled measure value	400602
CIII_SMV_02	O2 input flow control action	400546
CIII_SMV_N2	N2 input flow control action	400548
CIII_SMV_CO2	CO2 input flow control action	400540
CIII_SMV_P	Pressure scaled measure value	400552
CIII_RL_P	Activation of Pressure Safety Valve	000087
CIII_CNS_OpModeGas	Gas control operational mode (0=Off, 1=Auto, 2=Manual)	400566
CIII_CNS_OpModeDO	DO regulation operational mode (0=Off, 1=Auto, 2=Manual)	400568

6.3.5.1 Navigation

- CIII_HMI_Temp
- CIII_HMI_pH
- CIII_HMI_Liquid
- CIII_HMI_Gas
- CIII_HMI_Main

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6.4 CIV HMI Displays

6.4.1 CIV_HMI_Main: CIV main display

Main display which shall visualize following values:

Name	Description	PLC_Address
CIV_SMV_BP	Biomass production	400584
CIV_SMV_CxDW	Conditioned biomass concentration in dw units	400200
CIV_SMV_FrCO2	CO2 at input measure scaled value	400210
CIV_SMV_LiFr	Liquid input flow rate	400586
CIV_SMV_LoFr	Liquid output pump flow rate	400238
CIV_SMV_FrGas	Gas flow at compartment input	400212
CIV_SMGO_02	O2 at output measure scaled value	400216
CIV_SMGO_CO2	CO2 at output measurement scaled value	400218
CIV_SMV_P	Pressure measurement scaled value	400220
CIV_SMV_T	Scaled Temperature value	400228
CIV_SMV_pH	Scaled pH measurement	400230
CIV_SSP_LightWm	Light supervision set-point in w/m2	400558

6.4.1.1 Navigation

- CIV_HMI_pH
- CIV_HMI_BP
- CIV_HMI_Gas
- CIV_HMI_Main

6.4.2 CIV_HMI_pH: pH regulation display

Display to visualise pH measure, pH actuators and modify pH set point. It shall visualize following values:

Name	Description	PLC_Address
CIV_SSP_pH	pH set-point fixed by the supervision	300234
CIV_SMV_FrCO2	CO2 at input measure scaled value	400210

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Name	Description	PLC_Address
CIV_SMV_pH	pH measurement	400230
CIV_SMV_Bs	Additional Base source actuation in %	400232
CIV_SMV_Ac	Additional Acid source actuation in %	400234
CIV_CNS_OffsetCO2	Offset to provided a constant flux of CO2 to the reactor	400536
CIV_CNS_OpModepH	pH control mode ((0=Off, 1=Auto, 2=Manual)	400567
CIV_SMV_FrGas	Gas flow at compartment input	400212

6.4.2.1 Navigation

- CIV_HMI_pH
- CIV_HMI_BP
- CIV_HMI_Gas
- CIV_HMI_Main

6.4.3 CIV_HMI_BP: Biomass production regulation display

Display to visualise Biomass concentration measure, liquid input/output flow actuators and biomass production and liquid input set points. It shall visualize following values:

Name	Description	PLC_Address
CIV_RL_Li1	Liquid Pump input1 on	000065
CIV_RL_Li2	Liquid Pump input2 on	000066
CIV_RL_Cx	Aeration of biomass sensor for cleaning	000067
CIV_SMV_Li1	Liquid Pump input1 set point in %	400222
CIV_SMV_Li2	Liquid Pump input2 set point in %	400224
CIV_SMV_LO	Liquid Pump output set point in %	400226
CIV_SMV_CxDW	Conditioned biomass concentration in dw units	400200
CIV_SMLI_V1	Volume liquid input buffer tank1	400202
CIV_SMLI_V2	Volume liquid input buffer tank2	400204
CIV_SSP_LightWm	Global variable to store light intensity in w/m2	400558
CIV_SSP_L1BP	Level 1 Biomass production set-point	400554
CIV_SSP_L2BP	Level 2 Biomass production set-point	400564

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Name	Description	PLC_Address
CIV_SSP_L1LiFr	Level 1 Liquid input flow rate set point	400508
CIV_SSP_L2LiFr	Level 2 Liquid input flow rate set point	400556
CIV_SMV_BP	Biomass production	400584
CIV_SMV_LiFr	Liquid input flow rate	400586
CIV_SMV_LOFR	Liquid output pump flow rate	400238
CIV_CNS_OpModeBP	Biomass Production control mode (0=Off, 1=Auto, 2=Manual)	400566

6.4.3.1 Navigation

- CIV_HMI_pH
- CIV_HMI_BP
- CIV_HMI_Gas
- CIV_HMI_Main

6.4.4 CIV_HMI_Gas: Gas flows regulation display

Display to visualise Gas input / output flows and CO2, air, pressure set points. It shall visualize following values:

Name	Description	PLC_Address
CIV_RL_Safety	Pressure safety valve activation	000068
CIV_IND_OverPress	Over pressure indicator	000168
CIV_IND_UnderPress	Under pressure indicator	000169
CIV_SMV_P	Pressure measurement scaled value	400220
CIV_SMGO_O2	O2 at output measure scaled value	400216
CIV_SMGO_CO2	CO2 at output measurement scaled value	400218
CIV_SMV_DO	Percent DO saturation scaled value	400206
CIV_SMGI_FrGas	Gas flow at external input	400208
CIV_SMV_FrGas	Gas flow at compartment input	400212
CIV_SMGO_FrGas	Gas flow at compartment output scaled value	400214
CIV_SMV_FrCO2	CO2 at input measure scaled value	400210
CIV_SSP_NomPress	Nominal pressure in the reactor set-point	400522

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Name	Description	PLC_Address
CIV_SSP_Fgi	Gas flow at input regulation supervision set point	400526
CIV_SSP_Fgo	Gas flow at output regulation supervision set point	400528
CIV_SSP_Fgex	Gas flow external input supervision set point	400532
CIV_CNS_OpModeGas	Gas control mode (0=Off, 1=Auto, 2=Manual)	400568

6.4.4.1 Navigation

- CIV_HMI_pH
- CIV_HMI_BP
- CIV_HMI_Gas
- CIV_HMI_Main

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7 MASTER CONTROL

7.1 Target Platform

Master control will run in the Supervision Server using the iFix platform.

7.2 CIV_CL_BP: Biomass production control law

The software that implements the Biomass regulation for Compartment IV is composed as follows:

- Control software package: C software modules funcalc.c, lightcalc.c and lspc.c provided by SHERPA that implement the control algorithm. This is described in 7.2.1, which is an excerpt of [R5].
- CIV_BPCtrlLaw: a Dynamic Link Library (DLL) that composes a binary module that can be called externally to calculate the control law outputs.
- CIV_BPCtrl: an ActiveX control to be attached to the Supervision to communicate with the PLC. Implements the control algorithm calling the CIV_BPCtrlLaw DLL.

7.2.1 SHERPA's control software package

The control software package for CIV consists of 3 files:

- lspc.c: main control program;
- funcalc.c: mathematical functions necessary to lspc.c;
- lightcal.c: bijective conversion between the light flux (W/m^2) and the index of the potentiometer of the lamps.

The source file 'lightcal.c' is not included in the main 'lspc.c' so that it can be changed when the lighting system is modified. When modification occurs on the lighting system, the relation between the light flux and the index of the potentiometer of the lamps has to be identified again. The program 'lightcal.c' has to be called :

- before the call to 'lsps.c' with the conversion option potentiometer index \rightarrow light flux;
- after the call to 'lsps.c' with the conversion option light flux \rightarrow potentiometer index;

Two main programs 'tst_lspc.c' and 'tst_lightcal.c' show an example of how to call the functions 'lspc' and 'lightcal'.

7.2.1.1 Arguments of the main control program

The arguments of the main program are listed hereafter :

LSPC(PROD_SP2,CX,QE_SP2,FR,QE_MES,SM_SUP,CONS_SUP, VOL,FI,DT,LAMBDA,INIT,VAR_OUT,TRACE)

and can be parted into different groups :

• set-points that are fixed by the operator : prod_SP2, QE_SP2;

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- measurements : CX, FR(computed by 'lightcal'), QE_MES; It is very important to note that FR is also an output argument. It has to be converted by 'lightcal' into 'potentiometer index' which has to be sent to the lighting system.
- internal variables that must be kept into the supervision program (but not initialized) from one call to the next one : SM_SUP, CONS_SUP;
- physical values : VOL, FI;
- parameters of the control : DT, LAMBDA;
- initialization flag : INIT ; It is very important to note that this flag has to be set to zero by supervision program at the first call of 'lspc' in order to initialize 'lspc' and must not be managed by the supervision program after this first call. It is set to 1 by 'lspc' itself.
- output arrays : VAR_OUT, TRACE; Only the coefficient 1 of the array VAR_OUT is useful now and contain the flow rate set-point that has to be sent to the FRC (Flow Rate Controller) of the pump. The array contains internal variables of the control and has to be saved on a disk file at each call of 'lspc' in order to check internal computations of the control.

Arguments description:

```
(v) : numerical value
(p) : pointer
PROD_SP2 (v):level2 production set point (g/h)
       (v):biomass concentration (g/l)
(v):level2 flow rate set point (l/h)
CX
QE_SP2
FR
         (p):light intensity : measured or computed by the control (W/m2)
             . input argument : measured value of FR
             . output argument : computed by the control
QE\_MES (v):measure of flow rate (1/h)
SM_SUP (p):production model output computed by the supervisor (q/h)
             . input argument : value at previous moment
             . output argument : value at present moment
CONS_SUP (p): production set point computed by the supervisor (q/h)
             . input argument : value at previous moment
             . output argument : value at present moment
VOL (v):volume of the reactor (1)
        (v):illuminated surface fraction (no dimension)
FΤ
DT
        (v):control period (h)
LAMBDA (v):dynamic of the reference trajectory (dimension less)
INIT
       (p):initialisation flag (when equal to 0)
            put to 1 by this programme
VAR_OUT[0] :level 1 production set point (g/h)
VAR_OUT[1] :level 1 flow rate set point (l/h)
VAR_OUT[2] :derivative of the model biomass concentration (g/l/h)
            (to be compared to the derivative of the process conc.)
TRACE[50] :array of internal variables to check the control
```

7.2.1.2 Conversion program between light flux and potentiometer index

A bijective function binding the light flux F_R and the 'potentiometer index of the lamps' has been built (in TN 44.1) from the UAB data (TN 37.2, p.22, April 1998) and is plotted in Figure 2.

Given :

 \boldsymbol{x} : potentiometer index of the lamps (between 0 and 1)

y : light flux F_R .

The expression of y function of x is :

 $y = a^*x^2 + b^*x + c$

The inverse function x versus y is :

 $x = (-b + (b2 - 4*a *(c-y))^{1/2} / (2*a))$

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with : a = 289.0b = 54.56c = -24.19





Figure 2: : Bijective function binding ' F_R ' and 'potentiometer index' Note : 'potentiometer index' is named 'controller action' in the figure

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7.2.2 CIV_BPCtrlLaw Dynamic Link Library

This Dynamic Link Library encapsulates the SHERPA's software control package and allows external programs to use the control function. It implements the following interface:

7.2.2.1 CIV_FR_LigthCal

Calculate FR from setting point value and the setting point value from FR

7.2.2.1.1 Input parameters

Parameter	Туре	Description
pdLightIndex	double*	Lamps Actuator Setting Point Value (between 0 and 1)
pdFR	double*	light intensity (W/m2)
iMode	int	Can be:
		CAL_FR = 0 - Calculate Light Intensity
		CAL_PO = 1 - Calculate Setting Point Value

7.2.2.1.2 Output parameters

Parameter	Туре	Description
return	int	=1 : OK =0 : Error in parameter iMode

7.2.2.2 CIV_FR_ControlLaw

Non linear PFC control of Spirulina production by light

7.2.2.2.1 Input parameters

Parameter	Туре	Description
prod_sp2	double	level2 production set point (g/h)
CX	double	biomass concentration (g/l)
qe_sp2	double	level2 flow rate set point (I/h)
Fr	double*	light intensity measured or computed by the control (W/m2)
		 input argument : measured value of FR
		output argument : computed by the control
qe_mes	double	measure of flow rate (I/h)
sm_sup	double*	production model output computed by the supervisor (g/h)
		input argument : value at previous moment
		output argument : value at present moment
cons_sup	double	production set point computed by the supervisor (g/h)
		input argument : value at previous moment
		output argument : value at present moment
Vol	double	volume of the reactor (I)
FI	double	illuminated surface fraction (no dimension)
dt	double	control period (h)
Lambda	double	dynamic of the reference trajectory (dimension less)
Init	double*	initialisation flag (when equal to 0) put to 1 by this program
var_out	double[3]	var_out[0] :level 1 production set point (g/h)
		var_out[1] :level 1 flow rate set point (l/h)
		var_out[2] :derivative of the model biomass concentration (g/l/h) (to be
		compared to the derivative of the process conc.)
Trace	double[50]	array of internal variables to check the control

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7.2.3 CIV_BPCtrl Activex Control

This Activex component eases the integration with the supervision software. Implements the following interface:

7.2.3.1 CIV_FR_LigthCal

Calculate FR from setting point value and the setting point value from FR

7.2.3.1.1 Input parameters

Parameter	Туре	Description
p_light_index	double FAR*	Lamps Actuator Setting Point Value (between 0 and 1)
p_fr	double FAR*	light intensity (W/m2)
Mode	short	Can be:
		CAL_FR = 0 - Calculate Light Intensity
		CAL_PO = 1 - Calculate Setting Point Value

7.2.3.1.2 Output parameters

Parameter	Туре	Description
Return	short	=1 : OK =0 : Error in parameter iMode

7.2.3.2 CIV_FR_ControlLaw

Non linear PFC control of Spirulina production by light

7.2.3.2.1 Input parameters

Parameter	Туре	Description
prod_sp2	double	level2 production set point (g/h)
СХ	double	biomass concentration (g/l)
qe_sp2	double	level2 flow rate set point (I/h)
p_fr	double FAR*	light intensity measured or computed by the control (W/m2)
		input argument : measured value of FR
		output argument : computed by the control
qe_mes	double	measure of flow rate (I/h)
p_sm_sup	double FAR*	production model output computed by the supervisor (g/h)
		 input argument : value at previous moment
		output argument : value at present moment
cons_sup	double	production set point computed by the supervisor (g/h)
		input argument : value at previous moment
		output argument : value at present moment
Vol	double	volume of the reactor (I)
FI	double	illuminated surface fraction (no dimension)
dt	double	control period (h)
Lambda	double	dynamic of the reference trajectory (dimension less)
p_init	double FAR*	initialisation flag (when equal to 0) put to 1 by this program
var_out	VARIANT FAR&	var_out[0] :level 1 production set point (g/h)
	size=3	var_out[1] :level 1 flow rate set point (I/h)
	type=double	var_out[2] :derivative of the model biomass concentration (g/l/h) (to be
		compared to the derivative of the process conc.)

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Parameter	Туре	Description
Trace	VARIANT FAR&	array of 50 internal variables to check the control
	size = 50	
	type = double	

7.2.4 Deployment

To use the ActiveX control in the supervision:

- 1. Copy CIV_BPCtrlLaw.dll into the System32 folder of the Supervision Server.
- 2. Copy CIV_BPCtrl.ocx control into the System32 folder of the Supervision Server.
- 3. Register CIV_BPCtrl.ocx using the tool regsvr32:
- ex.: regsvr32 CIV_BPCtrl.ocx

After these steps, the control CIV_BPCtrl is available to be used in the iFix platform. The control must be used from a scheduled task in background running as a Windows service (see Scheduler in iFix documentation).

7.2.5 PLC variables

Name	Description	PLC_Address	Device	Туре	Range
CIV_SMV_CxDW	Biomass concentration in dw units	400200		real	0-2 gr/l
CIV_SSP_LightWm	Light set-point (w/m2)	400558		real	0-300 w/m2
CIV_SSP_Light	Light supervision set-point	400520		real	0-1
CIV_SSP_L1BP	Level 1 Biomass production set-point	400554		real	0-2 g/h
CIV_SSP_L1LiFr	Level 1 Liquid input flow rate set point	400508		real	0-10 l/h
CIV_SSP_L2BP	Level 2 Biomass production set point	400564		real	0-2 g/h
CIV_SSP_L2LiFr	Level 2 Liquid input flow rate set point	400556		real	0-10 l/h

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7.3 CIII CL_NO: Nitrite Control Law

The software that implements the Biomass regulation for Compartment IV is composed as follows:

• Control software package: C software modules provided by SHERPA that implement the control algorithm. This is described in 7.3.1, which is an excerpt of [R6].

•

- CIII_NitCtrlLaw: a Dynamic Link Library (DLL) that composes a binary module that can be called externally to calculate the control law outputs.
- CIII_NitCtrl: an ActiveX control to be attached to the Supervision to communicate with the PLC. Implements the control algorithm calling the CIII_NitCtrlLaw DLL.

7.3.1 SHERPA's control software package

The control software package is composed of following files:

Name	Function of the sub-routine
nctrl.c	: Gateway from computer system
acq_par.c	: Break down of the parameters array by vectors of parameters table
estim_3.c	: Main function of estimation of state of internal model
estim_NX.c	: Estimation of nitrite and biomass concentrations
order.c	: Second and third order filter
con_3.c	: Main function of control itself
extremum.c	: Computation of the extreme of NO2 on horizon H of the scenario
integ_im.c	: Integration of state for scenario method
linterp.c	: Linear interpolation
im_nitr2.c	: State derivative of the internal model
stasysim.c	: Computation of matrices of the internal model
transbi.c	: Transfer parameters of the biphase compounds
irate.c	: Limiting coefficients for growth and maintenance rate of biomass

7.3.1.1 Functions of the control program

The program is conceived as a module with only one gateway connected to the computer system for exchanging data at a given period of time.

The 2 main functions of the program are :

- estimation of the state of the internal model;
- control itself based on a scenario method.

These 2 main functions run at different sampling periods of time : 0.1 and 1 h for the estimator and the control, respectively. The shorter value (0.1 h) is the period for exchanging data with the computer system.

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7.3.1.2 Arguments of the gateway routine

This section describes the arguments of the main C routine (named *nctrl*) that are exchanged with the external environment. This routine *nctrl* has to be called by the machine (PC or PLC) system at given period of time. This period is the sampling period of the estimator that is set to 0.1 hour. The routine *nctrl* has 6 arguments:

Name	Definition
Х	Outputs vector of control
Errors	Number and code of errors occurred in a run of the program
U	Inputs vector of control
flag_sav	Flag for saving spy files 'f_x.txt' and 'f_xef.txt' when set to 1 by the external environment
flag_ini	Initialization flag when set to 0 by the external environment
Param	Array of parameters of the control

The first two arguments are output arrays; the 2 following ones are inputs (1 array and 1 scalar).

The last argument 'flag_ini' is an input/output argument. Its function is <u>very important</u> as it implies the initialization of all the arrays of the program when its value is 0. Its returned value that is set by *nctrl* routine is 1. It has to be set to 0 by the supervisor system <u>when and only</u> when an initialization is needed, particularly to start the control or to make it to re-start.

The initial values of the arrays and internal variables depend on the values of the inputs of the process that is assumed to be at steady state at the moment of the initialization.

Description of the inputs vector 'u' :

The vector 'u' is composed of the following 21 components:

Index	Unit	Description
0	l/h	Measured liquid flow rate or setpoint of the FRC of the liquid pump
1	mol/l	O ₂ concentration in the gas input stream
2	mol/l	CO ₂ concentration in the gas input stream
3	mol/l	NH ₃ concentration in the gas input stream
4	mol/l	O ₂ concentration in the liquid input stream
5	mol/l	total CO ₂ concentration in the liquid input stream
6	mol/l	total NH ₃ concentration in the liquid input stream
7	mol/l	unused (room for NO ₂ concentration if not null)
8	mol/l	NO ₃ concentration in the liquid input stream
9	mol/l	PO ₄ concentration in the liquid input stream
10	mol/l	SO ₄ concentration in the liquid input stream
11	mol/l	O ₂ concentration in the liquid output stream
12	mol/l	total CO ₂ concentration in the liquid output stream
13	mol/l	total NH ₃ concentration in the liquid output stream
14	mol/l	NO ₃ concentration in the liquid output stream
15	mol/l	PO ₄ concentration in the liquid output stream
16	mol/l	SO ₄ concentration in the liquid output stream
17	l/h	Measured gas flow rate or setpoint of the FRC of the gas pump
18	l/h	'Required' liquid flow rate
19	mol/l	Maximum constraint of NO ₂
20	mol/l	Compensation term for estimator

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When a component of 'u' can not be measured, it should be replaced by a constant value set from the keyboard by the operator.

Description of the outputs vector 'x' :

The vector 'x' contains a lot of internal variables of the estimator and of the controller itself and has to be saved by the supervisor from one call to the next one. It is described as follows:

Limits of indices in x (C convention)	Description
0 to 20	Raw estimated state (concentrations of compounds in liquid phase of the parts A, B and C of the column)
21 to 37	Estimated NO ₂ and biomass and internal variables of the estimator
38 to 80	Array for delayed inputs
81 to 87	MV and internal variables of the controller itself
88 to 129	Temporal evolution of NO ₂ on the horizon H
130 to 150	Saving of 'u' for next call of the program by the supervisor

It is composed of 3 groups of components :

- x1 contains 81 components : the nitrite, biomass and state estimations and also internal variables of the estimator ;
- x2 contains 49 components : the MV, the behaviour of NO₂ on the scenario horizon H ;
- x3 is a saving of the inputs vector 'u' from a call to the next one and has the same size as 'u'.

With the C convention for index (where the index of the first component is 0), the MV is the component of index 81 and the estimation of NO2 is the component of index 25.

Description of the vector 'errors' :

The vector 'errors' has got 5 components :

- the first one is the number of detected errors in a run;
- the 4 following ones are the codes of the four first errors (errors are arranged in sequence of occurrence if any). The message attached to a code is detailed in a next section.

7.3.1.3 Parameters of the control

The parameters of the control are saved in an ASCII file 'f_ctrl_3.txt' that is read by the system 'iFix' at initialization (each time flag_ini is equal to 0) and loaded in the array param that will be transferred to the main control program. The parameters file is attached to the software package.

Name	Definition
dt_c	Sampling period of controller
dt_e	Sampling period of estimator
Н	Horizon of simulation of the scenario
T_s	Vector of periods of time on H
stepmax	Maximum step of the iterative algorithm in routine 'con_3'
zone_c	Vector of parameters of the zone defined around the nitrite constraint
coefil	Coefficient of the low pass filter of the inputs
Par_im0	Vector of parameters of the internal model of the control
Vv_e	Vector of volumes for the estimator time constants
beta_e	Vector of coefficients of the linear system binding rates of NH3 NO3 and NO2

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Name	Definition
delta_e	Vector of coefficients of the linear system binding rates of NH3 NO3 and the biomass
ind_3e	Vector of indices for the estimator
i_ctrl	Flag for running estimator and controller (if 1) or estimator alone (if 0)
boundin	Bounds of the validity domain of the components of the vector of inputs 'u'

7.3.1.4 Code of message

Message or error detection coming from the program are returned to the supervisor by means of a code number (in the output argument 'errors') at end of each run.

The table 6 gives the message corresponding to a code number and the subroutine where the message comes from.

Code	Content of Message	Origin
10,11,12	Identity of volumes will imply division by 0 in routine 'order'. The volumes have to corrected	acq_par
	before restarting the program.	
20	Input liquid flow rate is null. Estimation is frozen	estim_NX
21	Input liquid flow rate is null at initialization. Restart the program when liquid flow is no more	estim_NX
	null.	
22	Negative value of time constant 'tauB'	estim_NX
23	Negative value of time constant 'teta'	estim_NX
24	Negative value of time constant 'teta1'	estim_NX
25	Negative value of time constant 'teta2'	estim_NX
26	Negative value of time constant 'teta3'	estim_NX
27	Ammonia consumption rate cannot be positive (non reversible reaction)	estim_NX
28	Nitrate production rate cannot be negative (non reversible reaction)	estim_NX
29	Nitrosomonas concentration cannot be negative	estim_NX
30	No interval found for dichotomy method	con_3
31	No interval found for dichotomy method : max number of iterations has been trespassed	con_3
32	No convergence for dichotomy method	con_3
33	Sizing problem with Euler integration step and array dimension	con_3
400+j	The concentration of the component 'j' of the state vector is negative	integ_im
500+j	The value of the component 'j' of the inputs vector 'u' is outside its validity domain.	nctrl
70	Complex square root	transbi
71, 74	The first order approximation is not justified in part A of the column	transbi
72, 75	The first order approximation is not justified in part B of the column	transbi
73, 76	The first order approximation is not justified in part C of the column	transbi
90,91,92	Identity of time constants implies division by 0. The volumes have to corrected before	order
	restarting the program.	
95,96	The components of the vector x are not monotonic ascending	linterp

7.3.1.5 Method of integration on the scenario horizon

The computation of the outputs of the state system during the horizon H of the scenario is done by integration of the derivative of the state system. The Euler method has been chosen because of the simplicity of the algorithm and despite its big computational time (big computational time is acceptable because the period of the control is long : 1 hour). When the concentration of a compound reaches its limit, the system becomes non linear and the Euler method, which has no variable step, may have difficulty to deal with and the solution may be a negative concentration. So, at each integration step, each solution that is negative or zero is forced to be equal to the tenth of the limiting concentration. In fact this

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value is assumed to be the lowest value that is physically possible. This rule is applied in the routine 'integ_im'.

7.3.2 CIII_NitCtrlLaw Dynamic Link Library

This Dynamic Link Library encapsulates the SHERPA's software control package and allows external programs to use the control function. It implements the following interface:

7.3.2.1 CIII_nctrl

Main function of nitrite control

7.3.2.1.1 Input parameters

Parameter	Туре	Description
Х	double FAR*	see section 6.3.1.2
errors	double FAR*	see section 6.3.1.2
u	double FAR*	see section 6.3.1.2
flag_sav	double	Flag to save data on ASCII files (for checking internal variables)
flag_ini	double FAR*	Initialisation flag (when set to 0 by the calling program)
-		'flag_ini' is set to 1 by this program and must not be changed by the calling
		system
param	double FAR*	see section 6.3.1.2

7.3.2.1.2 Output parameters

(none)

7.3.3 CIII_NitCtrl Activex Control

This Activex component eases the integration with the supervision software. Implements the following interface:

7.3.3.1 CIII_nctrl

Main function of nitrite control

7.3.3.1.1 Input parameters

Parameter	Туре	Description
Х	VARIANT FAR& array of double	see section 6.3.1.2
	size = 151	
errors	VARIANT FAR& array of double size ₌ 5	see section 6.3.1.2
u	VARIANT FAR& array of double size = 21	see section 6.3.1.2
flag_sav	double	Flag to save data on ASCII files (for checking internal variables)

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Parameter	Туре	Description
flag_ini	double FAR&	Initialisation flag (when set to 0 by the calling program) 'flag_ini' is set to 1 by this program and must not be changed by the calling system
param	VARIANT FAR& array of double size = 21	

7.3.3.1.2 Output parameters

(none)

7.3.4 Deployment

To use the ActiveX control in the supervision:

- 1. Copy CIII_NitCtrlLaw.dll into the System32 folder of the Supervision Server.
- 2. Copy CIII_NitCtrl.ocx control into the System32 folder of the Supervision Server.
- Register CIII_NitCtrl.ocx using the tool regsvr32: ex.: regsvr32 CIII_NitCtrl.ocx

After these steps, the control CIII_NitCtrl is available to be used in the iFix platform.

The control must be used from a scheduled task in background running as a Windows service (see Scheduler in iFix documentation).

7.3.5 PLC variables

Name	Description	PLC_Address	Device	Туре	Range
CIII_SMV_NH4	Ammonium concentration scaled measure	400528		real	0-200 ppm
CIII_SMV_NO3	Nitrate concentration scaled measure	400530		real	0-1000 ppm
CIII_SSP_L1Lin	Level 1 liquid input supervision set point	400524		real	0-5 l/h
CIII_SSP_L2Lin	Level 2 liquid Input supervision set point	400542		real	0-5 l/h
CIII_SMV_NO2	Estimation of NO2 concentration (calculated by control law)	400562		real	mol/l

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8 SUPERVISION

Supervision is used to display the control system status and to modify control system parameters.

8.1 Target Platform

Supervision software runs in the iFix platform over the Supervision Server and the Supervision Client. The Supervision Server runs the supervision algorithms while the Supervision client is used as the user interface.

8.2 Display layout

Following layout is used in the supervision displays:

Mages	MELISSA C	ontrol System:	Name of the scree	n taht will ge in tyh	ies display to be	ifled with	11:33:28	AM
Meesa	🐴 cr	V Mein	CIV. pH	CIV Biomass	e CRV	- G 99	Alanns	
Ack Prienty Time	In Time Last	1	Tagname	Status	Value		Description	-
		Har Area 6 1491	Jame (recedul)	(Part: Inca)				۲
nona Alamis. 0	11	itel Ales III (94	ammerealer	Son Time	m. Descending		Run	

Title bar: Placed on the top of the window shows information about the current display and the clock.

Navigation toolbar: Placed on the top of the window allows the user to navigate to other displays.

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Working area: The green area is where the process variables and parameters will be displayed using schematics.

Alarm area: Placed on the bottom of the window will show the last alarms, allowing the user to acknowledge the alarm.

8.3 Main Supervision Display

8.3.1 MEL_Main: Main Display

8.3.1.1 Function

Form this display principal loop measures and set points will be visualised.

8.3.1.2 Values displayed

Name	Description
CIII_SMV_DO	DO scaled measure value
CIII_SMV_NO2	Estimation of NO2 concentration (calculated by control law)
CIII_SMV_LiFr	Liquid input flow rate
CIII_SMV_LoFr	Liquid output flow rate
CIV_SMV_BP	Biomass production
CIV_SMV_LiFr	Liquid input flow rate
CIV_SMV_LoFr	Computed liquid output flow rate
CIV_SMGO_O2	O2 at output measure scaled value

8.3.1.3 Navigation

From this display it is possible to navigate using the buttons next to compartment images to the following displays:

- CIII_SUP_Main
- CIV_SUP_Main

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8.4 Compartment III displays

8.4.1 MEL_CIII_MAIN: CIII Main Display

8.4.1.1 Function

Displays a general view of the compartment with the most relevant measure values of each loop.

8.4.1.2 Values displayed

Name	Description
CIII_SMV_NO3	Nitrate concentration scaled measure
CIII_SMV_NH4	Ammonium concentration scaled measure
CIII_SMV_pH	pH scaled measure
CIII_SMV_T	Temperature scaled measure
CIII_SMV_DO	DO scaled measure value
CIII_SMV_P	Pressure scaled measure value
CIII_SMV_NO2	Estimation of NO2 concentration (calculated by control law)
CIII_SMV_LiFr	Liquid input flow rate
CIII_SMV_LoFr	Liquid output flow rate
CIII_CNS_OpModeO2	DO control operational mode (0=Off, 1=Auto, 2=Manual)
CIII_CNS_OpModeP	Pressure control operational mode (0=Off, 1=Auto, 2=Manual)
CIII_CNS_OpModepH	pH control operational mode (0=Off, 1=Auto, 2=Manual)
CIII_CNS_OpModeT	Temperature control operational mode (0=Off, 1=Auto, 2=Manual)

8.4.1.3 Parameters

 Set all control loops Operational Mode to Off (CIII_CNS_OpModeO2, CIII_CNS_OpModeP, CIII_CNS_OpModePH, CIII_CNS_OpModeT = 0)

8.4.1.4 Navigation

From this display it is possible to navigate using the common navigation bar and additionally to the following displays:

- CIII_SUP_pH
- CIII_SUP_Liquid
- CIII_SUP_Gas
- CIII_SUP_Temp

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8.4.2 MEL_CIII_pH: pH Loop Display

8.4.2.1 Function

Displays variables and values that participate in the pH regulation loop.

8.4.2.2 Values displayed

Name	Description
CIII_CNS_pHramp	pH supervision set point ramp coefficient
CIII_CNS_CO2Kp	Additional proportional constant for CO2
CIII_CNS_pHKp	Proportional constant for Acid/Base PI
CIII_CNS_pHKi	Integration constant for Acid/Base PI
CIII_CNS_pHMode	PH regulation mode variable (1=CO2 only, 2=CO2+Base, 3=Base+Acid)
CIII_CNS_OpModepH	pH control operational mode (0=Off, 1=Auto, 2=Manual)
CIII_IND_CO2	Enable CO2 output to regulate pH
CIII_IND_Ac	Enable Acid pump output to regulate pH
CIII_IND_Bs	Enable Base pump output to regulate pH
CIII_RL_Ac	Relay acid pump
CIII_RL_Bs	Relay base pump
CIII_SMV_Ac	Acid pump control action
CIII_SMV_Bs	Base pump control action
CIII_SMV_CO2	CO2 input flow control action
CIII_SMV_pH	pH scaled measure
CIII_SMV_PHt	Scaled pH value at top
CIII_SMV_PHb	Scaled pH value at bottom
CIII_SSP_pH	pH supervision set point

8.4.2.3 Parameters

From this display the following parameters can be modified:

Name	Description
CIII_SSP_pH	pH supervision set point
CIII_CNS_pHramp	pH supervision set point ramp coefficient
CIII_CNS_CO2Kp	Additional proportional constant for CO2
CIII_CNS_pHKp	Proportional constant for Acid/Base PI
CIII_CNS_pHKi	Integration constant for Acid/Base PI
CIII_CNS_pHMode	PH regulation mode variable (1=CO2 only, 2=CO2+Base, 3=Base+Acid)
CIII_CNS_OpModepH	pH control operational mode (0=Off, 1=Auto, 2=Manual)

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pH regulation modes:

- 1- CO2 used to regulate pH.
- 2- CO2 fixed and a base source to regulate pH.
- 3- CO2 fixed and a base and acid sources are used to regulate pH.

8.4.2.4 Navigation

Common navigation bar.

8.4.2.5 Alarms

Alarm	Description
CIII_ALM_AcErr	Alarm to notify acid pump link error
CIII_ALM_BsErr	Alarm to notify base pump link error
CIII_ALM_pH	Alarm of pH deviation
CIII_ALM_pHbot	Alarm to notify pH bottom sensor link error
CIII_ALM_pHtop	Alarm to notify pH top sensor link error

8.4.2.6 Manual values

Allow the edition of following manual values:

Name	Description	Туре	Range
CIII_MAN_Ac	Manual acid pump set point	real	0-100%
CIII_MAN_Bs	Manual base pump set point	real	0-100%
CIII_MAN_CO2	Manual CO2 flow controller set point	real	0-100%
CIII_MAN_EnAc	Manual enable of acid pump	Bool	0-1
CIII_MAN_EnBs	Manual enable of base pump	Bool	0-1

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8.4.3 MEL_CIII_Liquid: Liquid Loop Display

8.4.3.1 Function

Displays variables and values that participate in the Liquid input / output flow regulation.

8.4.3.2 Values displayed

Name	Description
CIII_CNS_LinA	Input pump calibration constant parameter A
CIII_CNS_LinB	Input pump calibration constant parameter B
CIII_CNS_LoA	Output pump calibration constant parameter A
CIII_CNS_LoB	Output pump calibration constant parameter B
CIII_CNS_OpModeL	Liquid control operational mode (0=Off, 1=Auto, 2=Manual)
CIII_IND_Llow	Liquid level low indicator
CIII_IND_Lhigh	Liquid level high indicator
CIII_IND_CaINH4	Analyzer calibration indicator
CIII_IND_CaINO3	Nitrate calibration indicator
CIII_RL_Lbt	Activation of the pump for the buffer tank
CIII_SMV_LiFr	Liquid input flow rate
CIII_SMV_LO	Liquid output flow control action
CIII_SMV_LoFr	Liquid output flow rate
CIII_SMV_NH4	Amonium concentration scaled measure
CIII_SMV_NO2	Estimation of NO2 concentration (calculated by control law)
CIII_SMV_NO3	Nitrate concentration scaled measure
CIII_SSP_L1LI	Level 1 liquid input supervision set point
CIII_SSP_L2LI	Level 2 liquid input supervision set point

8.4.3.3 Parameters

From this display the following parameters can be modified:

Name	Description
CIII_SSP_LI	Liquid input supervision set point

8.4.3.4 Navigation

Common navigation bar.

8.4.3.5 Alarms

Alarm	Description
CIII_ALM_L	Alarm of high level
CIII_ALM_LIErr	Alarm to notify liquid input pump link error
CIII_ALM_LOErr	Alarm to notify liquid output pump link error
CIII_ALM_NH4	Alarm to notify NH4 sensor link error

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Alarm	Description
CIII_ALM_NO3	Alarm to notify NO3 sensor link error

8.4.3.6 Manual values

Allow the edition of following manual values:

Name	Name Description		Range
CIII_MAN_Lin	Liquid input pump manual value	real	0-100%
CIII_MAN_LO	Liquid output pump manual value	real	0-100%

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8.4.4 MEL_CIII_Gas: Gas Loop Display

8.4.4.1 Function

Displays variables and values that participate in the gas phase.

8.4.4.2 Values displayed

Name	Description
CIII_CNS_DOBias	Disturbance variable (Feed_fw) for DO PID
CIII_CNS_DOKd	Derivative constant for DO PID
CIII_CNS_DOKi	Integrative constant for DO PID
CIII_CNS_DOKp	Proportional constant for DO PID
CIII_CNS_DOramp	DO supervision set point ramp coefficient
CIII_CNS_N2Kp	Proportional constant for N2 regulation
CIII_CNS_OpModeGas	Gas control operational mode (0=Off, 1=Auto, 2=Manual)
CIII_RL_P	Activation of Pressure Safety Valve
CIII_SMV_DO	DO scaled measure value
CIII_SMV_DObot	DO at bottom scaled measure value
CIII_SMV_DOtop	DO at top scaled measure value
CIII_SMV_N2	N2 input flow control action
CIII_SMV_O2	O2 input flow control action
CIII_SMV_CO2	CO2 input flow control action
CIII_SMV_P	Pressure scaled measure value
CIII_SSP_DO	DO Supervision set point
CIII_SSP_P	Pressure supervision set point

8.4.4.3 Parameters

From this display the following parameters can be modified:

Name	Description
CIII_CNS_DOBias	Disturbance variable (Feed_fw) for DO PID
CIII_CNS_DOKd	Derivative constant for DO PID
CIII_CNS_DOKi	Integrative constant for DO PID
CIII_CNS_DOKp	Proportional constant for DO PID
CIII_CNS_OpModeGas	Gas control operational mode (0=Off, 1=Auto, 2=Manual)
CIII_CNS_DOramp	DO supervision set point ramp coefficient
CIII_CNS_N2Kp	Proportional constant for N2 regulation
CIII_SSP_DO	DO Supervision set point
CIII_SSP_P	Pressure supervision set point

8.4.4.4 Navigation

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Common navigation bar.

8.4.4.5 Alarms

Alarm	Description
CIII_ALM_DO	Alarm to notify DO is over the set point
CIII_ALM_DOBot	Alarm to notify DO bottom sensor link error
CIII_ALM_DOTop	Alarm to notify DO top sensor link error
CIII_ALM_P	Over pressure alarm
CIII_ALM_Perr	Alarm to notify Pressure sensor link error

8.4.4.6 Manual values

Allow the edition of following manual values:

Name	Description	Туре	Range
CIII_MAN_N2	Manual N2 flow controller set point	real	0-150%
CIII_MAN_O2	Manual O2 flow controller set point	real	0-100%
CIII_MAN_EnP	Manual enable of pressure safety valve	Bool	

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8.4.5 MEL_CIII_Temp: Temperature Loop Display

8.4.5.1 Function

Displays variables and values that participate in the temperature regulation.

8.4.5.2 Values displayed

Name	Description
CIII_CNS_Tramp	Temperature supervision set point ramp coefficient
CIII_CNS_OpModeT	Temperature control operational mode (0=Off, 1=Auto, 2=Manual)
CIII_RL_CV	Open/close the cooling valve
CIII_RL_HT	Activate Heater
CIII_SMV_T	Temperature scaled measure
CIII_SMV_Tb	Temperature at bottom scaled measure
CIII_SMV_Tt	Temperature at top scaled measure
CIII_SSP_T	Temperature supervision set point

8.4.5.3 Parameters

From this display the following parameters can be modified:

Name Description	
CIII_SSP_T	Temperature supervision set point
CIII_CNS_Tramp	Temperature supervision set point ramp coefficient
CIII_CNS_OpModeT	Temperature control operational mode (0=Off, 1=Auto, 2=Manual)

8.4.5.4 Alarms

Alarm	Description
CIII_ALM_Tbot	Alarm to notify Temperature bottom sensor link error
CIII_ALM_Tdif	Alarm of temperature difference between top and bottom
CIII_ALM_Tover	Over temperature alarm
CIII_ALM_Ttop	Alarm to notify Temperature top sensor link error
CIII_ALM_Tunder	Under temperature alarm

8.4.5.5 Manual values

Allow the edition of following manual values:

Name	Description	Туре	Range
CIII_MAN_EnCV	Manual enable of the cooling valve	Bool	0-1
CIII_MAN_EnHT	Manual enable of the heater	Bool	0-1

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8.5 Compartment IV displays

8.5.1 MEL_CIV_MAIN: CIV Main Display

8.5.1.1 Function

Displays a general view of the compartment with the most relevant measure values of each loop.

8.5.1.2 Values displayed

Name	Description
CIV_SMGO_O2	O2 at output measure scaled value
CIV_SMGO_CO2	CO2 at output measurement scaled value
CIV_SMV_BP	Biomass production
CIV_SMV_CxDW	Conditioned biomass concentration in dw units
CIV_SMV_FrCO2	CO2 at input measure scaled value
CIV_SMV_FrGas	Gas flow at compartment input
CIV_SMV_LiFr	Liquid input flow rate
CIV_SMV_LoFr	Liquid output flow rate
CIV_SMV_P	Pressure measurement scaled value
CIV_SMV_pH	Scaled pH measurement
CIV_SMV_T	Scaled Temperature value
CIV_SSP_LightWm	Light supervision set-point in w/m2
CIV_CNS_OpModeBP	Biomass Production control mode (0=Off, 1=Auto, 2=Manual)
CIV_CNS_OpModeGas	Gas control mode (0=Off, 1=Auto, 2=Manual)
CIV_CNS_OpModepH	pH control mode ((0=Off, 1=Auto, 2=Manual)

8.5.1.3 Parameters

 Set all control loops Operational Mode to Off (CIV_CNS_OpModeBP, CIV_CNS_OpModeGas, CIV_CNS_OpModepH = 0)

8.5.1.4 Navigation

From this display it is possible to navigate using the common navigation bar and additionally to the following displays:

- CIV pH Loop display
- CIV Biomass Production display
- CIV Gas Loop display

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8.5.2 MEL_CIV_pH: pH Loop Display

CIV_pH_Display

8.5.2.1 Function

Displays variables and values that participate in the pH regulation loop.

8.5.2.2 Values displayed

Name	Description	
CIV_CNS_AcKp	Acid pump regulator proportional constant for PID	
CIV_CNS_BsKp	Base pump regulator proportional constant for PID	
CIV_CNS_CO2Kd	CO2 flow regulator derivative constant for PID	
CIV_CNS_CO2Ki	CO2 flow regulator integration constant for PID	
CIV_CNS_CO2Kp	CO2 flow regulator proportional constant for PID	
CIV_CNS_OffsetCO2	Offset to provided a constant flux of CO2 to the reactor	
CIV_CNS_OpModepH	pH control mode ((0=Off, 1=Auto, 2=Manual)	
CIV_CNS_PHMODE	PH regulation mode parameter (1=CO2 only, 2=CO2+Base, 3=Base+Acid)	
CIV_IND_CO2	Enable addition of CO2 for pH regulation	
CIV_IND_Ac	Enable addition of Acid for pH regulation	
CIV_IND_Bs	Enable addition of Base for pH regulation	
CIV_SMV_FrCO2	CO2 at input measure scaled value	
CIV_SMV_Ac	Additional Acid source actuation in %	
CIV_SMV_Bs	Additional Base source actuation in %	
CIV_SMV_CacCO2	Control action to regulate CO2 input	
CIV_SMV_pH	pH measurement	
CIV_SMV_FrGas	Gas flow at compartment input	
CIV_SSP_pH	pH set-point fixed by the supervision	

8.5.2.3 Parameters

From this display the following parameters can be modified:

Name	Description
CIV_SSP_pH	pH set-point fixed by the supervision
CIV_CNS_AcKp	Acid pump regulator proportional constant for PID
CIV_CNS_BsKp	Base pump regulator proportional constant for PID
CIV_CNS_CO2Kd	CO2 flow regulator derivative constant for PID
CIV_CNS_CO2Ki	CO2 flow regulator integration constant for PID
CIV_CNS_CO2Kp	CO2 flow regulator proportional constant for PID
CIV_CNS_OffsetCO2	Offset to provided a constant flux of CO2 to the reactor
CIV_CNS_OpModepH	pH control mode ((0=Off, 1=Auto, 2=Manual)

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Name	Description
CIV_CNS_PHMODE	PH regulation mode parameter (1=CO2 only, 2=CO2+Base, 3=Base+Acid)

pH regulation modes:

- 1. CO2 used to regulate pH.
- 2. CO2 fixed and a base source to regulate pH.
- 3. CO2 fixed and a base and acid sources are used to regulate pH.

8.5.2.4 Navigation

Common navigation bar.

8.5.2.5 Alarms

Register a high-priority alarm when:

Alarm	Description
CIV_ALM_AcErr	Alarm to notify pH sensor link error
CIV_ALM_BsErr	Alarm to notify base pump link error
CIV_ALM_Ph	Alarm to notify problems in pH regulation
CIV_ALM_PhErr	Alarm to notify pH sensor link error

8.5.2.6 Manual values

Allow the edition of following manual values:

Name	Description		Range
CIV_MAN_Ac	Manual Acid Pump set point	Real	0 – 100 %
CIV_MAN_Bs	Manual Base Pump set point	Real	0 – 100 %
CIV_MAN_FrCO2	Manual CO2 flow regulation set point	Real	0 – 5 nLm

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8.5.3 MEL_CIV_BP: Biomass Production Display

8.5.3.1 Function

Displays variables and values that participate in the biomass production regulation loop.

8.5.3.2 Values displayed

Name	Description
CIV_CNS_Li1FrA	Parameter A for liquid input pump 1 set-point calculation
CIV_CNS_Li1FrB	Parameter B for liquid input pump 1 set-point calculation
CIV_CNS_Li2FrA	Parameter A for liquid input pump 2 set-point calculation
CIV_CNS_Li2FrB	Parameter B for liquid input pump 2 set-point calculation
CIV_CNS_LoFrA	Parameter A for liquid output pump set-point calculation
CIV_CNS_LoFrB	Parameter B for liquid output pump set-point calculation
CIV_CNS_MinV	Minimum volume to switch liquid input tank
CIV_CNS_ConvV	Density factor to translate Kg to liters
CIV_CNS_OpModeBP	Biomass Production control mode (0=Off, 1=Auto, 2=Manual)
CIV_RL_Li2	Liquid Pump input2 on
CIV_RL_Li1	Liquid Pump input1 on
CIV_RL_Cx	Aeration of biomass sensor for cleaning
CIV_SMV_Li1	Liquid Pump input1 set point in %
CIV_SMV_Li2	Liquid Pump input2 set point in %
CIV_SMV_LO	Liquid Pump output set point in %
CIV_SMV_Ls	Regulator of light supply actuation in %
CIV_SMV_CxDW	Conditioned biomass concentration in dw units
CIV_SMLI_V1	Volume liquid input buffer tank1
CIV_SMLI_V2	Volume liquid input buffer tank2
CIV_SMV_LiFr	Liquid input flow rate
CIV_SMV_BP	Biomass production
CIV_SMV_LoFr	Liquid output pump flow rate
CIV_SSP_LightWm	Light supervision set-point in w/m2
CIV_SSP_L1BP	Level 1 Biomass production set point
CIV_SSP_L2BP	Level 2 Biomass production set point
CIV_SSP_L1LiFr	Level 1 Liquid input flow rate set-point
CIV_SSP_L2LiFr	Level 2 Liquid input flow rate set-point
CIV_CNS_CxAbsMin	Configurable max range of biomass sensor
CIV_CNS_CxAbsMax	Configurable min range of biomass sensor
CIV_CNS_DW	Dry weight conversion factor

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8.5.3.3 Parameters

Name	Description
CIV_CNS_MinV	Minimum volume to switch liquid input tank
CIV_CNS_ConvV	Density factor to translate Kg to liters
CIV_CNS_Li1FrA	Parameter A for liquid input pump 1 set-point calculation
CIV_CNS_Li1FrB	Parameter B for liquid input pump 1 set-point calculation
CIV_CNS_Li2FrA	Parameter A for liquid input pump 2 set-point calculation
CIV_CNS_Li2FrB	Parameter B for liquid input pump 2 set-point calculation
CIV_CNS_LoFrA	Parameter A for liquid output pump set-point calculation
CIV_CNS_LoFrB	Parameter B for liquid output pump set-point calculation
CIV_SSP_L2BP	Level 2 biomass production set-point
CIV_SSP_L2LiFr	Level 2 liquid input flow rate set-point
CIV_CNS_CxAbsMin	Configurable max range of biomass sensor
CIV_CNS_CxAbsMax	Configurable min range of biomass sensor
CIV_CNS_DW	Dry weight conversion factor

From this display the following parameters can be modified:

8.5.3.4 Chart

The following variables are displayed in chart format:

Name	Description
CIV_SSP_L2BP	Global variable to store biomass production set-point
CIV_SMV_BP	Biomass production
CIV_SSP_L2LiFr	Level 2 liquid input flow rate set-point
CIV_SMV_LiFr	Liquid input flow rate
CIV_SSP_Light	Light supervision set-point
CIV_SMV_CxDW	Conditioned biomass concentration in dw units

8.5.3.5 Navigation

Common navigation bar.

8.5.3.6 Alarms

Alarm	Description
CIV_ALM_LiEmpty	Alarm liquid input tanks empty
CIV_ALM_V1Err	Alarm to notify scale1 sensor link error
CIV_ALM_V2Err	Alarm to notify scale2 sensor link error
CIV_ALM_CxErr	Alarm to notify biomass sensor link error
CIV_ALM_LsErr	Alarm to notify light supply link error

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8.5.3.7 Manual values

Allow the edition of following manual values:

Name	Description		Range
CIV_MAN_EnCx	Manual enable of biomass sensor aeration valve		0 – 1 (=cleaning)
CIV_MAN_EnLi1	Manual enable of Liquid input Pump 1	Bool	0 – 1 (=active)
CIV_MAN_EnLi2	Manual enable of Liquid input Pump 2	Bool	0 – 1 (=active)
CIV_MAN_EnLO	Manual enable of Liquid output Pump	Bool	0 – 1 (=active)
CIV_MAN_Li1	Manual Liquid Pump input1 set point	Real	0 – 100 %
CIV_MAN_Li2	Manual Liquid Pump input2 set point	Real	0 – 100 %
CIV_MAN_LO	Manual Liquid Pump output set point	Real	0 – 100 %
CIV_MAN_Ls	Manual regulator of light supply set point	Real	0 – 100 %

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8.5.4 MEL_CIV_Gas: Gas Loop Display

8.5.4.1 Function

Displays variables and values that participate in the gas flow and pressure regulation loop.

8.5.4.2 Values displayed

Name	Description	
CIV_CNS_MaxPress	Maximum allowed pressure in the reactor	
CIV_CNS_OpModeGas	Gas control mode (0=Off, 1=Auto, 2=Manual)	
CIV_IND_CalCO2O2	Calibration indicator of CO2/O2 sensor.	
CIV_IND_ErrCO2O2	Error Indicator of CO2/O2 sensor.	
CIV_IND_Scale1CO2O2	CO2/O2 sensor scale	
CIV_IND_Scale2CO2O2	CO2/O2 sensor scale	
CIV_IND_OverPress	Over pressure indicator	
CIV_IND_UnderPress	Under pressure indicator	
CIV_RL_Safety	Pressure safety valve activation	
CIV_SMGI_FrGas	Gas flow at external input	
CIV_SMGO_FrGas	Gas flow at compartment output scaled value	
CIV_SMGO_CO2	CO2 at output measurement scaled value	
CIV_SMGO_02	O2 at output measure scaled value	
CIV_SMV_DO	Percent DO saturation scaled value	
CIV_SMV_FrCO2	CO2 at input measure scaled value	
CIV_SMV_FrGas	Gas flow at compartment input	
CIV_SMV_P	Pressure measurement scaled value	
CIV_SSP_Fgex	Gas flow external input supervision set point	
CIV_SSP_Fgi	Gas flow at input regulation supervision set point	
CIV_SSP_Fgo	Gas flow at output regulation supervision set point	
CIV_SSP_NomPress	Nominal pressure in the reactor set-point	
CIV_CNS_DOMax	Configurable DO range max	
CIV_CNS_DOMin	Configurable DO range min	
CIV_CNS_CO2Max	Configurable CO2 range max	
CIV_CNS_CO2Min	Configurable CO2 range min	
CIV_CNS_O2Max	Configurable O2 range max	
CIV_CNS_O2Min	Configurable O2 range min	
CIV_CNS_CO2E2Max	Configurable Scale2 CO2 range max	
CV_CNS_CO2E2Min	Configurable Scale2 CO2 range min	
CIV_CNS_O2E2Max	Configurable Scale2 O2 range max	
CV_CNS_O2E2Min	Configurable Scale2 O2 range min	

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8.5.4.3 Parameters

Name	Description		
CIV_CNS_MaxPress	Maximum allowed pressure in the reactor		
CIV_CNS_OpModeGas	Gas control mode (0=Off, 1=Auto, 2=Manual)		
CIV_SSP_Fgex	Gas flow external input supervision set point		
CIV_SSP_Fgi	Gas flow at input regulation supervision set point		
CIV_SSP_Fgo	Gas flow at output regulation supervision set point		
CIV_SSP_NomPress	Nominal pressure in the reactor set-point		
CIV_CNS_DOMax	Configurable DO range max		
CIV_CNS_DOMin	Configurable DO range min		
CIV_CNS_CO2Max	Configurable CO2 range max		
CIV_CNS_CO2Min	Configurable CO2 range min		
CIV_CNS_O2Max	Configurable O2 range max		
CIV_CNS_O2Min	Configurable O2 range min		
CIV_CNS_CO2E2Max	Configurable Scale2 CO2 range max		
CV_CNS_CO2E2Min	Configurable Scale2 CO2 range min		
CIV_CNS_02E2Max	Configurable Scale2 O2 range max		
CV_CNS_02E2Min	Configurable Scale2 O2 range min		

From this display the following parameters can be modified:

8.5.4.4 Chart

The following variables are displayed in chart format:

Name	Description	
CIV_SMV_P	Pressure measurement scaled value	
CIV_SSP_NomPress	Nominal pressure in the reactor set-point	

8.5.4.5 Navigation

Common navigation bar.

8.5.4.6 Alarms

Alarm	Description
CIV_ALM_CO2Err	Alarm to notify CO2 sensor link error
CIV_ALM_DOErr	Alarm to notify DO sensor link error
CIV_ALM_Gas	Alarm notification for overpressure
CIV_ALM_O2Err	Alarm to notify O2 sensor link error
CIV_ALM_Perr	Alarm to notify pressure sensor link error

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8.5.4.7 Manual values

Allow the edition of following manual values:

Name	Description		Range
CIV_MAN_EnSafety	Manual enable of pressure safety valve	Bool	0 – 1 (=active)

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8.5.5 MEL_CIV_Temp: Temperature Display

8.5.5.1 Function

Displays variables and values that participate in the temperature regulation loop.

8.5.5.2 Values displayed

Name	Description	
CIV_SMV_T	Scaled Temperature value	
CIV_SSP_T	Temperature set-point fixed by the supervision	

8.5.5.3 Parameters

From this display the following parameters can be modified:

Name	Description
CIV_SSP_T	Temperature set-point fixed by the supervision

8.5.5.4 Chart

The following variables are displayed in chart format:

Name	Description
CIV_SMV_T	Scaled Temperature value
CIV_SSP_T	Temperature set-point fixed by the supervision

8.5.5.5 Navigation

Common navigation bar.

8.5.5.6 Alarms

Alarm	Description
CIV_ALM_T	Alarm to notify over temperature
CIV_ALM_Terr	Alarm to notify Temperature sensor link error

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<u>8.6</u> Supervision Database

Supervision Database is implemented as a set of Microsoft® Access MDB files with a file for each compartment. Each file contains only one table to store measured values. Files are located in the same folder as the iFix pictures ("\DYNAMICS\PIC"). Tables are separated into different MDB files in order to allow the manipulation of individual files without perturbation on the other compartments.

NOTE: To enable Database Access in iFix, DAO library has to be added into VB script object library references. See iFix documentation.

8.6.1 Update method

Supervision database is updated from iFix. A task has to be configured in the Scheduler for every compartment that updates regularly the database (initially every 1h).

8.6.2 Compartment III

Scheduler Task: MEL CIII SAVEVALUES

File	CIII_DB.mdb		
Table	CIII Measure	dValues	
Column		Description	Туре
DateTim	e (PK)	Time stamp	Date/Time
CIII_SSF	P_L2Lin	Level 2 Liquid input flow rate set point	Double
CIII_SSF	P_L1Lin	Level 1 Liquid input flow rate set point	Double
CIII_SM	V_NO3	Nitrate concentration scaled measure	Double
CIII_SM	V_NO2	Estimated nitrite concentration	Double
CIII_SM	√_N2	N ₂ to regulate DO concentration	Double
CIII_SM	V_NH4	Amonium concentration scaled measure	Double
CIII_SM	V_02	O ₂ to regulate DO concentration	Double
CIII_SSF	P_pH	pH set point	Double
CIII_SM	V_pH	pH scaled measure	Double
CIII_SM	V_CO2	CO ₂ to regulate pH	Double
CIII_SM	V_AC	Acid medium to regulate pH	Double
CIII_SM	∕_BS	Base medium to regulate pH	Double
CIII_SSF	P_T	Temperature set point	Double
CIII_SM	V_T	Temperature scaled measure	Double
CIII_SSF	P_DO	DO set point	Double
CIII_SM	V_DO	DO scaled measure value	Double
CIII_SSF	р_Р	Pressure set point	Double
CIII_SM	V_P	Pressure scaled measure value	Double
CIII_SM	V_LiFr	Liquid input flow rate	Double

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8.6.3 Compartment IVa

Scheduler Task: MEL_CIV_SAVEVALUES

File	CIV_DB.mdb		
Table	CIV_Measure	edValues	
Column		Description	Туре
DateTim	e (PK)	Time stamp	Date/Time
CIV_SM	V_CxDW	Biomass concentration in dw units	Double
CIV_SS	P_L1LiFr	Level 1 Liquid input flow rate set-point	Double
CIV_SS	P_L2LiFr	Level 2 Liquid input flow rate set-point	Double
CIV_SM	V_LiFr	Liquid input flow rate	Double
CIV_SM	V_LoFr	Liquid output flow rate supervision set-point	Double
CIV_SM	V_BP	Biomass production	Double
CIV_SSI	P_L2BP	Level 2 Biomass production set point	Double
CIV_SSI	P_L1BP	Level 1 Biomass production set point	Double
CIV_SS	P_Light	Light supervision set-point	Double
CIV_SSI	⊃_pH	pH supervision set point	Double
CIV_SM	V_pH	Scaled pH measurement	Double
CIV_SM	GO_CO2	CO ₂ at output measurement scaled value	Double
CIV_SS	P_P	Pressure supervision set point	Double
CIV_SM	V_P	Pressure measurement scaled value	Double
CIV_SM	GO_02	O ₂ at output measure scaled value	Double
CIV_SM	V_FrCO2	CO ₂ at input measure scaled value	Double
CIV_SSI	P_T	Temperature set point	Double
CIV_SM	V_T	Temperature measurement	Double
CIV_SM	V_DO	DO measurement	Double
CIV_SM	LI_V1	Tank 1 volume	Double
CIV_SM	LI_V2	Tank 2 volume	Double

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9 NETWORK CONFIGURATION

Network Address: 172.16.0.0 (reserved for private networks, not routed in Internet)

Group	Addresses
Supervision Servers	172.16.0.1 to 172.16.0.64
Supervision Clients	172.16.0.65 to 172.16.0.85
HMI	172.16.0.86 to 172.16.0.128
Local Control	172.16.0.129 to 172.16.0.256

Server Name	IP Address	Mask
MEL_SUPV_SERV01	172.16.0.1	255.255.255.0

Client Name	IP Address	Mask
MEL_SUPV_CLI01	172.16.0.65	255.255.255.0
HMI	IP Address	Mask
MEL_HMI_01	172.16.0.86	255.255.255.0
Local Control	IP Address	Mask
CI_PLC	172.16.0.129 (*)	255.255.255.0
CII_PLC	172.16.0.133	255.255.255.0
CIII_PLC	172.16.0.137	255.255.255.0
CIV_PLC	172.16.0.141	255.255.255.0

(*) Four addresses are reserved for each PLC to reserve addresses for a second CPU for redundant configuration and for a second Ethernet module to implement the redundant network.

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10 APPENDIX A. VARIABLE MNEMONICS

Process variables mnemonics have been selected following MELISSA's common used naming conventions stated in [A3], section 11.2.

In addition to the process variables there are internal variables that need to be used for calculations or to exchange data between the PLC and the Supervision (tags). Internal variables are not considered here but the tags follow the following rules:

All tag names can be divided into three parts:

- Compartment identification (CIV, CIII)
- Purpose of the tag:
 - CNS: Constant parameter
 - RL: Digital output (relay)
 - ALM: Alarm
 - IND: Indicator
 - MV: Measured variable (of the process)
 - SP: Set point
 - SMV: Scaled value to be monitored from the Supervision.
 - SSP: Supervision provided set point.
 - MAN: Manual set points.
- Name

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MELISSA

Contract Number: ESTEC/CONTRACT: 15671/01/NL/ND

Technical Note: 72.4 VOLUME II-c

Control System Demonstrator Operations Manual

Version: 1

Issue: 1



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NTE Document Number:	MEL-3320-HB-042-NTE
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Document Change Log

Version	Issue	Date	Observations
1	0	15 Apr 2004	New document
1	1	28 Jul 2004	Acronyms list added
			ESA comments dated 21/07/04 implemented.

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ACRONYMS LIST

AC	Alternate Current
CIII	Compartment III
CIV	Compartment IV
CPU	Central Process Unit
DC	Direct Current
DW	Dry weight
ESA	European Space Agency
FBD	Function Block Diagram .
FG	Function Generator
GND	Ground
HDD	Hardware Design Document
HMI	Human Machine Interface
LED	Light Emitting Diode
PID	Proportional, Derivative, Integration
PLC	Programmable Logic Controller
SCADA	Supervisory Control And Data Acquisition
SDD	Software Design Document
STP	Shielded Twisted Pair
UAB	Universitat Autònoma de Barcelona
VBA	Visual Basic for Applications

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1 SCOPE

This Operations Manual is intended to help the operation and maintenance of the Control System Demonstrator for compartments III and IV in the MELISSA Plant installed at the UAB.

The detailed design description of this system is provided in the Hardware Design Document and Software Design Document, [R2] and [R3] respectively.

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

- [A1] MELISSA. Adaptation for Space, Phase 1. Statement of Work.TOS-MCT/2000/2977/ln/CL. Issue 5. April 2001.
- [A2] MELISSA. Adaptation for Space-Phase 1. Proposal issued by NTE. MEL-0000-OF-001-NTE. Issue 2. October 2001.
- [A3] Memorandum of Understanding between the UAB and NTE S.A. MEL-0000-SP-007-NTE. Version 1. Issue 0. 21 January 2002.
- [A4] *Reglamento de Baja Tensión* (**RBT**), July 2002.
- [A5] MELISSA Control System Architecture and Trade-off. TN 72.3. Version 1. Issue 0. February 2003.

<u>2.2 Reference Documents</u>

- **[R1] Definition of the control requirements for the MELISSA Loop.** TN 72.2, v.1.2, November 2002.
- [R2] Melissa Control System Demonstrator Hardware Design Document, TN 72.4 Volume IIa, v.1.1, July 2004 (MEL-3320-RP-020-NTE)
- [R3] Melissa Control System Demonstrator Software Design Document, TN 72.4 Volume IIb, v.1.1, July 2004 (MEL-3320-RP-025-NTE)
- [R4] iFix Electronic Books. iFIX Version 3.0 06.02 software distribution, 2002
- [R5] Modicon Quantum Automation Series Hardware Reference Guide. 840 USE 100 00 version 10.0, 2002
- [**R6**] Concept User Manual. Volume 1, 840 USE 493 00 eng., Version 2.5 SR2. September 2001

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3 INTRODUCTION

3.1 Intended Readership

This manual is intended for personnel in charge of the operation of the MELISSA Control System for both maintenance and scientific purposes.

- Investigators responsible of performing in-plant experiments.
- Maintenance and troubleshooting personnel in charge of the installation and maintenance of the MELISSA Pilot Plant Software.

It is expected that users have some basic Microsoft® Windows knowledge and familiarity with the MELISSA Pilot Plant.

Note that no detailed explanation about the operation of third-party software(s) used to implement the Control System is given in this manual, but only reference to their corresponding user manuals when more detail is needed.

3.2 Applicability Statement

This manual applies to the Control System Demonstrator developed to assess the capability of the Control System Architecture [A5] to achieve Control System Requirements stated in [R1]. The Control System comprises the following parts:

- CIII Rack, including control hardware for compartment III and running CIII local regulation loops.
- CIV Rack, including control hardware for compartment IV and running CIV local regulation loops.
- Supervision Rack including the Supervision server and the network switch and running Supervision software iFIX 3.0 (server application).
- Client Computer, running the supervision software iFIX 3.0 (client application), Concept 2.6 (Quantum PLC programming tool) and XBT-L1000 V3 (MAGELIS programming tool).

3.3 Purpose

The purpose of this document is to provide the user with an understanding of the functions available in the MELISSA Control System Demonstrator and a description of the common operations to be performed during its utilisation and maintenance. Following the instructions described in this manual will lead to a better understanding and to obtain a full profit of the MELISSA Control System Demonstrator.

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3.4 How to use this document

The Overview section is intended for all users. It summarises what this system is used for, into the process of using the MELISSA Pilot Plant.

The Table of Contents can be used to easily locate the detailed description of a specific function.

Maintenance and troubleshooting are addressed in par. 12 and 13 respectively.

3.5 Problem reporting instructions

Problems found must be reported to NTE following the form included in APPENDIX B.

NTE S.A. Pol. Can Malé s/n 08186 Lliça d'Amunt Barcelona Spain www.nte.es info@nte.es Tel.: 93 860 9001 Fax: 93 860 9019

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4 OVERVIEW

The Melissa Control System Demonstrator has been designed as to permit the verification of some key aspects of the new MELISSA Control System Architecture described in [A5]. The aspects to be verified as previously agreed with ESA, are the following:

- In-plant verification of the Control law for the *Spirulina* compartment (variables, loops etc.) with the new control HW.
- In-plant verification of the Control law for the Nitrifying compartment. (Variables, loops etc.) with the new control HW.
- Verification of local regulation loops.
- Non-nominal tests to verify alarm management

Based on these verification objectives NTE proposed for implementation the Control System demonstrator for compartments CIII and CIV. HW and SW design details can be found in [R2] and [R3].

Figure 1 presents the demonstrator conceptual design and how it is implemented in terms of equipment and products. Redundant elements are not implemented within the demonstrator HW.

The demonstrator HW presents the following configuration:

- Client computer
- Supervisory rack, housing the supervision server and the Ethernet switch
- Compartment III (CIII) rack, housing the CIII PLC and auxiliary electronic equipment, implementing the local control for the MELISSA Nitrifying compartment and providing electrical interface to the Plant's sensors and actuators related to CIII.
- Compartment IV (CIV) rack, housing the CIV PLC and auxiliary electronic equipment implementing the local control for the MELISSA Spirulina compartment and providing electrical interface to the Plant's sensors and actuators related to CIV.
- HMI Touch screen

All these elements are to be interconnected through an Ethernet network.

Note: CIII and CIV racks are generically referred in this document as controller racks.

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Figure 1: Control System demonstrator concept

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5 HARDWARE DESCRIPTION

5.1 Controller racks common characteristics

Controller racks house the hardware necessary to implement the control of the Compartment III and IV. The mechanical characteristics of the controller racks are the following:

- Brand and model: RITTAL TS 8
- Ruggerised for laboratory environment
- Dimensions (h x w x l): 200 X 61 X 62 cm
- Includes a Fan system with 2 units for thermal dissipation
- Includes four wheels for mobility

5.2 Compartment III rack

This section contains the description of the specific characteristics of the rack for the Compartment III.

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5.2.1 Compartment III rack description

Figure 2. Rack III elements localisation.

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Rack III elements (as in Figure 2):

- 1. PLC Power supply module
- 2. PLC CPU module
- 3. PLC Ethernet communications module
- 4. I/O modules (16 AI, 8 AO, 16 DI, 16 DO)
- 5. AC input (6 Amp max.)
- 6. I/O signals (CIII_CP)
- 7. AC output (direct or via relay, 2 Amp max.) (CIII_AC_OUT)
- 8. Free space reserved for future use
- 9. Ethernet connector
- 10. I/O connectors
- 11. Relays
- 12. Power supply 12 V DC
- 13. 12 V connector panel
- 14. AC output magnetothermic switch (bipolar circuit breaker at 2 Amp).
- 15. Differential switch (current leak circuit breaker at AC input, 30 mA sensibility).
- 16. AC input magnetothermic switch (bipolar circuit breaker at 6 Amp).
- 17. Ground strip bar
- 18. Uninterrupted Power Supply

Туре	10	N	CIII_CP pin out	Name	Device	Electric Range	Measurement Range	Description
А	I	01	001 005	CIII_MV_DObot	Oxygen analyser	4-20 mA	0 – 100 %	DO at bottom
А	I	02	009 013	CIII_MV_DOtop	Oxygen analyser	4-20 mA	0 – 100 %	DO at top
A	I	03	017 021	CIII_MV_NH4	Ammonium analyser	4-20 mA	0 – 200 ppm N- NH4+	Ammonium concentration at top
A	I	04	025 029	CIII_MV_NO3	NO3 analyser	4-20 mA	0 – 1000 ppm N- NO3-	Nitrate concentration
А	Ι	05	033 037	CIII_MV_P	Pressure sensor	4-20 mA	0 – 1000 mb	Pressure at top of the gas phase
А	Ι	06	041 045	CIII_MV_PHb	pH meter	4-20 mA	3 – 13	pH at bottom
А	Ι	07	049 053	CIII_MV_PHt	pH meter	4-20 mA	1.5 – 11.5	pH at Top
A	I	08	057 061	CIII_MV_PsI	Sampling line pressure sensor	4-20 mA	-10 – 15 mb	Pressure sensor for the sampling lineq
А	Ι	09	065 069	CIII_MV_Tb	Thermometer	4-20 mA	0.2 – 147 °C	Temperature at bottom
А	Ι	10	073 077	CIII_MV_Tt	Thermometer	4-20 mA	0.2 – 147 °C	Temperature at top
А	Ι	11	081 085	Not used	Not used	4-20 mA	Not used	Not used
А	Ι	12	089 093	Not used	Not used	4-20 mA	Not used	Not used
А	I	13	097 101	Not used	Not used	4-20 mA	Not used	Not used
А	I	14	105 109	Not used	Not used	4-20 mA	Not used	Not used

5.2.2 Compartment III I/O signals table (CIII_CP)

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Туре	10	N	CIII_CP pin out	Name	Device	Electric Range	Measurement Range	Description	
А	I	15	113 117	Not used	Not used	4-20 mA	Not used	Not used	
А	I	16	121 125	Not used	Not used	4-20 mA	Not used	Not used	
А	0	01	129 133	CIII_FC_CO2	CO2 flow controller	0-5 V	0 – 100 %	CO2 mass flow meter	
А	0	02	137 141	CIII_FC_N2	N2 flow controller	0-5 V	0 – 150 %	N2 flow controller	
А	0	03	145 149	CIII_FC_02	O2 flow controller	0-5 V	0 – 100 %	O2 flow controller	
А	0	04	153 157	Not used	Not used	0-5 V	Not used	Not used	
А	0	05	161 165	CIII_PM_Ac	Acid pump	4-20 mA	0 – 100 %	Acid pump	
А	0	06	169 173	CIII_PM_Bs	Base pump	4-20 mA	0 – 100 %	Base pump	
А	0	07	177 181	CIII_PM_FI	Input media pump	4-20 mA	0 – 100 %	Input media pump	
А	0	80	185 189	CIII_PM_L	Output liquid pump	4-20 mA	0 – 100 %	Output liquid pump	
D	I	01	193 197	CIII_CAL_NH4	Ammonium analyser	N/A	0-1 (=calibrating)	Analyser calibration indicator	
D	Ι	02	002 006	CIII_CAL_NO3	NO3 analyser	N/A	0-1 (=calibrating)	Nitrate calibration indicator	
D	I	03	010 014	CIII_MV_L1	Level sensor	N/A	0-1 (=level reached)	Level measurement top	
D	I	04	018 022	CIII_MV_L2	Level sensor	N/A	0-1 (=level reached)	Level measurement bottom	
D	I	05	026 030	CIII_MVI_Lbt	Level sensor	N/A	0-1 (=level reached)	Indicator of max level reached for a buffer tank	
D	I	06	034 038	Not used	Not used	N/A	Not used	Not used	
D	I	07	042 046	Not used	Not used	N/A	Not used	Not used	
D	I	08	050 054	Not used	Not used	N/A	Not used	Not used	
D	Ι	09	058 062	Not used	Not used	N/A	Not used	Not used	
D	Ι	10	066 070	Not used	Not used	N/A	Not used	Not used	
D	Ι	11	074 078	Not used	Not used	N/A	Not used	Not used	
D	Ι	12	082 086	Not used	Not used	N/A	Not used	Not used	
D	Ι	13	090 094	Not used	Not used	N/A	Not used	Not used	
D	Ι	14	098 102	Not used	Not used	N/A	Not used	Not used	
D	Ι	15	106 110	Not used	Not used	N/A	Not used	Not used	
D	I	16	114 118	Not used	Not used	N/A	Not used	Not used	
D	0	01	122 126	CIII_PM_Lbt	Pump buffer tank	0-24 V	0-1 (=Active)	Activation of the pump for the buffer tank	
D	0	09	130 134	CIII_RL_Ac	Acid pump	0-24 V	0-1 (=Active)	Activation of Acid pump	
D	0	10	138 142	CIII_RL_Bs	Base pump	0-24 V	0-1 (=Active)	Activation of Base pump	
D	0	11	146 150	Not used	Not used	0-24 V	Not used	Not used	
D	0	12	154 158	Not used	Not used	0-24 V	Not used	Not used	
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Туре	10	Ν	CIII_CP pin out	Name	Device	Electric Range	Measurement Range	Description
D	0	13	162 166	Not used	Not used	0-24 V	Not used	Not used
D	0	14	170 174	Not used	Not used	0-24 V	Not used	Not used
D	0	15	178 182	Not used	Not used	0-24 V	Not used	Not used
D	0	16	186 190	Not used	Not used	0-24 V	Not used	Not used

5.2.3 Compartment III AC output table (CIII_AC_OUT)

Туре	10	Ν	CIII_AC_OUT pin out	Name	Device	Electric Range	Measurement Range	Description
D	0	04	146 150	CIII_RL_Comp	Compressor	220 VAC	0-1 (=Active)	Compressor activation
D	0	05	154 158	CIII_RL_CV	Cooling valve	220 VAC	0-1 (=Active)	Cooling valve
D	0	06	162 166	CIII_RL_HT	Heater resistance	220 VAC	0-1 (=Active)	Heater
D	0	08	178 182	CIII_RL_P	Pressure solenoid valve	220 VAC	0-1 (=Active)	Solenoid valve for pressure regulation

5.3 Compartment IV rack

This section contains the description of the specific characteristics of the rack for the compartment IV.

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5.3.1 Compartment IV rack description

Figure 3. Rack IV elements localisation.

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Rack IV elements (as in Figure 3):

- 1. PLC Power supply module
- 2. PLC CPU module
- 3. PLC Ethernet communications module
- 4. PLC I/O modules (16 AI, 8 AO, 16 DI, 16 DO)
- 5. Ethernet connector
- 6. I/O signals connection panel (CIV_CP)
- 7. AC output connector panel (direct or via relay, 2 Amp max.) (CIV_AC_OUT)
- 8. AC input connection (6 Amp max.)
- 9. Free space reserved for future use
- 10. I/O internal connectors
- 11. AC input magnetothermic switch (bipolar circuit breaker at 6 Amp).
- 12. AC output magnetothermic switch (bipolar circuit breaker at 2 Amp).
- 13. Relays
- 14. Power supply 12 VDC
- 15. 12 VDC connection panel
- 16. Differential switch (current leak circuit breaker at AC input, 30 mA sensibility)
- 17. Ground strip
- 18. Uninterrupted Power Supply

5.3.2 Compartment IV I/O signals table (CIV_CP)

Туре	10	N	CIV_CP pin out	Name	Device		Electric Range	Measurement range	Description	
А	I	01	001 005	CIV_MV_Cx	Biomass sensor		4-20 mA	Configurable	Biomass measurement	
A	Ι	02	009 013	CIV_MV_M1	Scale 1		4-20 mA	0 – 150 kg	Mass measurement to determine input flow	
A	Ι	03	017 021	CIV_MV_M2	Scale 2		4-20 mA	0 – 150 kg	Mass measurement to determine input flow	
А	Ι	04	025 029	CIV_MV_P	Pressure sensor		4-20 mA	0 – 1.5 bar	Pressure measurement	
А	Ι	05	033 037	CIV_MV_pH	pH sensor		4-20 mA	0 – 14	pH measurement	
А	Ι	06	041 045	CIV_MV_T	Temperature sensor	r	4-20mA	0 – 150 °C	Temperature measurement	
А	Ι	07	049 053	CIV_MGO_02	O2 gas sensor		4-20 mA	Configurable	Measure O2 at gas output	
А	Ι	08	057 061	CIV_MGO_CO2	CO2 gas sensor		4-20 mA	Configurable	Measure CO2 at gas output	
А	Ι	09	065 069	CIV_MV_DO	Dissolved Oxygen sen	ISOr	4-20 mA	Configurable	Percent of O2 saturation in the reactor	
А	Ι	10	073 077	Not used	Not used		4-20 mA	Not used	Not used	
А	Ι	11	081 085	Not used	Not used		4-20 mA	Not used	Not used	
А	Ι	12	089 093	Not used	Not used		4-20 mA	Not used	Not used	
А	Ι	13	097 101	CIV_MGI_Fg	Flowmeter		0-5 V	0 – 30 nLm*	30 nLm* Gas flow at input	
А	Ι	14	105 109	CIV_MGO_Fg	Flowmeter		0-5 V	0 – 30 nLm	Gas flow at output	
А	Ι	15	113 117	CIV_MV_CO2	CO ₂ flowmeter	0-5 V 0 – 5 nLm CO ₂ flow me		flow measurement		
А	Ι	16	121 125	CIV_MV_Fg	Flowmeter		0-5 V	0 – 30 nLm	Gas flow re-circulation	
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Туре	10	Ν	CIV_CP pin out	Name	Device	Electric Range	Measurement range	Description	
А	0	01	129 133	CIV_FR_CO2	CO ₂ flow regulator	0-5 V	0 – 5 nLm	CO ₂ flow regulation	
А	0	02	137 141	CIV_PM_Fgi	Flow regulator	0-5 V	0 – 30 nLm	Gas flow at input regulation	
А	0	03	145 149	CIV_PM_Fgo	Flow regulator	0-5 V	0 – 30 nLm	Gas flow at output regulation	
А	0	04	153 157	CIV_PM_Fgex	Flow regulator	0-5 V	0 – 30 nLm	Gas flow re-circulation regulation	
А	0	05	161 165	CIV_PM_Li1	Liquid input pump1	0-5 V	0 – 100 %	Liquid Pump input1 set point	
А	0	06	169 173	CIV_PM_Li2	Liquid input pump2	0-5 V	0 – 100 %	Liquid Pump input1 set point	
А	0	07	177 181	CIV_PM_LO	Liquid output pump	0-5 V	0 – 100 %	Liquid Pump output set point	
А	0	08	185 189	Not used	Not used	0-5 V	Not used	Not used	
А	0	09	193 197	CIV_PM_Bs	Base pump	4-20mA	0 – 100 %	Additional Base source for pH regulation	
А	0	10	201 205	CIV_RG_Ls	Light regulator	4-20 mA	0 – 100 %	Regulator of light supply	
А	0	11	209 213	CIV_PM_Ac	Acid pump	4-20 mA	0 – 100 %	Additional Acid source for pH regulation	
А	0	12	002 006	CIV_PM_Ac	Acid pump	4-20 mA	0 – 100 %	Additional Acid source for pH regulation	
А	0	13	010 014	CIV_PM_Ac	Acid pump	4-20 mA	0 – 100 %	Additional Acid source for pH regulation	
А	0	14	018 022	CIV_PM_Ac	Acid pump	4-20 mA	0 – 100 %	Additional Acid source for pH regulation	
А	0	15	026 030	CIV_PM_Ac	Acid pump	4-20 mA	0 – 100 %	Additional Acid source for pH regulation	
А	0	16	034 038	CIV_PM_Ac	Acid pump 4-20 mA		0 – 100 %	Additional Acid source for pH regulation	
D	Ι	01	042 046	CIV_CAL_CO2O2	CO2/O2 sensor	N/A	0-1 (=Calibr.)	Calibration indicator of CO2/O2 sensor.	
D	Ι	02	050 054	CIV_ERR_CO2O2	CO2/O2 sensor	N/A	0 (=Error) – 1 (=Ok)	Error Indicator of CO2/O2 sensor.	
D	Ι	03	058 062	CIV_SCL1_CO2O2	CO2/O2 sensor	N/A	0 =using scale 1 1=using scale 2	CO2/O2 sensor is using scale 1	
D	-	04	066 070	CIV_SCL2_CO2O2	CO2/O2 sensor	N/A	0 =using scale 1 1=using scale 2	CO2/O2 sensor is using scale 2	
D	Ι	05	074 078	Not used	Not used	N/A	Not used	Not used	
D	Ι	06	082 086	Not used	Not used	N/A	Not used	Not used	
D	Ι	07	090 094	Not used	Not used	N/A	Not used	Not used	
D	Ι	08	098 102	Not used	Not used	N/A	Not used	Not used	
D	Ι	09	106 110	Not used	Not used	N/A	Not used	Not used	
D	Ι	10	114 118	Not used	Not used	N/A	Not used	Not used	
D	Ι	11	122 126	Not used	Not used	N/A	Not used	Not used	
D	Ι	12	130 134	Not used	Not used	N/A	Not used	Not used	
D	Ι	13	138 142	Not used	Not used	N/A	Not used	Not used	
D	Ι	14	146 150	Not used	Not used	N/A	Not used	Not used	
D	Ι	15	154 158	Not used	Not used	N/A	Not used	Not used	
D	Ι	16	162 166	Not used	Not used	N/A	Not used	Not used	
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Туре	10	N	CIV_CP pin out	Name	Device	Electric Range	Measurement range	Description
D	0	01	170 174	CIV_RL_Li1	Enable liquid input pump1	0-24 V	0 – 1 (=active)	Relay liquid Pump input1
D	0	02	178 182	CIV_RL_Li2	Enable liquid input pump2	0-24 V	0 – 1 (=active)	Relay liquid Pump input2
D	0	05	186 190	Not used	Not used		Not used	Relay 05
D	0	06	194 198	Not used	Not used		Not used	Relay 06
D	0	07	202 206	Not used	Not used	0-24 V	Not used	Not used
D	0	08	210 214	Not used	Not used	0-24 V	Not used	Not used

5.3.3 Compartment IV AC output table (CIV_AC_OUT)

Туре	10	Ν	CIV_AC_OUT pin out	Name	Device	Electric Range	Measurement range	Description
D	0	03	001 003 005	CIV_RL_Cx	Electrovalve	220 VAC	0 – 1 (=cleaning)	Aeration of biomass sensor for cleaning
D	0	04	007 009 011	CIV_RL_Fg	Pressure valve	220 VAC	0 – 1 (=close)	Pressure safety valve activation

5.4 Supervision rack

This rack has to be placed in a conditioned room (UAB Plant Control room). Allocates an Ethernet switch (MEL_SWITCH01) and the Supervision Server (MEL_SUPV_SERV01). No specific design is associated to this element, whose characteristics are standard. Some detailed information is presented hereafter:

MEL_SUPV_SERV01	
Model:	Dell Power Edge 2600
	17" monitor, mouse and keyboard.
Power supply:	2x220 VAC 50 Hz redundant.
Network:	2xEthernet 10/100/1000
Storage:	2 SCSI disks 36 GB in Raid 3 configuration
	1 Floppy
	1 CDR
	1 Tape (for backup purposes)
Main SW components:	MS Windows 2000 Server
	iFix (Server Only license)
	MBE Driver (PLC communications driver)
Physical location:	Plant's control room (in Supervision Rack)

MEL_SWITCH01							
Model:		3Com - Super Stack 3					
Power supply: 2		220 VAC 50 H	220 VAC 50 Hz redundant.				
Characteristics:		16 x 10/1000 Mbps Standard Ethernet ports					
Physical location: Plant's contr		Plant's control	l room (in S	upervision	Rack)		
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- Dimensions (h x w x l): 625 X 600 X 800 mm
- equipped with wheels to easy the mobility.



Figure 4. Supervision Rack components distribution.



Figure 5. Supervision Rack rear side view.

Supervision Rack rear side view elements:

- 1. AC power cable, to be connected to main power line.
- 2. Network cables to be connected to racks, supervision clients and HMI.
- 3. Supervision Server mouse, keyboard and monitor cables.
- 4. Redundant AC power cable, to be connected to secondary power line.

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5.5 Supervision client

This computer is used to visualise supervision displays and to upload / download PLC programs.

No specific design is associated to this element, whose characteristics are standard. Some detailed information is presented hereafter:

MEL_SUPV_CLI01			
Model:	Dell OptiPlex GX260 P4 1.8 GHz		
	1 DVD		
	1 Floppy		
	17" monitor, mouse and keyboard.		
Power supply:	220 VAC 50 Hz		
Network:	Ethernet 10/100		
Main SW components:	MS Windows XP Professional Edition		
	Concept V2.6 XL EN		
	iFix (Developer Client license)		
	XBT-L1000 V3 (HMI SW development tool)		
Physical location:	Plant's control room		

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<u>5.6 HMI</u>

The HMI will be placed near to the compartments to provide a way of monitor process data of any compartment from inside the lab. This device consists on a MAGELIS touch-screen XBT with the following characteristics:

MEL_HMI_01					
Model:	XBT-F34X touch-sensitive screen 10,4" 640x480 colour display.				
Power supply:	24 VC				
Main SW components:	XBT-L1000 V3				
Network:	Ethernet 10/100				
Physical location	Laboratory				

The device has been mounted into a PVC box that includes:

- A 24VC power supply dimensioned to power the screen (including a 1m power cord to plug to the 220/50 Hz AC source)
- An Ethernet connector to provide connection to the control network.
- A parallel port for an optional printer
- A serial port for maintenance



Figure 6. HMI touch-screen front view.

HMI touch-screen elements (as in Figure 6):

- 1. Parallel connector, to be connected to an optional printer for alarm management.
- 2. Serial connector, to download the software in case Ethernet is not available.
- 3. Display
- 4. Ethernet connector, to be connected to the control network.
- 5. AC power cable, to be connected to power line.

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6 HARDWARE OPERATION

6.1 Supervision rack installation

This procedure will describe the steps to perform the installation of the Supervision rack. The Supervision Rack is described in section 5.4. To install the rack perform the following steps:

- 1. Remove the screws on the back part of the rack and dismount the back door.
- 2. Pass all cables through the slot in the back door and connect them to the respective connectors in the Supervision Server (Power, mouse, monitor and keyboard) and in the switch (network cables).
- 3. Mount the back door in the rack.
- 4. Plug the power cables to the main power line.

Important

The Supervision Server is equipped with a dual redundant power supply. In order to avoid power loss both power cables must be connected and preferably to two different power sources, that is, to an emergency power source and to the common power line.

6.2 Controller racks installation

This procedure will describe the steps to perform the installation of the controller racks. The installation will consist on:

- Connecting power pipe to the rack AC input.
- Connecting the rack to the control network.
- Connecting analogue and digital outputs.
- Connecting AC outputs via relay.
- Connecting the rack to the mains.

CAUTION

Plugging the power pipe to the mains must be the last step in installation procedure. In addition, to avoid personal injures and device damages during hardware operation a proper ground shall be provided to the power input.

To install the rack perform the following steps:

- 1. Connect a proper dimensioned power line 3-wire cable to AC in (see localisation in figure 2 and 3). Connect GND (yellow/green), AC L (brown), and AC N (blue) to the respective connectors.
- 2. Plug a Cat5 STP network cable to Ethernet input (see localisation in figure 2 and 3).
- 3. Connect analogue and digital signals as described in sections 5.2.2 and 5.3.2.
- 4. Plug the AC connector to the mains.
- 5. Power on the rack following the procedure described in section 6.4.

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6.3 Controller racks power off

This section will describe the steps to power off the controller racks (CIII and CIV Racks) properly. This action will be usually taken before performing any maintenance operation in the rack since the rack must be powered off.

CAUTION

When the rack is powered off the controller outputs are disabled and all devices receiving power directly from the rack electronics will be powerless. Therefore the related reactor will be out of control.

Once the rack has been powered off, the PLC controller, power supplies and all electronic devices will be powerless. This can be verified checking activity LED in all those devices. The PLC controller has a battery that can maintain the status of the controller memory during some hours (depending on the status of the battery). Therefore, when the rack is powered again, the same status as when powered off will be recovered and used.

To power off the rack perform following steps:

- 1. Switch off the AC output magnetothermic. This action will interrupt power to the devices connected via relay to AC.
- 2. Turn off the uninterrupted power supply that powers the PLC. This action will switch off the PLC.
- 3. Switch off the AC input magnetothermic. This action will cut AC power input. The 24VC power supply will be switched off.
- 4. Switch off the differential switch. This action will interrupt AC power input.

Note: switches can be identified in Figure 2 for CIII rack and in Figure 3 for CIV rack.

6.4 Controller racks power on

This section will describe the steps to power on the controller racks (CIII and CIV Racks) properly. This action will be usually taken after performing any maintenance operation in the rack.

CAUTION

In case that during a maintenance operation any modification of the wiring has been performed a connectivity test must be passed before powering on the rack.

Once the rack has been powered on, the PLC controller, power supplies and all electronic devices will be switched on, this can be verified checking activity LED in all these devices. Because the PLC controller has a battery that can maintain the status of the controller memory during some hours (depending on the status of the battery), when the rack is powered again, the same status as when powered off will be recovered and used.

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To power on the rack perform following steps:

- 1. Switch on the differential switch. This action will restore AC power input.
- 2. Switch on the AC input magnetothermic. This action will connect AC power input. The 24VC power supply will be switched on.
- 3. Turn on the uninterrupted power supply that powers the PLC. This action will switch on the PLC. Activity can be verified looking at the PLC module activity LED.
- 4. Switch on the AC output magnetothermic. This action will restore power to the devices connected via relay to AC.

Note: switches can be identified in Figure 2 for CIII rack and in Figure 3 for CIV rack.

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7 CONTROL NETWORK

Network Address: 172.16.0.0 (reserved for private networks, not routed in Internet)

Group	Addresses
Supervision Servers	172.16.0.1 to 172.16.0.64
Supervision Clients	172.16.0.65 to 172.16.0.85
HMI	172.16.0.86 to 172.16.0.128
Local Control	172.16.0.129 to 172.16.0.256

Server Name	IP Address	Mask
MEL_SUPV_SERV01	172.16.0.1	255.255.255.0

Client Name	IP Address	Mask
MEL_SUPV_CLI01	172.16.0.65	255.255.255.0

HMI	IP Address	Mask
MEL_HMI_01	172.16.0.86	255.255.255.0

Local Control	IP Address	Mask
CI_PLC	172.16.0.129 (*)	255.255.255.0
CII_PLC	172.16.0.133	255.255.255.0
CIII_PLC	172.16.0.137	255.255.255.0
CIV_PLC	172.16.0.141	255.255.255.0

(*) Four addresses are reserved for each PLC to reserve addresses for a second CPU for redundant configuration and for a second Ethernet module to implement the redundant network.

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8 SOFTWARE DESCRIPTION

8.1 PLC software description

PLC software is implemented using the Concept 2.6 programming tool provided by Schneider that is installed in the Supervision Client computer. To start this software, in the Supervision Client go to the Programs menu and select Concept V2.26 XL EN and then Concept.

This tool is used to:

- Configure the PLC (see Figure 7).
- Program local control loops using IEC languages
- Download / Upload the programs to/from the PLC
- Monitoring the execution of the programs in the PLC.
- Simulate the programs.

The programs for each PLC are organised in projects. Each project has two main parts: the part storing the configuration of the PLC (modules, addresses and system configuration) and the sections containing the control loops (as shown in Figure 8). The PLC configuration is defined using the PLC Configuration window. The sections of the PLC program can be accessed through the Project Browser.

Summary PLC Selection	Type: 140 CPU 434 12		Available Logic Area:	0
PLC Memory Partition	IEC Enabled		IEC Heap Size	892
3 Specials Config Extensions 3 VO Map 3 Segment Scheduler 3 Modbus Port Settings	Coils: Discrete Inputs: Input Registers: Holding Registers:	000001 001536 100001 100512 300001 300512 400001 401872	Number installed:	0
ASCI	Specials Battery Coil: Timer Register: Time of Day:	000001 400001 400002 400009	Segment Scheduler Segments:	32
	Config Extensions	Disabled	ASCII	0
	Peer Cop:	Disabled	Message Area Size:	0
	Hot Standby: Ethernet: Profibus DP:	Disabled 1 0	Number of Ports:	0

Figure 7. Concept configurator window

In the MELISSA control system, the programming language that has been selected for the implementation of the local control loops is the Function Blocks Diagram (FBD). The project is organised into sections. Each section implements a local regulation loop. For example, the CIV_PLCSW_pH section regulates pH for the compartment CIV controller.

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In each section a group of digital and analogue inputs are related to a group of analogue and digital outputs. The variables in the controller are addressed as follows:

Address range	Variable type
0xXXXXXX	Digital inputs
1xXXXXXX	Digital outputs
3xXXXXXX	Analogue inputs
4xXXXXXX	Analogue outputs

Projec	t Browser 🔳 🗖 🗙
💻 Proj	ect : CIVPLCSW
FBD	CfgAnalo
FBD	AnalnErr
FBD	AnaOutErr
FBD	CIV_PLCSW_Biomass
FBD	CIV_PLCSW_Gas
FBD	CIV_PLCSW_Light
FBD	CIV_PLCSW_pH
FBD	CIV_PLCSW_T
FBD	CIV_PLCSW_Liquid
	87475 37475 324

Figure 8. PLC Program sections of CIV

8.2 Supervision software description

Supervision software is implemented using the Intellution iFix platform. Intellution iFix is a SCADA software that allows the monitoring and modification of process variables. Variable values are acquired through an interface driver (the so-called Mod-Bus Ethernet driver) that communicates with the PLC. Values are acquired and processed by the iFix Server, according to the information stored in the iFix Database. Once processed, these values are displayed numerically, as object animations or in charts in the client displays. In addition, iFix handles automatically alarm events, displaying the alarm information in a predefined area (Alarm Area) and can execute pre-programmed tasks defined in scripts using Visual Basic for Applications (VBA).

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The MBE driver runs in the Supervision Server. This application uses Modbus over TCP/IP to communicate with the PLC. The configuration of the driver is edited with the MBE Power Tool, this application can be accessed directly from the iFix Database Manager. The resulting file defines the configuration of the blocks of information transferred from/to the PLC.

Data sent and received from the MBE driver is processed according to the iFix Database configuration. The iFix Database Manager application is used to modify this information, allowing the addition, modification and deletion of tags. A tag is an element of information that can be displayed product of a calculation or directly a measured process variable (input) or process set point/parameter (output). The configuration of a tag includes alarm generation by allowing the definition of several predefined alarm conditions. The iFix Database Manager application can be accessed directly from a desktop icon or from the iFix Workspace application.

Calculations, process variables and alarms are visualised in displays. These displays group related data in a schematic representation of the process. From these displays it is possible to modify set points, fix regulation parameters, change the operational mode, etc. They define the user interaction with the control system. The displays are accessed from the iFix client, starting the Intellution iFix Workspace application.

Intellution iFIX development and operation is performed through the Intellution iFIX Workspace application (Figure 9). This application can be used as the development environment to define displays, scripting, etc. (Configuration mode) or as the run environment to visualise the displays and interact with the process (Run Mode). The two modes can be changed through the menu option Workspace and Switch to run/configuration according to the current mode.

The application is installed in the Supervision Client and the Supervision Server. The following tasks is mandatory to be performed using the Supervision Server installation:

- Changes in the process database using the Database Manager.
- Changes in the task configurations.

The rest of the configuration tasks can be performed either from the Client or the Server installation.

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Figure 9. iFIX Workspace application.

To start this software for monitoring purposes, in the **Supervision Client** go to the Programs menu, select iFIX and Intellution iFIX Workspace. It is configured in such manner that the process displays are displayed automatically.

To start this program to change the configuration in the **Supervision Server** go to the Programs menu, select iFIX and Intellution iFIX Workspace.

8.3 Master Control software description

The Master Control is in charge of executing Level 2 control algorithms so-called the compartment control laws. For this demonstrator system the control laws will consist of regulating the biomass production in compartment IV and regulating the Nitrite in compartment III. For each compartment this SW consists of the compartment's Control Law algorithm supplied by former ADERSA in the form of C SW modules plus additional SW modules needed to integrate the algorithms into the Master Control environment.

The Master Control environment is implemented using the iFix capability to execute scheduled tasks (Figure 10), and therefore is part of the Supervision Software. The execution of these tasks is controlled by the iFIX Scheduler, which allows the execution of a task at defined time intervals. The tasks are implemented in scripts using Visual Basic for Applications, which is provided as part of the iFIX development environment.

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St	atus	Name Number of Times Fired		Last Fired At		Next tir	me to fire		
Active	CIII_	SAVEVALUES	1		11:38:0	0 AM	11:39:0	DO AM	
A MI	EL_CIII_NIT	CONTROL.ev	/\$		1			_	
	ie Based E	ntries Eve	nt Base	d Entrie	s	-		r.	
F	Status	Na	Name		Number of Times Fired		Fired At	Next time to fi	
1	Active		AW_NIT	1		11:38:0	00 AM	11:39:00 AN	
2									
3	-			-		-		3	
4	-								
0		-							
				-		-		-	

Figure 10. Scheduled tasks in the iFIX

8.4 HMI software description

The HMI display is programmed using the XBT-L1000 V3 software (Figure 11). This software is installed in the Supervision Client and is used to:

- Implement HMI displays and alarm management.
- Configure HMI displays
- Debug displays through simulation.

To start this software using the Programs menu select the XBT-L1000 V3 submenu and XBT-L1000 V3.80.

The HMI application can be modified using the Supervision Client. Any modification needs to be downloaded to the HMI device through the Ethernet network.

The HMI device connects transparently to the PLC to receive the required display values, the configuration of the PLC IP addresses and communication protocol is provided in the application.

This device is connected to the control network and can display variable values numerically and as object animations. No modification of process variables can be performed from the HMI.

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Figure 11. XBT-L1000 application.

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9 PLC SOFTWARE OPERATION

9.1 Connect to PLC

First step to perform changes in a PLC using Concept will be to connect to this PLC. The connection is performed through the TCP/IP protocol by using the PLC IP address, which has been configured at installation time.

To connect to the PLC perform the following steps:

- 1) Start Concept
- 2) Load the software project corresponding to the PLC where the change will be performed (for example CIVPLCSW or C3PLCSW).
- 3) Select Online and Connect... The connection parameters dialog will be displayed.

Connect to PLC				×
Protocol type: Modbus Modbus Plus TCP/IP IEC Simulator (32-bi	 Protocol settings: TC <u>I</u>P address or DNS I 172.16.0.129 	P/IP nost name:	<u>B</u> ridge MB+ ▼	index
Access Level Monitor only C Change Data C Change Program C Change Configuration	List of nodes o	n Modbus Plus ne	ivvork:	×
OK Can	cel <u>H</u> escan	K Previous	<u>N</u> ext >	<u>H</u> elp

4) Select TCP/IP as the protocol type, the corresponding IP address and set Change Program in Access Level. Press OK to confirm and close this dialog. Once connected the caption of the main window will indicate the IP address of the PLC and the status bar will display the status of the PLC.

9.2 Modify constant values

This section will indicate how to modify constant values directly stored in the PLC. These values cannot be modified through the Supervision because there is not a variable tag associated to it. Therefore, it is necessary to access directly to the memory of the PLC to modify the values and update the PLC program accordingly. A common situation where a constant value will need to be modified is when a sensor is changed and the scale for this measure needs to be redefined.

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The modification of values will be performed using the Concept software from the Supervision Client computer.

To modify the constant values stored in the PLC perform the following steps:

- 1) Connect to the PLC (follow procedure explained in section 8.1).
- 2) Select Project and Variable Declarations (or press F8). This action will display the Variable Editor dialog. Select Constants and modify the values needed. Press OK to confirm.

<u>V</u> ariab	les 💿 <u>C</u> onstants				Search/Replace
Ĩ	Variable Name	Data Type	Value	Used	l l
54	CNS_SP_Ls_MIN	REAL	0.0	1	Min. regulator of
55	CNS_SV_CO2	REAL	0.0	1	Safety value for
56	CNS_SV_CxAbs	REAL	1.0	1	Safety value for
57	CNS_SV_DO	REAL	0.0	1	Safety value for
58	CNS_SV_Li1	REAL	0.0	1	Safety value for
59	CNS_SV_Li2	REAL	0.0	1	Safety value for
60	CNS_SV_Ls	REAL	10.0	1	Safety value for
61	CNS_SV_02	REAL	0.0	1	Safety value for
62	CNS_TIME_AFTER_VALVE	TIME	T#5S	1	Seconds after th
63	CNS_TIME_ALARM_GAS	TIME	t#5s	1	Timer of pressure
64	CNS_TIME_ALARM_pH	TIME	T#15M	1	Time to activate
65	CNS_TIME_CLEAN_AGAIN	TIME	t#5m	1	Interval time to c
66	CNS_TIME_OPEN_VALVE	TIME	t#1s	1	Seconds to oper
67					
68	9 (A.		•		
		A. W.			

3) To update the values into the PLC select Online and Download changes. The list of changes will contain the item "Const. values" which indicates that constant values are pending to be updated. Press OK to update the values.

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Const. values	
	Cancel
	Select a
	Help
	*

The last step should be to modify the values into the documentation since when these values will be reviewed it will be verified according to the specifications.

Although most constant values have a constant name associated, there are some trivial that are defined in the diagram. These values can be directly changed in the same diagram. Doubleclicking the value will display a dialog where value can be changed. Once the change is confirmed follow step 6 defined above.



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9.3 Monitor on-line values

All current variable values stored in the PLC memory can be displayed using Concept. This will allow, for example, the verification of the values currently used by the local regulation loops.

The following steps will describe how to display the value of a variable from the PLC memory by using the Reference Data Editor tool, which is invoked from Concept.

To display a variable value from the PLC perform the following steps:

- 1) Connect to the PLC.
- 2) From the Online menu select the Reference Data Editor command. This action will display the Reference Data Editor window (Figure 12).

🖉 RD	E Template (untitled) - Ar	nimation OFF						_ 0	×
	Variable Name	Data Type	Address	Value	Set Value	Format	Disable	Cyclic Set	•
1						•	1	I	-
2						-	圓	3	
3						-	1	I	
4						-	1	3	
5						-	1	I	
6						-	1		1
7						•	1	I	
8						-	圓	3	
9						-	1	I	
10						-	圓		
11						-	1	I	
12						-	圓		
13						•	I	I	
14						-	1		
15						-	1	I	
16						-	1		
17						•	E	I	
18						-	圓		
19						•		I	Ļ
								•	F

Figure 12. Reference Data Editor window.

- 3) Specify the name of the variable whose value needs to be displayed in the Variable Name column.
- 4) From the Online menu select Animate. This action will cause the value of the variable to be displayed in the Value column (Figure 13).

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<u>₿</u> R	DE Template (untitled) - A	nimation ON							_ 🗆 X
	Variable Name	Data Type	Address	Value	Set Value	Form	at	Disable	Cyclic Set
1	CIV_ALM_T	BOOL	000170	Off	21	Bool	•	1	
2							-		3
3							•		目
4							-		3
5							•		目
6							•		3
7							•		三
8					ř.		-		
9							•		三
10							-		圓
11							•		目
12							+		司
13							•		目
14							+		圓
15							•		目
16							-		3
17							•	11	1
18							-		3
19							•	1	
↓]				-t					

Figure 13. Reference Data Editor window with Animation ON

9.4 Monitor control loops

In case it is necessary to check the execution of a local regulation loop it is possible to enable the monitoring of a diagram. This action will cause to display the values calculated by the PLC in real-time.

To monitor the execution of a control loop perform the following steps:

- 1) Connect to the PLC.
- Open the section that will be monitored. This can be achieved selecting the section from the Project Browser. To open the Project Browser select from the Project Menu the Project Browser command. From the Project Browser double-click over the desired section.
- 3) To monitor the execution of part of the diagram, using the mouse, select the modules that will be monitored.

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- 4) To monitor the execution of part of the diagram, using the mouse, select the blocks that will be monitored. A blue line will surround the blocks selected.
- 5) From the Online menu, select the Animate Selected command. This action will cause the values currently used and calculated by the PLC to be displayed in the diagram.

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When a selection of blocks is animated the analogue values are with a yellow background and the digital ones are red (0) and green (1).

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10 SUPERVISION SOFTWARE OPERATION

10.1 Getting Started

Supervision is accessed by means of the Intellution iFIX Workspace application. The same application is used to create and modify Supervision displays, the Configure Mode, and to run the displays, the Run Mode.

The system is configured to start automatically in Run Mode.

To start Supervision Client application:

- 1) Switch on the Supervision Client.
- 2) From the Start Menu, run the Login application and input the User name and Password.
- 3) Once logged in correctly, select to run the iFix Workspace application.

Workspace Application will start and display the MELISSA Control System Main Window.

To close Supervision Client application:

- 1) Press F10, a main menu will appear on the top of the window.
- 2) Select File/Exit. Workspace application will close.
- 3) Run the Login application and press Logout.

10.1.1 General display layout

All implemented displays follow the same display layout as shown in Figure 14:

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Figure 14. Supervision display general layout.

Display Title

The title of the current display can be located in the top of the window, in light blue background.

Navigation Bar

The Navigation bar is located below the display title. It allows, by pressing one of the buttons, the navigation to the indicated display. The button with a house allows returning to the main screen.

Working Area

The working area is where variables are displayed using a schema of the process (pumps, valves, pipes, etc.). The working area is placed under the Navigation bar, with green background.

<u>Alarm Area</u> The Alarm Area is placed in the lower part of the display. This area contains information about the alarms detected. Alarms can be acknowledged by performing a double-click with the mouse over the alarm.

Pressing the right mouse button over the Alarm Area displays a menu pop-up with allowed alarm actions.

The Alarm Area displays the following attributes:

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- **Priority:** High (red background), Medium (gray background), Low (White background).
- **Date In:** Date in which first alarm event was fired.
- **Time In:** Time in which first alarm event was fired.
- **Time Last:** Time in which last alarm event was fired.
- **Tag name:** Name of the tag that fired the alarm.
- **Status:** Analogue tags display alarms such as High (HIHI), Low (LOLO), Rate of Change (ROF), or Deviation (DEV). Digital tags display alarms such as Change of State (COS) or Change from Normal (CFN)
- Value: Current value of the tag that produced the alarm.
- **Description:** Description of the tag.

10.1.2 Colour conventions

The next conventions are followed in objects with parts animated with different colours:

- Red: Stopped. The object is enabled but not running at his moment.
- Green: Nominal, OK, running. Object is enabled and running.
- Yellow: Caution. The object status indicates temporary malfunction, or the status can affect negatively to the process.
- Black: Disabled. Object is not active.

For example, the operational mode control in each loop (Figure 15):



Figure 15. Colour of the operational mode indicators in Supervision displays.

- OFF is indicated in red, since loop is not regulated and outputs are set to 0.
- AUTO is the nominal situation, where outputs are regulated automatically by the control and is indicated in green.
- MAN is a situation that needs caution, then sets manual values to the outputs, and this action has to be used carefully since it can cause several malfunctions to the process. This indicator has the yellow colour.
- Options not active are displayed in black.

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10.1.3 General display actions

From every display, a set of common actions can be performed:

Change Operational Mode

In each process loop there is a control to change the operational mode. The control is a switch (see Figure 16) with three positions and can be set from their respective displays independently. The operational modes are:

- OFF: All outputs regulated in the loop are set to 0. Indicator is red light.
- AUTO: In this mode the control algorithms perform the regulation of the loops. Indicator is green light (normal operation mode).
- MAN: Values of outputs regulated by the loop are set manually. Indicator is yellow light.



Figure 16. Operational Mode Control in Supervision displays.

CAUTION

Manual operational mode will set the outputs of the current loop to the manual values. This action can cause damage to the process and the system devices and therefore shall be used carefully. The user should edit and review the manual values before setting this operational mode.

Edit Manual Values

Every loop display contains a button to allow the edition of the manual values. Click over the Edit Manual Values and a dialog will appear to allow the manual values modification.

Edit Set Points

Set points can be identified because are in blue foreground colour. To edit a value, doubleclick over the value and overwrite the selection. Non-editable values are in black foreground colour.

Chart configuration

Chart configuration can be changed double-clicking the chart. A system dialog will appear which allows the modification of the default values.

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10.1.4 Displays hierarchy

Supervision displays navigation is implemented as follows:



A process display has been implemented for every main loop, grouping process variables and control actions.

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10.2 Compartment III Displays

10.2.1 Compartment III – Main window

The Compartment III Main window displays the principal values measured on the Compartment III. The lines indicate the approximated situation of the sensors in the reactor.



Figure 17. Compartment III Main Window

Specific Actions

• STOP process regulation

To stop regulation for all loops press the STOP button. This action will set all control loop outputs to 0. To restore the automatic regulation (AUTO mode), navigate to every display and change it manually.

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10.2.2 Compartment III – pH Regulation

The pH regulation display shows the relevant values of the process variables related to the pH regulation.



Figure 18. Compartment III pH regulation display

Specific Actions

• pH Control Mode

Set the pH control mode as follows:

- 1) CO2 only: The system tries to regulate pH by controlling the CO2 input. Base and Acid pumps are displayed in black background colour and CO2 valve "hat" is displayed in blue.
- 2) CO2 + basic medium: The system tries to regulate pH controlling the CO2 input and the Base medium pump. Acid pump is displayed in black colour and Basic pump and CO2 vale are displayed in blue
- 3) Basic + Acid media: The system tries to regulate pH controlling the Base and Acid input media pumps. Acid and Basic pumps are displayed in blue.

To edit the pH control mode, double-click over the control. A dialog appears which allow the modification of the control mode.

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• Edit PI controller constants for Acid and Base pumps

To edit the proportional and integrative constants, double-click over the Acid or Base pumps. A dialog will appear to allow the edition of the PI regulator parameters (common to both pumps).

• Edit CO2 regulation constant

To edit parameter for the CO2 regulation, double-click over the CO2 valve. A dialog will appear to allow the edition of the Proportional constant applied to acid/base PI regulator output, to adapt this output to the CO2 regulation.

• Edit Ramp Parameter

To edit parameter to smooth set point changes, click the Edit Ramp Parameter button. A dialog will appear, allowing the user to change the value. The value is applied in units per second.

10.2.3 Compartment III – Liquid

Figure 19 displays liquid flow regulation relevant values. Estimated NO2 concentration resulting of the Nitrite Estimator Control Algorithm is displayed in the Estimated NO2 concentration box. Estimation depends on the "Level 2 Liquid Input Flow Set Point", providing as output the better possible value for the given conditions. This value is displayed in the "Level 1 Liquid Input Flow Set Point" box, which actually, is the value used to regulate the liquid input pump.

Liquid flows are regulated according to Level High/Low sensors (yellow light when active), actuating over the input and output pumps (output pump in green when active). In addition, the display shows the activation (green background) of the output pump for the liquid output buffer tank when maximum allowed level (level high indicator) is reached.

Specific Actions

• Edit input / output pump calibration parameters

To edit the calibration parameters for liquid input and output pumps, double-click over the pump. A dialog will appear allowing the user to modify the calibration parameters. Parameters are used as follows:

y(% of actuation) = Parameter A * (litres/h set point) + Parameter B

• Edit Nitrite Estimator Parameters

The Nitrite Estimator Algorithm needs a set of parameters. Current installed sensors provide some of them, the user can provide the other parameters through the Nitrite Estimator Parameters dialog (Figure 20). To open this dialog, click over the Nitrite Estim. Parameters button.

Parameters with grey background are acquired directly from the sensors and therefore are defined as read only.

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Figure 19. Compartment III Liquid regulation display

	Gas Input Conc. (mol/l)	Liquid Input conc. (mol/l)	Liquid Output conc. (mol/l)
⊃2 : [1	11	0
co2 : [2	12	21
чнз : Г	3	13	0
VO3 :		14	0
PO4 :		15	22
504 :		16	23
Liau	id Ioput Flow Rate (I/b): 0	
Gas	Flow Rate (l/h):	31	
Reg	uired Liquid Input Fl	ow Rate (I/h): 0	
Max	imum constraint of N	102: 32	
Com	pensationt term for	estimator: 33	

Figure 20. Nitrite Estimator parameters dialog.

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10.2.4 Compartment III – Gas

The Gas Loop Regulation display shows the relevant values related with the Gas regulation. The user can set the operational modes for Pressure and DO regulation separately through the Press. Loop and DO Loop controls. CO2 regulation is controlled from the pH Regulation display.



Figure 21. Compartment III Gas regulation display.

Specific Actions

• Edit Ramp Parameter

The Ramp Parameter is used to filter changes of the DO set point. To edit this parameter click on the Edit Ramp Parameter button. A dialog will appear, allowing the user to change the previous value. The value is applied in units per second.

• Edit PID parameters for the O2 input regulation

To edit the proportional, derivative and integrative constants of the O2 regulator double-click the O2 input valve. A dialog will appear to allow the edition of the PID regulator parameters.

• Edit proportional constant for the N2 input regulation

To edit the proportional constant of the N2 regulator double-click over the N2 input valve. A dialog will appear to allow the edition of the Proportional regulator parameter. Note that this proportional constant is applied to the output of the O2 PID regulator.

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10.2.5 Compartment III – Temperature

The Temperature display shows the process variable values related to the Temperature regulation loop. When the heater is on, the heater object blinks in red/yellow and when the compartment needs refrigeration, the Cooling Valve switches to green colour indicating is open.



Figure 22. Compartment III Temperature regulation display.

Specific Actions

• Edit Ramp Parameter

To edit parameter to smooth set point changes, click the Edit Ramp Parameter button. A dialog will appear, allowing the user to change the value. The value is applied in units per second.

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10.3 Compartment IV Displays

10.3.1 Compartment IVa – Main Window

The Compartment IV Main window displays the principal values measured on the Compartment IV. The lines indicate the approximated situation of the sensors in the compartment.



Figure 23. Compartment IV Main Window.

• STOP process regulation

To stop loop regulation, press the STOP button. This action will set all control loop outputs to 0. To restore the automatic regulation (AUTO mode), the user should navigate to every display and change it manually.

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10.3.2 Compartment IVa – pH

The pH regulation display shows the relevant values of the process variables related to the pH regulation.



Figure 24. Compartment IV pH regulation display.

Specific Actions

• pH Control Mode

Set the pH control mode as follows:

- 1) CO2 only: The system tries to regulate pH by controlling the CO2 input. Base and Acid pumps are displayed in black background colour and CO2 valve "hat" is displayed in blue.
- 2) CO2 + basic medium: The system tries to regulate pH controlling the CO2 input and the Base medium pump. Acid pump is displayed in black colour and Basic pump and CO2 vale are displayed in blue
- 3) Basic + Acid media: The system tries to regulate pH controlling the Base and Acid input media pumps. Acid and Basic pumps are displayed in blue.

To edit the pH control mode, double-click over the control. A dialog appears which allow the modification of the control mode.

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• Edit proportional constant for Acid and Base pumps

To edit the proportional constant, double-click over the Acid or Base pumps. A dialog will appear to allow the edition of the constant for the proportional regulator (common to both pumps).

• Edit PID parameters of CO2 regulation

To edit the PID parameters for the CO2 regulation, double-click over the CO2 valve. A dialog will appear to allow the edition of the Proportional, Derivative and Integrative constants of the regulator.

10.3.3 Compartment IVa – Biomass

Displays the relevant values of the biomass production regulation. Level 2 Biomass Production and Level 2 Liquid Input Flow set points, are the inputs for the Biomass Production Model Predictive Control algorithm. The algorithm calculates the best possible values the system can provide and these values are displayed in the "Level 1 Biomass Production set point" and "Level 1 Liquid Input Flow set point" boxes. Actually, the last one is the set point used to fix the pump that regulates the liquid input flow rate (Level 1 control). The real flow rate is displayed in the "Liquid Input Flow" box.

The tanks display graphically the current level, and the active liquid input pump is displayed in green. When the aeration valve is opened to clean the biomass sensor, colour of the valve (Air) switches from read to green.

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Figure 25. Compartment IV Biomass regulation display.

Specific Actions

• Edit Tank minimum value and volume conversion parameters

To edit the tank parameters, double-click over one tank. A dialog will appear to modify the minimum liquid level to switch to the alternative tank, and the density constant to convert Kg to litres. Parameters are common to both tanks.

• Edit pump calibration parameters

To edit the calibration parameters for liquid input and output pumps, double-click over the pump. A dialog will appear allowing the user to modify the calibration parameters. Parameters are used as follows:

y(% of actuation) = Parameter A * (litres/h set point) + Parameter B

• Edit biomass sensor parameters

To edit the biomass sensor parameters, double-click over the Biomass Concentration box. A dialog will appear which will allow the user to modify the sensor range and the Absorbance units (A.U.) to Dry weight units (gr./l) conversion parameter.

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10.3.4 Compartment IVa – Gas

Displays the relevant values of the Gas regulation. From this display the user can change the gas input and output set points. When in Auto operational mode, if the pressure reaches the maximum allowed, the safety pressure valve is opened (changes from red to green), over pressure and under pressure is also regulated by actuating over the input and output gas valves.



Figure 26. Compartment IV Gas regulation display.

Specific actions

• Edit O2/CO2 sensor ranges

To edit the O2/CO2 sensor ranges, double-click over the O2/CO2 values box. A dialog will appear allowing the user to edit the sensor ranges

• Edit Maximum allowed pressure

To edit the maximum allowed pressure, double-click over the Safety Valve. A dialog will appear allowing the user to edit the maximum pressure value.

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10.3.5 Compartment IVa – Temperature

Display values relevant to the Temperature regulation. Actually, temperature regulation is not performed by PLC but apart with a specific controller.



Figure 27. Compartment IV Temperature regulation display.

Specific Actions

No specific actions are available in this display.

10.4 Master Control

The Master Control is executed by the iFix Scheduler module. This module allows the configuration of a task that needs to be executed periodically at fixed time intervals. The tasks can be configured to run in background, and therefore, is not necessary to start a Windows session in the Supervision Server. From this module, algorithms can access to process variables. By default, tasks will be running in background, to perform a change or to initialise a control algorithm, task configuration needs to be changed to run in foreground.

Task configuration is managed from the Supervision Server Workspace application.

In this MELISSA Control System, following tasks are configured:

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• MEL_CIV_BPCONTROL

This task runs the Biomass Production control law algorithm, which regulates biomass production.

• MEL_CIV_SAVEVALUES

This task saves the principal process variable values of the Compartment IV in the Supervision Database.

• MEL_CIII_NITCONTROL

This task runs the Nitrite Estimator algorithm, which regulates Compartment III input flow and estimates dissolved Nitrite in the reactor.

• MEL_CIII_SAVEVALUES

This task saves the principal process variable values of the Compartment III in the Supervision Database.



Figure 28. Tasks scheduled in the System Tree of the iFIX Workspace Application.

10.4.1 Open configured tasks

To access to configured tasks, from the Supervision Server follow these steps:

- 1) Open Intellution iFix Workspace application. Application will be started in configuration mode.
- 2) In the object tree, expand Schedules node. There, a list of scheduled tasks will be presented.
- 3) To modify one task, double-click it. In the right pane, a table will appear displaying all configuration parameters.

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10.4.2 Change the task run mode (foreground/background)

Tasks can be configured to run in foreground or in background. Executing the tasks in foreground will allow the user to test the task by firing its execution manually and initialise algorithm status by changing the run mode. To execute a task in foreground perform following steps:

- 1) In the iFIX Workspace open the task.
- 2) Open the pop-up menu, pressing the right mouse button.
- 3) Select Scheduler Properties. A dialog with Run in Foreground and Run in Background options will appear.
- 4) In the dialog, select run in foreground.
- 5) Press OK.
- 6) Select the task and from the Workspace menu select Workspace and Switch to Run. Task Status is displayed in green showing "Active". Switching again the Workspace to Configuration mode will stop the task.
- 7) To restore the run mode to background, open again the configuration dialog, select "Run in background" and confirm changes. Task status will be displayed in green showing "Active".

In case Biomass production control law or Nitrite estimator tasks need to be initialised before starting a test, change the configuration to run it in foreground and restore the previous configuration to run the task again in background. Task status is displayed in green showing "Active" and if the user switches Workspace mode to Run, it can be verified that the "Number of Times Fired" is reset to 0.

cheduler Properties		?
Run Time State Wind	dow Properties Stats Refres	sh Background Files
	Run in Foreground	
	C Run in Background	
		Cancel Help

Figure 29. Task foreground/background run mode configuration.

Important

Control algorithms such as the Spirulina Biomass Production or the Nitrite Estimator must run in Background in order to allow the user to change other configuration parameters of the system without affecting the execution of these algorithms. Running in foreground a task blocks the Workspace Application in run mode since mode cannot be changed to configuration again without stopping the tasks that are running in foreground.

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10.4.3 Enable/Disable logs

The Master Control tasks can generate logs to monitor its execution. These logs are stored in the folder SUPERVISION\Pic\Logs. The activation or deactivation of these logs is controlled by a global variable to change the value of this variable perform the following steps:

- 1) In the iFIX Workspace access to the elements tree.
- 2) Open the Globals\User branch.
- 3) Select the EnableLogs item and open the context menu by clicking the right mouse button.
- 4) Select the "Property Window..." command.
- 5) Modify the property CurrentValue to True to activate the logs and to False to deactivate it.

E nableLogs FixVaria	able
Alphabetic Categor	rized
(Name)	EnableLogs
ContextID	-1
CurrentValue	True
Description	
EnableAsVbaControl	True
InitialValue	True
IsSelectable	False
VariableType	11 - vtBoolean

Figure 30. EnableLogs configuration dialog.

10.5 Supervision Database

Supervision Database is updated by means of the tasks MEL_CIII_SAVEVALUES and MEL_CIV_SAVEVALUES running under the iFIX Task Scheduler. These tasks are scripts that build the SQL sentence to update the corresponding Microsoft Access® database. Data can be retrieved using the Microsoft Access® application export features.

10.5.1 Change the update rate

It is possible to change the database update rate to adapt it to the characteristics of the current test.

To change the database update rate perform the following steps:

- 1) Open the corresponding schedule task.
- 2) Modify the Interval setting (1 in the figure 29).
- 3) Close the task and confirm save changes.

This action will reset the task, which will be fired at new time interval.

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<mark>2</mark> M	MEL_CIII_SAVEVALUES.evs								
Tin	ne Based Entries	Event Based Entrie	s						
F	Name	Trigger Type	Start Time	Enable End Time	End Time	Interval	-		
1	CIII_SAVEVALUES	Continuous 💌	12:00:00 AM	N/A	N/A	00:01:00			
2									
3			5		2				
4					\bigcap	\mathbf{X}			
F					(1)				

Figure 31. Supervision database task configuration.

10.5.2 Compartment III

The following values of the Compartment III are saved in the Supervision Database:

Scheduler Task: MEL CIII SAVEVALUES

File C	CIII_DB.mdb		
Table C	CIII Measure	dValues	
Column		Description	Туре
DateTime (F	PK)	Time stamp	Date/Time
CIII_SSP_L	.2LiFr	Level 2 Liquid input flow rate set point	Double
CIII_SSP_L	.1LiFr	Level 1 Liquid input flow rate set point	Double
CIII_SMV_N	NO3	Nitrate concentration scaled measure	Double
CIII_SMV_N	NO2	Estimated nitrite concentration	Double
CIII_SMV_N	NH4	Ammonium concentration scaled measure	Double
CIII_SSP_p	Η	pH set point	Double
CIII_SMV_p	pН	pH scaled measure	Double
CIII_SSP_T	Γ	Temperature set point	Double
CIII_SMV_	Т	Temperature scaled measure	Double
CIII_SMV_E	00	DO scaled measure value	Double
CIII_SSP_F	>	Pressure set point	Double
CIII_SMV_F	P	Pressure scaled measure value	Double
CIII_SMV_L	_iFr	Liquid input flow rate	Double

10.5.3 Compartment IVa

The following values of the Compartment IV are saved in the Supervision Database:

Scheduler Task: MEL CIV SAVEVALUES

File	CIV_DB.mdb	DB.mdb					
Table	CIV Measur	<u>edValues</u>					
Column	ľ	Description					Туре
DateTim	e (PK)	Time stamp					Date/Time
CIV_SM	V_CxDW	Biomass concentration in dv	v units				Double
CIV_SSI	P_L1LiFr	Level 1 Liquid input flow rate	e set-point				Double
CIV_SSI	P_L2LiFr	Level 2 Liquid input flow rate	e set-point				Double
CIV_SM	V_LiFr	Liquid input flow rate					Double
CIV_SM	V_LoFr	Liquid output flow rate supe	rvision set-point				Double
CIV_SM	V_BP	Biomass production					Double
CIV_SS	P_L2BP	Level 2 Biomass production	set point				Double
CIV_SS	P_L1BP	Level 1 Biomass production	set point				Double
CIV_SSI	P_Light	Light supervision set-point					Double
CIV_SS	P_pH	pH supervision set point					Double
CIV_SM	CIV_SMV_pH Scaled pH measurement					Double	
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File	CIV_DB.mdb			
Table	CIV MeasuredValues			
Column		Description	Туре	
CIV_SM	GO_CO2	CO2 at output measurement scaled value	Double	
CIV_SS	P_P	Pressure supervision set point	Double	
CIV_SM	V_P	Pressure measurement scaled value	Double	
CIV_SMGO_02		O2 at output measure scaled value	Double	
CIV_SM	V_FrCO2	CO2 at input measure scaled value	Double	
CIV_SS	P_T	Temperature set point	Double	
CIV_SM	V_T	Temperature measurement	Double	
CIV_SM	V_DO	DO measurement	Double	
CIV_SM	LI_V1	Tank 1 volume	Double	
CIV_SM	LI_V2	Tank 2 volume	Double	

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11 HMI SOFTWARE OPERATION

<u>11.1 HMI General layout</u>

HMI displays are composed by a working area, with a white background and an information area placed at the bottom of the window with grey background.



Figure 32. HMI Layout.

11.1.1 Working Area

The working area is where the values are displayed in form of object animations (pumps, valves, etc.) and numerical values.

11.1.1.1 Navigation Buttons

Navigation buttons are placed on the right side of the working area. Press these buttons to navigate to the indicated process display.

11.1.1.2 Control Action

All process displays show the Control Action mode (upper left box), which can be:

- OFF: All controller outputs are set to 0.
- AUTO: Regulation of output values is performed by the controller.
- MAN: Output values are set manually from the Supervision.

11.1.2 Information Area

This area shows the display number, the date and the time.

11.1.2.1 System Button

The System Button is placed on the left corner of this area. By pressing this button the System Toolbar is displayed.

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11.1.2.2 System Toolbar

	MENU SYST ALARM HELP
ESC	Return to previous screen.
HOME	Navigate to the Main Display.
MENU	Access to system menu with generic system options (List of pages, List of recipes, List of forms, Password, List of Alarms, Alarm history, Stop printing, Screen lock mode).
SYST	Access to system information menu (Terminal parameters, Protocol parameters, Printer parameters, Password, Product references, Adjust page, PLCs in online mode)
ALARM HELP	Access to alarm screen (not implemented). No action (not implemented).

<u>11.2 HMI Main Display</u>

It displays principal values of different compartments. Allows the navigation to compartment specific displays.



Figure 33. HMI Main Display.

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<u>11.3 Compartment III Displays</u>

11.3.1 Compartment III – Main

CIII_HMI_Main: Main Main ressure (mb): 5.00 NOE (ppm) Liquid Dutput Flow Rate Cl/h), 6j. 95.00 pH NOB (ppm) 61.00 91.00 NH4 (ppm) 27.00 00 (2) 54.00 LIA pH: 91.00 Gas Temperature {°C}: liquid Input Flow Rate 45.00 1.263 6E.00 Temp 0 5 12 04/12/2003 3 17:58

It displays the principal values of the Compartment III.

Figure 34. HMI Compartment III Main Display.

11.3.2 Compartment III - pH

It displays values related to the pH regulation.



Figure 35. HMI Compartment III - pH Display

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11.3.3 Compartment III – Liquid



It displays values participating in the liquid input / output regulation.

Figure 36. HMI Compartment III - Liquid

11.3.4 Compartment III – Gas

It displays values participating in the gas input / output regulation



Figure 37. HMI Compartment III - Gas

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11.3.5 Compartment III – Temperature



It displays values related to temperature regulation.

Figure 38. HMI Compartment III - Temperature

<u>11.4 Compartment IV Displays</u>

11.4.1 Compartment IV – Main

It displays values related to biomass production regulation.



Figure 39. HMI Compartment IV - Main

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11.4.2 Compartment IV – pH



It displays values related to pH regulation.

Figure 40. HMI Compartment IV - pH

11.4.3 Compartment IV – Biomass

It displays values related to biomass production regulation.



Figure 41. HMI Compartment IV - Biomass

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11.4.4 Compartment IV – Gas



It displays values related to the gas input / output regulation.

Figure 42. HMI Compartment IV - Gas

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12 MAINTENANCE

<u>12.1 Backup Procedure</u>

To prevent the system to lose the data stored due to a hardware failure, backups of relevant data must be performed regularly. The periodicity will vary depending on the type of experiments currently performed in the Plant. The recommended approach is to perform a backup of data at the end of every experiment and empty the data files.

In addition, a backup of the entire system is recommended each time a change on the configuration is performed in order to avoid loosing these changes.

To perform a backup use the tape device included in the Supervision Server and the Backup software tool accessible from the Windows menu Programs and Accessories.

Important

To perform a full backup using the Windows 2000 Backup tool the files must not be locked or otherwise are skipped. In order to avoid files locked the iFIX service must be stopped. To stop the service, close all iFIX applications and from the Control Panel select Services and stop the iFIX service. This will cause the Master Control to be stopped and therefore this operation can only be performed when there are not experiments on course. Once the backup process is ended, restart the iFIX service.

12.2 Data Management

In a regular basis, data generated must be removed in order to prevent the system to run out of disk space. The time will vary depending on the acquisition data rates used. Therefore, when a long test is going to start it is highly recommended to check if data can be reset for the compartment since data are generated independently for each compartment. To reset the data for a compartment perform the following steps:

- 1. Perform a backup of the corresponding Microsoft Access Database file (mdb) located in the SUPERVISION\PIC\Database.
- 2. Empty the database file.

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13 TROUBLESHOOTING

13.1 Rack power input is interrupted

When the rack power is interrupted the Uninterrupted Power Supply will start beeping. This is to alert that this device is powering the PLC. The power interruption can be caused for several reasons. To detect the cause of the power interruption perform the following steps:

- 1) Check that the rack receives external power. This can be checked by verifying that other devices have power. In case that the external power is not available the recovery procedure is out of the scope of this instructions.
- 2) Check the magnetothermic circuit breaker in the AC input (see figure 2 for rack III and figure 3 for rack IV). In case that the differential is open is because an over power consumption has occurred. The rack power consumption is limited to 6 Amp @ 220 V 50 Hz. An over power consumption most probably is caused by a short circuit. Review the connections and devices of the rack to identify and solve the short circuit problem and connect again the magnetothermic.
- 3) Check the differential circuit breaker status in the AC input. In case that the differential is open is because of a current leak. Review the connections and devices of the rack to identify and solve the current leak problem. After detecting and solving the current leak connect the differential circuit breaker.

13.2 Rack power output is interrupted

When the devices connected to the rack AC power output stop receiving power can be due to a short circuit in the wiring or devices connected.

- 1) Check the status of the magnetothermic at power output input (see figure 2 for rack III and figure 3 for rack IV). In case the status is open, check the devices and wiring to detect the short circuit and once detected and solved restore the magnetothermic status to closed. If the status is closed then the problem can be in the device that is not receiving power.
- 2) Check the status of the rest of the devices to isolate the problem. If the rest of the devices are not working check if the rack is receiving power at its input and follow procedure stated in section 13.1.

13.3 Communications with the PLC are broken

In case the supervision displays @@@@ symbols in the variable values can be due to the lost of communications with the PLC.

- 1) Check the rack receives power. In case that is not powered follow procedure stated in section 13.1.
- 2) Check the network connection. The network connection can be checked by looking at the led status of the switch (located in the Supervisory Rack) and the led status of the network module of the PLC (see figure 2 for rack III and figure 3 for rack IV). If the led are indicate malfunction check the network connectors to the switch and the PLC (plug and unplug the connectors), if still not working check the cable connectivity.

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15 APPENDIX B. Problem Report Form

MELISSA Control System Demonstrator - Problem Report							
Reported by:	Identifier:	Date:					
Title:		Reference:					
	Problem	Found					
	Suspecter	d Cause					
	Dianasitia	n Decult					
Disposition option:	DISPOSILIO	in Result					
Reject	Repair, re	ework Use as is					
Disposition Date:							
	Actic	DNS					
Verification results:	CIUSE	Out					
Verified by:		Authorised by:					
Date:		Date:					

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MELISSA

Contract Number: ESTEC/CONTRACT: 15671/01/NL/ND

Technical Note: 72.4 VOLUME III

Control System Demonstrator System Test Report

Version: 1

Issue: 1



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NTE Document Number:	MEL-3330-RP-030-NTE
Written by:	Jordi Duatis
Revised by:	Joan Mas
Quality Assurance:	Sònia Ferrer
Approved by:	Joan Mas



Version	Issue	Date	Observations
Draft	0	06 Oct '03	Created
	1	05 Mar '04	Reviewed. Included CVI HMI test results.
1	0	20 Apr'04	First Release
1	1	28 Jul'04	ESA comments dated 21/07/04 implemented
			-

Document Change Log



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1 SCOPE

This document contains the System Test Report resulting from the execution of the System Test procedures defined in the [R1] over the Control System Demonstrator implemented for the MELISSA loop compartments III and IVa.

Tests were carried out at NTE's premises in the time frame September – November 2003.

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

- [A1] MELISSA. Adaptation for Space, Phase 1. Statement of Work.TOS-MCT/2000/2977/ln/CL. Issue 5. April 2001.
- [A2] MELISSA. Adaptation for Space-Phase 1. Proposal issued by NTE. MEL-0000-OF-001-NTE. Issue 2. October 2001.

2.2 Reference Documents

- [R1] MEL-3310-PL-024-NTE, Control System Demonstrator System Test Plan and Procedure. TN 72.4 Volume Ia, v.1.1, July 2004
- [R2] MEL-3300-MN-028-NTE, Control System Test Readiness Review Meeting Minutes of Meeting, 17/09/03
- [R3] MEL-3300-MN-031-NTE, Control System (CIII) Test Readiness Review Meeting Minutes of Meeting, 13/11/03

3 TEST SUMMARY

The test procedures executed correspond to the verification of the compartments CIII and CIV before being transferred to the UAB for its connection to the plant.

Following the conduction of all the required test procedures / test cases it was concluded that the Control System Demonstrator implemented by NTE met all the design features in terms of control functionality and that the hardware was fit for its connection to the MELISSA plant at UAB's premises.

These results and conclusions were confirmed in the corresponding Test Review sessions documented in [R2] and [R3].

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4 COMPARTMENT VIa SYSTEM TEST REPORT

4.1 MEL-CIV-TP-01: Point to point connectivity test procedure

MEL-CIV-TP-01: Point to point connectivity test procedure							
Tester	JD	Date:	29-30 Jul 2003	Result:	ОК		
Comments:							

4.2 MEL-CIV-TP-02: Electrical isolation

MEL-CIV-TP-02: Electrical isolation								
Tester	XLL / JD	Date:	18 Sept 2003	Result:	OK			
Comments:								

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4.3 MEL-CIV-TP-03: Check Interfaces end-to-end

TC Ide	TC Identifier MEL-TC-CIV-0301 Purpose: Verify that analogue inputs are connected, acquired, supervised and ranged as specified							
Function	s Tested	Interface between CIV_CP - CIV_PLC - Supervision						
Descri	ption	Known values applied to analogue inputs shall be displayed in the Supervision ranged as specified.						
Special Re	equisites:	Values to apply / check must be between the indicated range	mat 2002					
Test	er:	JCM Date: 20 Aug	Just 2005					
Sten no	r	Course of Actions Description	Expected value	OK/NOK				
1	Apply	4 - 5 mA current to AI 01 (CIV MV CxAbs) and check the displayed value (Biomass	0 - 0.2	OK				
-	Concer	intration in DW units) in the Supervision screen MEL_CIV_Main and MEL_CIV_BP.	0 0.2	011				
2	Apply	19 – 20 mA current to AI 01 (CIV_MV_CxAbs) and check the displayed value (Biomass	1.8 - 2	OK				
	Concer	tration in DW units) in the Supervision screen MEL_CIV_Main and MEL_CIV_BP.						
3	Apply -	4 – 5 mA current to AI 02 (CIV_MV_M1) and check the displayed value (Tank1 Level)	0 – 15	OK				
	in the S	Supervision screen MEL_CIV_BP.						
4	Apply	19 – 20 mA current to AI 02 (CIV_MV_M1) and check the displayed value (Tank1	135 – 150	OK				
	Level)	in the Supervision screen MEL_CIV_BP.						
5	Apply	4 – 5 mA current to AI 03 (CIV_MV_M2) and check the displayed value (Tank2 Level)	0 – 15	OK				
	in the S	Supervision screen MEL_CIV_BP.						
6	Apply	19 - 20 mA current to AI 03 (CIV_MV_M2) and check the displayed value (Tank2	135 – 150	OK				
	Level)	in the Supervision screen MEL_CIV_BP.						
7	Apply -	4 – 5 mA current to AI 04 (CIV_MV_P) and check the displayed value (Pressure) in the	0-0.15	OK				
	Superv	ision screens MEL_CIV_Main and MEL_CIV_Gas.						
8	Apply	19 - 20 mA current to AI 04 (CIV_MV_P) and check the displayed value (Pressure) in	1.45 - 1.5	OK				
	the Sup	pervision screens MEL_CIV_Main and MEL_CIV_Gas.						
9	Apply -	4 – 5 mA current to AI 05 (CIV_MV_pH) and check the displayed value (pH) in the	0 - 1.4	OK				
	Superv	ision screens MEL_CIV_Main and MEL_CIV_pH.						
10	Apply	19 - 20 mA current to AI 05 (CIV_MV_pH) and check the displayed value (pH) in the	12.6 - 14	OK				
	Superv	ision screens MEL_CIV_Main and MEL_CIV_pH.						
11	Apply -	4 – 5 mA current to AI 06 (CIV_MV_T) and check the displayed value (Temperature) in	0-15	OK				
	the Sup	pervision screen MEL_CIV_Main.						

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12	Apply a 19 - 20 mA current to AI 06 (CIV_MV_T) and check the displayed value	145 - 150	OK
	(Temperature) in the Supervision screen MEL_CIV_Main.		
13	Apply 4 – 5 mA current to AI 07 (CIV_MGO_O2) and check the displayed value (O2 output) in	0 - 2.5	OK
	the Supervision screen MEL_CIV_Main, MEL_CIV_Gas.		
14	Apply 19 – 20 mA current to AI 07 (CIV_MGO_O2) and check the displayed value (O2 output)	22.5 - 25	OK
	in the Supervision screens MEL_CIV_Main, MEL_CIV_Gas.		
15	Apply 4 – 5 mA current to AI 08 (CIV_MGO_CO2) and check the displayed value (CO2	0 - 50	OK
	output) in the Supervision screens MEL_CIV_Main, MEL_CIV_Gas.		
16	Apply 19 – 20 mA current to AI 08 (CIV_MGO_CO2) and check the displayed value (CO2	450 - 500	OK
	output) in the Supervision screens MEL_CIV_Main, MEL_CIV_Gas.		
17	Apply 4 – 5 mA current to AI 09 (CIV_MV_DO) and check the displayed value (DO) in the	0 – 10	OK
	Supervision screen MEL_CIV_Gas.		
18	Apply 19 - 20 mA current to AI 09 (CIV_MV_DO) and check the displayed value (DO) in the	90 - 100	OK
	Supervision screen MEL_CIV_Gas.		
19	Apply 0 – 0.2 V to AI 13 (CIV_MV_FrGas) and check the displayed value (FR-CI) in the	0 – 3	OK
	Supervision screen MEL_CIV_Gas.		
20	Apply a 4.8 – 5 V to AI 13 (CIV_MV_FrGas) and check the displayed value (FR-CI) in the	27 - 30	OK
	Supervision screen MEL_CIV_Gas.		
21	Apply 0 – 0.2 V to AI 14 (CIV_MGO_FrGas) and check the displayed value (FR-GO) in the	0-3	OK
	Supervision screen MEL_CIV_Gas.		
22	Apply 4.8 – 5 V to AI 14 (CIV_MGO_FrGas) and check the displayed value (FR-GO) in the	27 - 30	OK
	Supervision screen MEL_CIV_Gas.		
23	Apply 0 – 0.2 V to AI 15 (CIV_MV_FrCO2) and check the displayed value (FR-CO2) in the	0-0.5	OK
	Supervision screen MEL_CIV_Gas.		
24	Apply 4.8 – 5 V to AI 15 (CIV_MV_FrCO2) and check the displayed value (FR-CO2) in the	4.5 - 5	OK
	Supervision screen MEL_CIV_Gas.		
25	Apply 0 – 0.2 V to AI 16 (CIV_MGI_FrGas) and check the displayed value (FR-GI) in the	0-3	OK
	Supervision screen MEL_CIV_Gas.		
26	Apply 4.8 – 5 V to AI 16 (CIV_MGI_FrGas) and check the displayed value (FR-GI) in the	27 - 30	OK
	Supervision screen MEL_CIV_Gas.		

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4.3.1 MEL-TC-CIV-0302: Check analogue outputs

TC Ide	Identifier MEL-TC-CIV-0302 Purpose: Verify that analogue inputs are connected, acquired and supervised as specified								
Function	s Tested			Interface betw	/een CIV_CP – C	IV_PLC – Supervision			
Descri	ption	Known values applied to will be checked by other	o Supervision varia r TC.	bles shall be translated to the a	nalogue outputs v	within the ranges specified. Only outputs w	vith direct set-points are cl	hecked, the rest	
Special Re	equisites:					r			
Test	ter:	J	osep Carles M	ariño	Date:	28 Aug	ust 2003		
				Course o	f Actions				
Step no	T .1			Description	<u></u>		Expected value	OK/NOK	
1	In the s	supervision screer	D2 Flow Rate" and measure	$0 V \pm 0.01$	ОК				
	AO 01 output volts.								
2	In the s	supervision screer	n MEL_CIV_	pH set the value 5 to	o "Fixed CO	D2 Flow Rate" and measure	5 V ±0.01	OK	
	AO 01	output volts.							
3	In the s	supervision screer	MEL CIV	Gas set the value 0	to "Gas Inp	ut Flow Rate" and measure	0 V +0 01	OK	
5	AO 02	output volts					0 1 ±0.01	011	
1	In the c	upervision screen	MEL CIV	Gas set the value 30	to "Gas In	put Flow Pate" and	$5 V \pm 0.01$	OK	
4	In the s			Oas set the value 50	to Gas III	put Flow Kate and	$5 V \pm 0.01$	OK	
_	measur	e AO 02 output v	olts.	~					
5	In the s	supervision screer	n MEL_CIV_	Gas set the value 0	to "Gas Out	put Flow Rate" and	$0 V \pm 0.01$	OK	
	measur	e AO 03 output v	olts.						
6	In the s	supervision screer	n MEL_CIV_	Gas set the value 30	to "Gas Oi	tput Flow Rate" and	5 V ±0.01	OK	
	measur	e AO 03 output v	olts.			-			
7	In the s	upervision screer	MEL CIV	Gas set the value 0 t	to "Air Flov	v Rate" and measure AO	0 V + 0.01	OK	
,	04 outr	ut volts				The and moustre TTO	0 1 ±0.01	on	
0	U- Uuu		MEL CIV	Cas set the webus 20		un Data" and measure AO	5 X 10 01	OV	
8	In the s	supervision screer	I MEL_CIV_	Gas set the value 50	The Air Fic	ow Rate and measure AO	$5 V \pm 0.01$	OK	
	04 outp	out volts.	_						
9	Apply	a resistance 1Koh	im between A	AO 10+ and AO 10-					
10	With th	ne iFix Database I	Manager set	the value 0 to CIV_S	SSP_LIGHT	and measure AO 10	4 V ±0.1	OK	
	output	volts	-						
11	With th	e iFix Database I	Manager set	the value 1 to CIV S	SP LIGH	Γ and measure AO 10	20 V +0.1	OK	
	output	volts					20 , 20.1		
	Juiput	10105							

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4.3.2 MEL-TC-CIV-0303: Check digital inputs

TC Ide	ntifier	MEL-TC-CIV-0303	MEL-TC-CIV-0303 Purpose: Verify that digital inputs are connected, acquired and supervised as specified							
Function	s Tested			Interface betw	veen CIV_CP – CI	V_PLC – Supervision				
Descri	ption	Status set to digital input	s shall be translate	to the supervision as specific	ed.					
Special Re	equisites:									
Test	ter:	Jo	osep Carles M	ariño	Date:	28 Au	gust 2003			
Course of Actions										
Step no			Expected value	OK/NOK						
1	Set DI 01 in open circuit and check in supervision screen MEL_CIV_Gas, indicator							OK		
	"Calibrating"									
2	Set DI	01 in closed circu	Gas, indicator	Enabled	OK					
	"Calibr	ating"								
3	Set DI	02 in open circuit	and check in	n supervision screen	MEL_CIV_	Gas, indicator "Error"	Disabled	OK		
4	Set DI	02 in closed circu	it and check	in supervision scree	en MEL_CIV	/_Gas, indicator "Error"	Enabled	OK		
5	Set DI 03 in open circuit and check in supervision screen MEL_CIV_Gas, indicator "Scale1" Disa							ОК		
6	Set DI	03 in closed circu	Enabled	ОК						
7	Set DI	04 in open circuit	and check in	n supervision screen	MEL_CIV_	Gas, indicator "Scale2"	Disabled	OK		
8	Set DI	04 in closed circu	it and check	in supervision scree	en MEL_CIV	Gas, indicator "Scale2"	Enabled	OK		

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4.4 MEL-CIV-TP-04: Biomass production regulation

4.4.1 EL-TC-CIV-0401: Verify biomass sensor cleaning

TC Ider	ntifier	MEL-TC-CIV-0401	Purpose:	Verify that output to acti	vate valve to clean the biomas	s sensor is activated	as specified a	nd Biomass value is maintained.			
Items T	Fested	CIV_PLCSW_Biomass	, MEL_CIV_BP, M	EL_CIV_MAIN							
Descri	ption	Every 5 minutes the dig	ital output 03 shall b	be activated during 5 seconds. I	During this time, and 5 second	s after, the biomass	sensor acquire	d value must be maintained.			
Special Re	equisites:	An APS is used to simulate the Biomass sensor.									
		Check supervision value	es in MEL_CIV_BP	and MEL_CIV_Main display	s						
Test	er:		JD		Date:		01/10/20	03			
				Course o	f Actions						
Step no			Des	Expected value	OK/NOK 01/10/2003	Comments					
1	Set 2.9 - the value	3.1 V to AI 01 (CIV e of Biomass concent	/_MV_CxAbs) ہ tration	$1 \text{ gr/l} \pm 0.1$	OK						
2	Check by inspection AIR valve is opened every 5 minutes during 5 seconds.						ОК	Constant value in PLC program LOC_TIME_OPEN_VALVE was empty, probably due to a bad modification when inserting initial values. Value restored.			
3	During t concentr	he time the valve is or ation is not changed	open modify AI in the supervisi	01 input and check value on.	e of Biomass		OK				
4	Immedia changed	ately after AIR valve during 5 seconds aft	is closed modif ter the valve is c	y AI 01 and check by ins losed.	pection value is not		OK				
5	Check the value is	Check that if value is modified 5 seconds after AIR value is closed, Biomass Concentration value is changed as well.					OK				

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4.4.2 MEL-TC-CIV-0402: Liquid flow regulation

TP Identifi	er	TP-TC-CIV-0402 Purpose: Verify that flow set points are tran	nsmitted to inpu	it output pumps acc	ording to specifi	cations.
Items Teste	ed	CIV_PLCSW_Liquid, CIV_BP_CL, CIV_PLCSW_Light, MEL_CIV_BP, MI	EL_CIV_MAIN	N		
Description	l	Flow rate set point and light set point are provided from the Supervision, by the output pump and activate alarm in case input media tanks are empty, and trans	e software mod fer the light set	lule CIV_BP_CL. T ting point to the lig	he PLC shall reg ht regulator devi	gulate the active input pump, flow rate of ce.
Special Req	quisites:	Two APS (APS1, APS2) are needed to simulate scale sensors of liquid input ta Use MEL_CIV_MAIN and MEL_CIV_BP supervision displays Use a multimeter to measure analogue values				
Test	ter:	Jordi Duatis	Date:		2	/10/2003
		Course of A	ctions			
Step no		Description		Expected value	OK/NOK 02/10/2003	Comments
1	Apply w	vith APS1 17 – 19 mA to AI 02 (CIV_MLI_M1) check in the sup	pervision	130 litres	OK	
	display I	MEL_CIV_BP the Tank 1 level.	±15			
2	Apply w	vith APS2 14 – 15 mA to AI 01 (CIV MV CxAbs) check in the	supervision	1.5 g/l	OK	
_	display 1	MEL_CIV_BP the Biomass concentration	+0.2	0 II		
3	Apply a	1Kohm resistor to AO 10 (CIV_SP_Ls)		-0.2		
	In the M	EL CIV MAIN display check Biomass concentration		1.5 g/l	OK	
				±0.2	011	
5	In the M	EL_CIV_BP display set Liquid input pump 1 calibration parame	eters to			
	A=18.31	15, B=11.0989				
6	In the M A=16.10	EL_CIV_BP display set Liquid input pump 2 calibration parame)3, B=0.8534	eters to			
7	In the M	EL_CIV_BP display set Liquid output pump calibration parame	ters to A=20),		
	B=10					
8	In the M	EL_CIV_BP display set minimum volume to switch input tank t	o 10 litres			
9	In the M	EL_CIV_BP display set:				Normalised variable names. LiFR need to be
	- Bio	mass production set-point to 1.2 gr/l				actuation using the calibration parameters.
	- Liq	uid input flow rate set-point to 0.7 l/h				
	Using th	ie iFix Database Manager set CIV_SSP_LISHTWM to 68.5844 a	ind			
10	CIV_SS	$P_{LIFK} = 0.7$	•			
10	Adjust A	APS2 to obtain a Biomass Concentration of 1.36±0.01 gr/l (check IV_BP)	111			
11	From the	e Supervision iFix Scheduler configure as Foreground task and f	ire schedule	d		
	event CI					

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TP Identif	ier	TP-TC-CIV-0402 Purpose: Verify that flow set points are tran	smitted to input o	output pumps acco	rding to specifi	cations.
Items Teste	ed	CIV_PLCSW_Liquid, CIV_BP_CL, CIV_PLCSW_Light, MEL_CIV_BP, ME	EL_CIV_MAIN			
Description	1	Flow rate set point and light set point are provided from the Supervision, by the	e software module	e CIV_BP_CL. Th	e PLC shall re	gulate the active input pump, flow rate of
Special Re	quisites:	Two APS (APS1, APS2) are needed to simulate scale sensors of liquid input ta Use MEL_CIV_MAIN and MEL_CIV_BP supervision displays Use a multimeter to measure analogue values	g point to the ligh	t regulator devi		
Tes	ter:	Jordi Duatis	Date:	•	2	/10/2003
		Course of A	ctions			
Step no		Description		Expected value	OK/NOK 02/10/2003	Comments
12	Check in	n the MEL_CIV_BP display the Level 1 liquid input flow rate set	t point.	0.77 l/h	OK	Clarify variable identification.
				±0.01		
13	Check in	1 the MEL_CIV_BP display the % actuation of input pump 1		25.20%	OK	
				±0.01		
14	Measure	voltage output in CIV_SP_Li1 (AO 05)	1.26 V	OK		
			±0.1	_		
15	Check in	the MEL_CIV_BP display the output flow rate (must be $+10\%$	0.84 l/h	OK	Clarification	
	input flo	w rate)		±0.01		
16	Check in	n the MEL_CIV_BP display the % actuation of output pump		26.8%	OK	
				±0.2		
17	Measure	voltage output in CIV_SP_LO (AO 07)		1.34 V	OK	
				±0.1		
18	Check in	n the MEL_CIV_BP display the liquid input pump1 status		Enabled	OK	
				(green)		
19	Check in	n the MEL_CIV_BP display the liquid input pump2status		Disabled	OK	
				(red)		
20	Check in	n the MEL_CIV_BP display the output light set-point		217.61	OK	
				w/m2 ± 1		
21	In the M	EL_CIV_MAIN display check light set-point (Light intensity)		217.61	OK	Easy identification
				w/m2 ± 1		
22	In the M	EL_CIV_BP display check light regulator actuation set point %		83.52%	OK	Precision tolerance too low. Fixed editorial
				±2		enor.

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TP Identifi	ier	TP-TC-CIV-0402 Purpose: Verify that flow set points are transmitted to input output pumps according to specifications.									
Items Teste	ed	CIV_PLCSW_Liquid,	CIV_BP_CL, CIV_	PLCSW_Light, MEL_CIV_B	P, MEL_CIV_MA	IN					
Description	1	Flow rate set point and output pump and active	light set point are p ate alarm in case inr	rovided from the Supervision, out media tanks are empty, and	by the software mo transfer the light s	odule CIV_BP_CL. If etting point to the ligh	t regulator devi	gulate the active input pump, flow rate of ce.			
Special Rec	quisites:	Two APS (APS1, APS Use MEL_CIV_MAIN Use a multimeter to ma	2) are needed to sin and MEL_CIV_B easure analogue value	nulate scale sensors of liquid in P supervision displays							
Tes	ter:		Jordi Duat	is	Date:	•	2	/10/2003			
				Course	of Actions						
Step no			Descri	ption		Expected value	OK/NOK 02/10/2003	Comments			
23	Measure	e voltage output in C	CIV_SP_Ls (AO	10)		17.36 V	OK	Precision tolerance too low			
						±0.2					
24	From the CIV_CT	e Supervision iFix S TRLLAW_BP again	cheduler displa	y fire scheduled event							
25	Check in	n the MEL_CIV_BP	display the out	put light set-point		223.00 w/m2 ±0.01	OK				
26	Disconn	ect APS2 from AI 0	1 and set output	to 17-18 mA							
27	Apply w	vith APS2 17-18 mA	to AI 03 (CIV	_MLI_M2)							
28	Check in	n the MEL_CIV_BP	display the tan	k 2 level		130 litres ±15	OK				
29	Set APS	1 output to $4 - 5 \text{ mA}$	Α.								
30	Check in	n the MEL_CIV_BP	display the tan	k 1 level		5 litres ±5	OK				
31	Check in	n the MEL_CIV_BP	display the inp	ut pump 1		Disabled	OK				
32	Check in	n the MEL_CIV_BP	display the inp	ut pump 2		Enabled	OK				
33	Set APS	2 output to 4 - 5 mA									
34	Check in	n the MEL_CIV_BP	display the tan	k 2 level		5 litres ±5	OK				
35	Check in	n the MEL_CIV_BP	display the inp	ut pump 1		Disabled	OK				
36	Check in	n the MEL_CIV_BP	display the inp	ut pump 2		Disabled	OK				
37	Check in	n the MEL_CIV_BP	display the out	put pump actuation		0%	OK				
38	Measure	e voltage output in C	VIV_SP_LO (AC	0 07)		0 V ±0.01	OK				

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4.4.3 MEL-TC-CIV-0403: Light index

TP Identifie	er	TP-TC-CIV-0402	Purpose:	Verify that when the light i	ndex set point changes	, a ramp is appli	ed to set point	output to smooth the variation.			
Functions T	ested	CIV_PLCSW_Light, N	AEL_CIV_BP								
Description		Light set point changes	s are applied usin	g a ramp that changes from 0 to	1 in 15 seconds.						
Special Req	uisites:	Use an oscilloscope (C	SC) to measure 1	amp.							
		Use MEL_CIV_TEST	_01 to apply a va	lue to the light set point.							
Test	er:	Jo	rdi Duatis / J	oan Ariño	Date:		29/08/2003	3, 18/09/2003, 02/10/2003			
	Course of Actions										
Step no	Description						OK/NOK 02/10/2003	Comments			
1	Apply a	1 Kohm resistor to	AO 10								
2	Connect AO 10 (A	the OSC channel 1 AO 4 mA => 0.4 V	to monitor TI / AO 20 mA =	B_ACO pin 2 (-) and pin 5 => 2V) . Time div 5 secon	(+) to monitor ds. V div 0.5 V						
3	Set in the	e CIV_SSP_Light v	ariable in the	iFix Data Manager displa	y the value 0.	0.4 V	OK				
	Wait until output voltage in AO 10 goes down to. 0.4V.										
4	Set in the CIV_SSP_Light variable in the MEL_CIV_TEST_01 display the value 1 Wait until output voltage in AO 10 goes up to 2V.					$2V\pm0.1$	OK				
5	Check in	the OSC the outpu	t voltage char	aged from $0,4V$ to 2 V in 1	5 ± 0.2 seconds.		OK				

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4.4.4 MEL-TC-CIV-0404: Over temperature alarm

TP Identifie	er	TP-TC-CIV-0404	Purpose:	Verify that when the over ter	nperature alarm is or	light supply is	set to a safety v	alue		
Functions T	ested	CIV_PLCSW_Light, Cl	IV_PLCSW_T, ME	L_CIV_Temp						
Description		When an over temperate	ure is detected, ligh	t supply is set to a low value to	avoid over heating					
Special Requ	uisites:	Use an APS to apply vo	oltages							
Test	er:	Jordi Duatis Date:			Date:			02/10/2003		
	Course of Actions									
Step no			Descrip	tion		Expected	OK/NOK		Comments	
							02/10/2003			
1	In the I	e MEL CIV Temp supervision screen set Temperature set point								
	to 27 °C	C I	1	Ĩ	Ĩ					
2	Apply	with the APS 1.9	-2.1 V to A	I 06		37 5 +4	OK			
_			201 00011			97.9 ±1	011			
						C				
3	Check the over temperature alarm is displayed in the Alarm area of the					OK				
	Supervision screen									
4	Check	in MEL_CIV_BI	P light supply	actuation		10%	OK			

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4.5 MEL-CIV-TP-05: Gas Flow Regulation

4.5.1 MEL-TC-CIV-0501: Control action enabled

TC Ide	entifier	MEL-TC-CIV-0501	Purpose:	,	Verify that set point	ts are m	nodified by the PLC	in case of over	r/under pressure		
Function	ns Tested	CIV_PLCSW_Gas, ME	L_CIV_GAS								
Descri	iption	In case of overpressure of and under pressure is wh	output flow increm ten pressure is 0.01	ents a 10%, in case of under p under the nominal value.	pressure input flow	increme	ents a 10%. Over pre	essure is when	pressure is 0.01 over the nominal value,		
Special R	equisites:	An APS is used to simul	late the pressure se	nsor.							
		Use the multimeter to m Check supervision value	easure currents and es in MEL CIV Ga	i voltages. as							
Test	ter:	1	JD		Date:		02/10/2003				
				Course	of Actions						
Step no			Descri	ption			Expected value	OK/NOK 02/10/2003	Comments		
1	In the M	EL_CIV_Gas set the	e max allowed p	pressure value to 1.1 bar							
2	In the M	EL_CIV_Gas set the	e nominal press	sure 1.0 bar							
3	In the M	In the MEL_CIV_Gas set the AIR input flow rate to 10 nLm									
4	Apply with the APS 3.66 – 3.68 V to CIV_MV_P (AI 04) and check pressure value in MEL_CIV_Gas.						1±0.005 bar	OK	Fixed ranges in doc. Recalculated ranges		
5	Measure	Measure CIV_SP_Fgex (AO 04) voltage						OK			
6	In the M	EL_CIV_Gas set the	e gas input flow	rate to 20 nLm							
7	Measure	e CIV_SP_Fgi (AO 0	2) voltage				$3.33\pm0.01\mathrm{V}$	OK			
8	In the M	EL_CIV_Gas set the	e gas output flov	w rate to 12 nLm							
9	Measure	e CIV_SP_Fgo (AO 0)3) voltage				2±0.01V	OK			
10	Check in	n MEL_CIV_Gas dis	play the over p	ressure & under pressur	e indicators		Disabled	OK			
11	Modify .	APS value to 3.69-3.	72 V and check	pressure value in MEL	_CIV_Gas.		1.015	OK			
							±0.005 bar				
12	Check in	Check in MEL_CIV_Gas display the over pressure indicator					Enabled	OK			
13	Measure	e CIV_SP_Fgo (AO 0)3) voltage (sha	ll be 10% over set poin	t measured in 9))	2.2 ±0.02V	OK			
14	Apply w MEL_C	vith the APS 3.59 – 3. IV_Gas.	.62 V to CIV_N	IV_P (AI 04) and checl	k pressure value	e in	0.98±0.005	OK	Fixed ranges in doc. Recalculated ranges, recalculated expec. value		
15	Check in	n MEL_CIV_Gas dis	play the under	pressure indicator			Enabled	OK			

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TC Ider	ntifier	MEL-TC-CIV-0501	Purpose:	Verify that set points are	modified by the PLC	in case of over	r/under pressure			
Functions	s Tested	CIV_PLCSW_Gas, ME	L_CIV_GAS							
Descrip	ption	In case of overpressure of	output flow increme	ents a 10%, in case of under pressure input flow increments	nents a 10%. Over pre	ssure is when	pressure is 0.01 over the nominal value,			
		and under pressure is wh	hen pressure is 0.01 under the nominal value.							
Special Re	equisites:	An APS is used to simu	An APS is used to simulate the pressure sensor.							
		Use the multimeter to m Check supervision value	Check supervision values in MEL_CIV_Gas							
16	Measure	CIV_SP_Fgex (AO	04) voltage (sha	all be 10% over set point measured in 5)	1.82 ±0.02V	OK				
17	Measure	e CIV_SP_Fgi (AO 0	2) voltage (shal	3.66 ±0.02V	OK					
18	Modify APS value to 3.67 – 3.69 V and chec			k pressure value in MEL_CIV_Gas.	1.005	OK	Fixed ranges in doc			
					±0.005 bar					
19	Check in	n MEL_CIV_Gas dis	play the under p	pressure indicator	Disabled	OK				
20	Check in	n MEL_CIV_Gas dis	play the over pr	essure indicator	Disabled	OK				
21	Measure CIV_SP_Fgex (AO 04) voltage (initial value)				$1.66 \pm 0.02 V$	OK				
22	2 Measure CIV_SP_Fgi (AO 02) voltage (initial value)					OK				
23	Measure	CIV_SP_Fgo (AO 0	03) voltage (init	ial value)	2.00 ±0.02V	OK				

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4.5.2 MEL-TC-CIV-0502: Pressure safety valve activation

TC Ide	entifier	MEL-TC-CIV-0502	Purpose:	V	erify that pressure saf	ety valve is activate	d in case of an	high overpressure		
Function	ns Tested	CIV_PLCSW_Gas, ME	L_CIV_GAS							
Descri	iption	In case pressure is over	the max allowed pr	essure, the pressure safety valv	ve shall be opened unt	til pressure is nomin	al			
Special R	equisites:	An APS is used to simu Use the multimeter to m	late the pressure sen leasure currents and	nsor. voltages.						
		Check supervision value	es in MEL_CIV_Ga	IS				110/2002		
Tes	ter:		Jordi Duati	s C	Date:	02/10/2003				
Ston no				Course o	of Actions	E-mosted volue	OV/NOV	Commente		
Step no			Descrip	tion		Expected value	02/10/2003	Comments		
1	In the M	IEL_CIV_Gas set the	e max allowed p	pressure value to 1.1 bar						
2	In the M	IEL_CIV_Gas set th	e nominal press	ure 1.0 bar						
3	In the M	IEL_CIV_Gas set the	e external input	flow rate to 10 nLm						
4	Apply with the APS 3.66 – 3.68 V to CIV_MV_P (AI 04) and check pressure value					1±0.005	OK	Fixed ranges in doc		
	in MEL_CIV_Gas.					bar				
5	In the M	n the MEL_CIV_Gas check safety valve status					OK			
6	Modify APS value to 4.2 – 4.5 V and check pressure value in MEL_CIV_Gas.				CIV_Gas.	1.25	OK	Fixed ranges in doc		
						±0.05 bar				
7	In the M	IEL_CIV_Gas check	safety valve sta	itus		Open	OK			
						(green)				
8	Measure	e output Voltage AC	CIV_RL_Fg (C	IV_AC_OUT 08, 10)		220 VEF	OK			
						±10%				
9	Modify	APS value to 3.70 -3	.72 V and checl	k pressure value in MEL	_CIV_Gas.	1.015	OK			
						±0.005 bar				
10	In the M	IEL_CIV_Gas check	safety valve sta	itus		Open	OK			
11	Apply w	with the APS $3.64 - 3$.66 V to CIV_N	IV_P (AI 04) and check	pressure value	0.995	OK	Fixed ranges in doc. Modified		
	in MEL	_CIV_Gas.				±0.005 bar		when P reaches set-point (no dead band)		
12	In the M	IEL_CIV_Gas check	safety valve sta	itus		Closed	OK			

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4.5.3 MEL-TC-CIV-0503: Check over pressure alarm

TC Ider	ntifier	MEL-TC-CIV-0503	Purpose:		Veri	fy that over press	sure alarm is a	ctivated			
Functions	s Tested	CIV_PLCSW_Gas, MEL_	_CIV_GAS								
Descrip	otion	When an overpressure occ	curs during more t	han 5 seconds, the over pressu	ure alarm shall be ac	tivated.					
Special Re	equisites:	An APS is used to simulat	te the pressure ser	sor.							
		Check supervision values	in MEL_CIV_Ga	8							
Test	er:		Jordi Duatis	i	Date:	29/08/2003, 18/09/2003, 02/10/2003					
	Course of Actions										
Step no		Description				Expected value	OK/NOK 02/10/2003	Comments			
1	In the MEL_CIV_Gas set the max allowed pressure value to 1.1 bar										
2	In the M	EL_CIV_Gas set the	nominal press	ure 1.0 bar							
3	In the M	EL_CIV_Gas set the A	AIR input flow	rate to 10 nLm							
4	Apply w	ith the APS 4.2 - 4.5 V	v to CIV_MV_	P (AI 04) and check pro	essure value in	1.25	OK	Fixed ranges in doc			
	MEL_CIV_Gas.				±0.05						
						bar					
5	After 5 s has been	econds check the MEI indicated.	L_CIV_Gas al	arms. Verify that over p	pressure alarm		OK				

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4.6 MEL-CIV-TP-06: pH Regulation

4.6.1 MEL-TC-CIV-0601: Regulate pH with CO2 only

TC Ide	ntifier	MEL-TC-CIV-0601 Purpose:	Verify that CO2	flow meter regulates	CO2 input to m	naintain pH set point
Function	s Tested	CIV_PLCSW_pH, MEL_CIV_pH				
Descri	ption	With the control action mode CO2 Only, the pH is regulated adding	CO2. Control action is	performed by means	of a PID	
Special Re	equisites:	Use the multimeter to measure currents and voltages. Use the FAG to simulate variations in the pH. Use the OSC to display CIV_SP_CO2 (CO2 regulation PID output in Check supervision values in MEL_CIV_pH Concept SW is used to modify enable/disable PID parameters	n AO 01)			
Test	ter:	Jordi Duatis, Joan Ariño	Date:		1/09/2003, 1	18/09/2003, 06/10/2003
		Cou				
Step no		Description		Expected value	OK/NOK 06/10/2003	Comments
1	In the M	EL_CIV_pH set the control action mode 1 (CO2 Only)				When pH input is in link error PID output goes to saturation, modified program to set PID
						output $= 0$ when sensor link error.
2	In the M	EL_CIV_pH set the pH set point to 6.5				
3	In the M D=0.01	EL_CIV_pH set the CO2 flow meter PID parameters to				
4	With the	e Concept tool connect to the PLC and open CIV_PLCS	W_pH section.			Changed due to review of declared constant values.
5	In Conce enabled)	ept set "FALSE" to ENNUI, END(only Proportional part)	of the PID is			Changed due to review of declared constant values.
6	With the Offset =	e FAG apply a squared wave with duty cycle = 50%, Am 2.7 ± 0.05 (2.7-2.9) and f=0.1 Hz to CIV_MV_pH (AI 05)	p=0.1±0.05 V,			
7	Check ir	n the MEL_CIV_pH display pH value is between the ran	ge	5.95±0.1 to 6.65±0.1	OK	
8	Measure	e CIV_SP_FrCO2 (AO 01) output MAX		0.75±0.3 V	ОК	
9	In Conce part of the	ept set "FALSE" to EN_P, EN_D and "TRUE" to EN_ he PID is enabled)	I (only Integrative			Changed due to review of declared constant values.
	In the FO	G increment $Amp = 0.5$ to increase integrative action				

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TC Ide	ntifier	MEL-TC-CIV-0601	Purpose:	Verify that CO2 flow	v meter regulates (CO2 input to n	naintain pH set point	
Function	s Tested	CIV_PLCSW_pH, MEI	CIV_pH					
Descri	ption	With the control action i	mode CO2 Only, the	e pH is regulated adding CO2. Control action is perf	formed by means of	of a PID		
Special Re	equisites:	Use the multimeter to m	easure currents and	voltages.				
	Use the FAG to simulate variations in the pH. Use the OSC to disclose CIV, SP, $CO2$ (CO2 regulation PID submit in AO 01)							
Use the OSC to display CIV_SP_CO2 (CO2 regulation PID output in AO 01)								
Check supervision values in MEL_CIV_pH								
Concept SW is used to modify enable/disable PID parameters								
10 Measure CIV_SP_FrCO2		CIV_SP_FrCO2 (A	O 01) output M	IAX	0.35±0.1	OK	Precision range too low	
					V			
11	In the Re	eference Data Editor	set "FALSE" t	to EN_P, EN_I and TRUE EN_D (only			Changed due to review of declared constant	
	Derivati	ve part of the PID is	enabled)				values.	
12 With the FG modify to a triangle wave with same parameters								
13 Measure CIV_SP_FrCO2 (AO 01) output MAX			IAX	0.035	OK	Modified CIV_PLCSW_pH when PH input is		
				+0.05 V		in error status, PID goes to saturation, PID is now disabled when pH input is in error		
					±0.03 V		now disabled when pri liput is in error.	

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4.6.2 MEL-TC-CIV-0602: CO2 and additional base medium

TC Ide	ntifier	MEL-TC-CIV-0602	Purpose:	Verify that Base pump i	is activated when p	pH is unc	der set-point and	CO2 flowmete	er is activated when pH is over set-point			
Functions	s Tested	CIV_PLCSW_pH, MEL	CIV_pH									
Descrij	ption	With the control action n	mode 2 CO2 + Base	e media, the pH is regulated add	ding CO2 when pH	H is over	the set point and	Base media w	hen pH is under the set-point. A PID			
		controller regulates CO2	2 flow and a P (prop	portional) controller controls Ba	ase pump.							
Special Re	equisites:	Use the multimeter to m	easure currents and	voltages.								
		Use the OSC to display	CIV SP CO2 (CO	2 regulation PID output in AO	TBD)							
	Check supervision values in MEL_CIV_pH											
Test	ster: Jordi Duatis, Joan Ariño Date: 06/10/2003											
				Course	of Actions							
Step no			Descri	ption	I	Expected value	OK/NOK 06/10/2003					
1	In the M	EL_CIV_pH set the	control action n	node 2 (CO2 + Base)								
2	In the M	EL_CIV_pH set the	pH set point to	6.5					Fixed error in document			
3	In the M	EL_CIV_pH set the	CO2 flow meter	er PID parameters to P=5	6, I=100, D=0.0	01						
4	With the	FG apply a squared	wave with duty	cycle = 50%, Amp=0.1	±0.05 V, Offse	et =						
	2.7±0.05	(2.7-2.9) and f=0.1	Hz to CIV_MV	_pH (AI 05)								
5	Check in	the MEL_CIV_pH	display pH valu	e is between the range		5	5.95±0.1 to	OK				
					6	5.65±0.1						
6	Apply a	1 Kohm resistor to A	AO 09					Added				
7	Measure	CIV_SP_Bs (AO 09	9) output MAX			1	12.8 ± 1 V	OK				
8	Check in	the MEL_CIV_pH	display Base pu	mp actuation		5	55±5 %	OK				

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4.6.3 MEL-TC-CIV-0603: Base and Acid additional media

TC Ide	ntifier	MEL-TC-CIV-0603	Purpose:	Verify that Base pump	o is activated when	n pH is	under set-point and A	Acid pump is a	ctivated when pH is over set-point			
Functions	s Tested	CIV_PLCSW_pH, MEI	CIV_pH									
Descrij	ption	With the control action i	mode 2 CO2 + Base	media, the pH is regulated ad	ding CO2 when pl	H is ov	er the set point and B	ase media whe	n pH is under the set-point. A PID			
		controller regulates CO ₂	2 flow and a P (prop	bortional) controller controls B	ase pump.							
Special Re	equisites:	Use the multimeter to m	Use the EG to simulate variations in the nH									
		Use the OSC to display	Use the OSC to display CIV_SP_CO2 (CO2 regulation PID output in AO TBD)									
	Check supervision values in MEL_CIV_pH											
Test	er:		Jordi Duatis	5	Date:		(01/09/2003,	06/10/2003			
				Course of	of Actions							
Step no			Descrij	otion		Expected value	OK/NOK	Comments				
								06/10/2003				
1	In the M	EL_CIV_pH set the	control action n	node 3 (Base + Acid)								
2	In the M	EL_CIV_pH set the	pH set point to	6.5								
3	In the M	EL_CIV_pH set the	CO2 flow meter	er PID parameters to P=5	5, I=100, D=0.0	01						
4	With the	FG apply a squared	wave with duty	cycle = 50%, Amp=0.1	±0.05 V, Offse	et =			Fixed document			
	2.8±0.05	(2.8-3.0) and f=0.1	Hz to CIV_MV	_pH (AI 05)								
5	Check in	the MEL_CIV_pH	display pH valu	e is between the range			6.30 ±0.1 to	OK				
						7.00 ± 0.1						
6	Apply a	1 Kohm resistor to A	AO 11						Added			
8	Measure	CIV_SP_Ac (AO 1	1) Output MAX			13±1 V		Fixed document				
9	Check in	the MEL_CIV_pH	display acid pur	np actuation			50 ±5 %		Fixed document			

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4.6.4 MEL-TC-CIV-0604: Check pH alarm

TC Ider	ntifier	MEL-TC-CIV-0604	Purpose:	Ver	ify that when pH is	out of the nominal valu	e during a perio	od of time an alarm is generated			
Functions	s Tested	CIV_PLCSW_pH, MEI	CIV_pH								
Descrij	ption	When pH is over or und	er the set point +/- c	lead band, during more than 15	5 minutes continuo	usly, an alarm is generate	ed and Supervi	sion shall display the alarm condition.			
Special Re	equisites:	Use APS to generate the	e pH value								
Test	er:		Jordi Duatis	5	Date:		01/09	9/2003, 06/10/2003			
	Course of Actions										
Step no			Descrij	ption		Expected value	OK/NOK 06/10/2003	Comments			
1	In the M	EL_CIV_pH set the	pH set point to	6							
2	With the	APS set 2.9±0.5 V t	o CIV_MV_pH	(AI 05)							
3 Check in the MEL_CIV_pH display pH value						6.65±0.1	OK				
4	Wait 15	minutes									
5	Check af	fter 15 minutes, the p	H alarm has bee	en notified to Supervision	n.		OK				

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4.7 MEL-CIV-TP-07: Initial Values

TC Identif	ier	MEL-CIV-TP-07	Purpose	Check th	nat correct initial values are used at PLC restart		
Tester:	Jordi Dua	tis	Date:	03/10/20	003		
Variable r	name	Туре	Address	Value	Description	ОК	Comments
CIV_CNS	_AcKp	REAL	400544	100.0	Acid pump regulator proportional constant.	OK	
CIV_CNS	_BsKp	REAL	400546	100.0	Base pump regulator proportional constant.	OK	
CIV_CNS_	_CO2_Kd	REAL	400552	0.01	CO2 flow regulator derivate constant for PID	OK	
CIV_CNS	_CO2_Ki	REAL	400550	100.0	CO2 flow regulator integration constant for PID	OK	
CIV_CNS_	_CO2_Kp	REAL	400548	5.0	CO2 flow regulator proportional constant for PID	OK	
CIV_CNS	_ConvV	REAL	400518	1.0	Density factor to translate Kg. to litres.	OK	
CIV_CNS_	DW	REAL	400542	1.0	Constant to calculate biomass dry weight	OK	
CIV_CNS	_Li1FrA	REAL	400512	18.315	Parameter A for liquid input pump 1 set point calc	OK	
CIV_CNS	_Li1FrB	REAL	400514	11.0989	Parameter B for liquid input pump 1 set point calc	OK	
CIV_CNS	_Li2FrA	REAL	400538	16.103	Parameter A for liquid input pump 2 set point calc	OK	
CIV_CNS	Li2FrB	REAL	400540	0.8534	Parameter B for liquid input pump 2 set point calc	OK	
CIV_CNS	LoFrA	REAL	400510	15.0	Parameter A for liquid output pump set point calc	OK	
CIV_CNS	_LoFrB	REAL	400516	1.0	Parameter B for liquid output pump set point calc	OK	
CIV_CNS	_MaxPress	REAL	400524	0.02	Maximum allowed pressure in the reactor	OK	
CIV_CNS_	MinV	REAL	400500	10.0	Minimum volume to switch liquid input tank.	OK	
CIV_CNS	_OffsetCO	2 REAL	400536	0.0	Offset to provided a constant flux of CO2 to the	OK	
CIV_CNS	_OpModeE	3P Integer	400566	0	Biomass Production control mode (0=Off, 1=Auto, 2=Manual)	OK	
CIV_CNS_	OpModeG	Bas Integer	400568	0	Gas control mode (0=Off, 1=Auto, 2=Manual)	OK	
CIV_CNS	_OpModep	H Integer	400567	0	pH control mode ((0=Off, 1=Auto, 2=Manual)	OK	
CIV_CNS_	_pHMode	Integer	400565	1	PH regulation mode parameter (1=CO2 only, 2=CO2+Base, 3=Base+Acid)	OK	Fixed address in document
CIV_SSP_	L1BP	REAL	400554	0.0	Level 1 Biomass production set-point	OK	
CIV_SSP_	Fgex	REAL	400532	0.0	Gas flow external input supervision set point	OK	
CIV_SSP_	Fgi	REAL	400526	0.0	Gas flow at input regulation supervision set point	OK	
CIV_SSP_	Fgo	REAL	400528	0.0	Gas flow at output regulation supervision set point	OK	
CIV_SSP_	L1LiFr	REAL	400508	0.0	Level 1 Liquid input flow rate set-point	OK	
CIV_SSP_	Light	REAL	400520	0.0	Light Supervision set point.	OK	
CIV_SSP_	NomPres	s REAL	400522	0.01	Nominal pressure in the reactor	OK	
CIV_SSP	_T	REAL	400562	36.0	Temperature set-point fixed by the supervision	OK	Fixed value in doc.
CIV_SSP_	_pH	REAL	400534	9.5	pH set-point fixed by the supervision	OK	Fixed value in doc.

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4.8 MEL-CIV-TP-08: Check Sensor / Actuator Link Errors

4.8.1 MEL-TC-CIV-0801: Check Link Errors on Analogue Inputs

TC Ide	ntifier	MEL-TC-CIV-0801 Purpose	:	Verify that	when a current analogue input	connection is broken is notified to s	upervision	
Function	s Tested	CIV_PLCSW_pH, MEL_CIV_pH						
Descri	ption	Errors on sensor links are displayed in	the supervision as alarms and safety	y values are displa	ayed blinking in the supervisio	on screens.		
Special R	equisites:	All current inputs shall be disconnected		Data		02/10/2003		
Test	ler:	Jorai D	02/10/2003					
Step no			Description			Expected value	OK/NOK	Comments
~~···P			F				02/10/2003	
1	In the I	MEL_CIV_BP supervision	display check Biomass	Concentrati	on value	1.0 (Blinking)	OK	
2	In the I	MEL_CIV_BP supervision	display check Tank 1 ve	olume value		0.0 (Blinking)	OK	
3	In the I	MEL_CIV_BP supervision	display check Tank 2 vo	olume value		0.0 (Blinking)	OK	
4	In the I	MEL_CIV_Gas supervision	n display set pressure set	point to 1.0)			
5	In the I	MEL_CIV_Gas supervision	n display check Pressure	(P) value		1.0 (Blinking)	OK	
6	In the I	MEL_CIV_Gas supervision	n display check O2 value	e		0.0 (Blinking)	OK	
8	In the I	MEL_CIV_Gas supervision	n display check CO2 valu	ue		0.0 (Blinking)	OK	
9	In the I	MEL_CIV_Gas supervision	n display check DO valu	e		0.0 (Blinking)	OK	
10	In the I	MEL_CIV_Temp supervisi	on display set Temperat	ure set-poin	t to 27 °C			
11	In the I	MEL_CIV_Temp supervisi	on display check Tempe	erature value	2	27.0 (Blinking)	OK	
13	In the I	MEL_CIV_pH supervision	display set pH set-point	to 6.5				
14	In the I	MEL_CIV_pH supervision	display check pH value			6.5 (Blinking)	OK	
15	In the I	MEL_CIV_Main supervision	on display check Biomas	ss Concentr	ation value	1.0 (Blinking)	OK	
16	In the I	MEL_CIV_Main supervision	on display check Pressur	e value		1.0 (Blinking)	OK	
17	In the I	MEL_CIV_Main supervision	on display check O2 valu	ue		0.0 (Blinking)	OK	
18	In the I	MEL_CIV_Main supervision	0.0 (Blinking)	OK				
19	In the I	MEL_CIV_Main supervision	0.0 (Blinking)	OK				
20	In the I	MEL_CIV_Main supervisi	on display Temperature	27.0 (Blinking)	OK			
21	In the I	MEL_CIV_Main supervision	on display pH value			6.5 (Blinking)	OK	
22	Check	following alarms are fired:					OK	

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TC Identifier	MEL-TC-CIV-0801	Purpose:	Verify that when a current analogue input connection	is broken is notified to supe	ervision	
Functions Tested CIV_PLCSW_pH, MEL_CIV_pH						
Description Errors on sensor links are displayed in the supervision as alarms and safety values are displayed blinking in the supervision screens.						
Special Requisites:	All current inputs shall be di	isconnected				
- Ala	arm to notify O2 sens	sor link err	or			
- Ala	arm to notify biomass	s sensor lir	nk error			
- Ala	arm to notify DO sen	nsor link er	ror			
- Ala	arm to notify CO2 se	ensor link e	error			
- Ala	arm to notify pressure	e sensor lin	nk error			
- Ala	arm to notify pH sens	sor link err	or			
- Ala	arm to notify Temper	rature sense	or link error			
- Ala	arm to notify scale1 s	sensor link	error			
- Ala	arm to notify scale2 s	sensor link	error			

4.8.2 MEL-TC-CIV-0802: Check Link Errors on Analogue Outputs

TC Ide	ntifier	MEL-TC-CIV-0802 Purpose:	Verify that v	when a current analogue output connection	n is broken is notified to sup	pervision						
Function	s Tested	CIV_PLCSW_pH, MEL_CIV_pH										
Descri	ption	Errors on actuator links are displayed in the supervision as alarms										
Special Re	equisites:	All current outputs shall be disconnected										
Test	er:	Jordi Duatis Date: 02/10/2003										
	Course of Actions											
Step no		Description	Description Expected value OK/NOK Comments									
						02/10/2003						
1	Check	following alarms are fired:				OK						
	A 1a	rm to notify acid nump link arror										
	- Ala	and pump mik enor										
	- Ala	arm to notify base pump link error										
	- Ala	n to notify light supply link error										
9												

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4.9 MEL-CIV-TP-09: Check operational modes

4.9.1 MEL-TC-CIV-0901: Check Biomass Production Loop Operational Modes

TC Ide	ntifier	MEL-TC-CIV-0901 Purpose:	Verify when operational mo	de is changed i	in the Biomass Production Loop, outputs are	set as specifie	d		
Function	s Tested	CIV_PLCSW_Biomass, CIV_PLCSW_Light, CIV_PLCSW_Liquid, ME	L_CIV_BP	the menual ve	alwas				
Special R	puon eanisites:	Use a Multimeter to measure expected outputs	ne operational mode and se	i ule manual va	nues.				
Special IX	equisitest	Use MEL_CIV_BP supervision screen to change operational modes and n	manual values.						
Test	ter:	Jordi Duatis	Date:		03/10/2003				
			Course of Actions						
Step no		Description			Expected value	OK/NOK 03/10/2003	Comments		
1	In the M	MEL_CIV_BP supervision screen set operational r	node to OFF						
2	Apply a 1 KOhm resistor to CIV_SP_Ls output (AO 10)								
	Connec	et a pilot light to CIV_RL_Cx							
3	Check]	Pilot light	OFF	OK					
4	Check	CIV_SP_Li1 voltage output	0±0.1 V	OK					
5	Check	CIV_SP_Li2 voltage output	0±0.1 V	OK					
6	Check	CIV_SP_LO voltage output	0±0.1 V	OK					
8	Check	CIV_RL_Li1 output status	OPEN	OK	Fixed expected output in doc.				
9	Check	CIV_RL_Li2 output status			OPEN	OK	Fixed expected output in doc.		
10	Check	CIV_SP_Ls voltage output			4±0.1 V	OK	Fixed value in doc.		
11	In the M	MEL_CIV_BP edit the manual values and set:							
	Activat	e valve to clean biomass sensor: checked							
	Enable	liquid input pump 1: checked							
	Liquid	input pump 1 set-point (0-100%): 10							
	Enable	liquid input pump 2: checked							
	Liquid input pump 2 set-point (0-100%): 20								
<u> </u>					l	1	I		
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TC Ide	ntifier	MEL-TC-CIV-0901	Purpose:	Verify when operational mode is changed in	the Biomass Production Loop, outputs a	re set as specif	fied		
Function	s Tested	CIV_PLCSW_Biomass,	CIV_PLCSW_Light	nt, CIV_PLCSW_Liquid, MEL_CIV_BP					
Descri	ption	From the Biomass Produ	action supervision so	creen it is possible to change the operational mode and set the manual valu	es.				
Special Re	equisites:	Use a Multimeter to mea	asure expected outp	uts					
	Use MEL_CIV_BP supervision screen to change operational modes and manual values.								
	Liquid	output pump set-	point (0-100%	6): 30					
	Light s	upply set-point (0)-100%): 50						
13	In the M	MEL_CIV_BP su	pervision scre	een set operational mode to MAN					
14	Check Pilot light				ON	OK			
15	Check CIV_SP_Li1 voltage output				0.5±0.1 V	OK			
16	Check CIV_SP_Li2 voltage output				1.0±0.1 V	OK			
17	Check	CIV_SP_LO volt	age output		1.5±0.1 V	OK			
18	Check	CIV_RL_Li1 out	put status		CLOSED	OK	Fixed expected		
			•				output in doc.		
19	Check	CIV_RL_Li2 out	put status		CLOSED	OK	Fixed expected		
							output in doc.		
20	Check CIV_SP_Ls voltage output				12±0.1 V		Fixed value in		
							doc		

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4.9.2 MEL-TC-CIV-0902: Check Gas Loop Operational Modes

TC Ide	ntifier	MEL-TC-CIV-0902 Purpose:		Verify when operational mode is	s changed in the Gas Loop, outputs are set as s	specified				
Function	s Tested	CIV_PLCSW_Gas, MEL_CIV_Gas								
Descri	ption	From the Gas regulation supervision screen in	t is possible to change the operationa	l mode and set the manual value	25.					
Special Re	equisites:	Use a Multimeter to measure expected output	its	_						
		Use MEL_CIV_Gas supervision screen to ch	ange operational modes and manual	values.						
Test	er:	Jordi Duatis	D	ate:	03/10/2003					
	Course of Actions									
Step no			Description	Expected value	OK/NOK 03/10/2003	Comments				
1	In the M	MEL_CIV_BP supervision scre	en set operational mode							
	Connec	nect a Pilot light to CIV_RL_Fg								
2	Check	Pilot light		OFF	OK					
3	Check	CIV_SP_Fgi voltage output			0±0.1 V	OK				
4	Check	CIV_SP_Fgo voltage output			0±0.1 V	OK				
5	Check	CIV_SP_Fgex voltage output			0±0.1 V	OK				
6	In the M	MEL_CIV_Gas edit the manual	values and set:							
	Enable	Pressure safety valve: checked								
8	In the M	MEL_CIV_Gas supervision scr								
9	Check	Pilot light			ON	OK				

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4.9.3 MEL-TC-CIV-0903: Check pH Loop Operational Modes

TC Ide	ntifier	MEL-TC-CIV-0903	Purpose:		Verify whe	n operational mode is changed in	the pH Loop, outputs are set as	specified	
Function	s Tested	CIV_PLCSW_pH, MEL_C	CIV_pH						
Descri	ption	From the pH regulation sup	pervision screen i	t is possible to change the ope	erational mode and s	et the manual values.			
Special R	equisites:	Use a Multimeter to measur	re expected outp	uts					
		Use MEL_CIV_pH supervi	ision screen to ch	ange operational modes and n	nanual values.				
Test	ter:		Jordi Duatis		Date:		03/10/2003		
					Course of A	ctions			
Step no				Description			Expected value	OK/NOK 03/10/2003	Comments
1	In the M	MEL_CIV_pH supe	ervision scr	een set operational r	node to OFF				
2	Apply a	a 1 Kohm resistor to	o CIV_SP_	Bs (AO 09) and CIV	V_SP_Ac (AC	D 11)			
3	Check	CIV_SP_Bs voltage output					4±0.1 V	OK	
4	Check	CIV_SP_Ac voltage output					4±0.1 V	OK	
5	Check	CIV_SP_FrCO2 voltage output					0±0.1 V	OK	
6	In the M Acid pu Base pu CO2 Fl	MEL_CIV_pH edit ump set-point (0-10 ump set-point (0-10 ow Rate set-point (the manual 0%): 10 0%): 20 (0-5 nLm): 1	values and set: 2.5					
8	In the M	MEL_CIV_pH supe	ervision scre	en set operational n	node to MAN	[
9	Check	CIV_SP_Ac voltage output				5.6±0.2 V	OK	Fixed exp. precision in doc.	
	Check	CIV_SP_Bs voltage	V_SP_Bs voltage output					OK	
	Check	CIV_SP_FrCO2 volta	age output				2.5±0.1 V	OK	

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5 COMPARTMENT III SYSTEM TEST REPORT

5.1 MEL-CIII-TP-01: Point to point connectivity test procedure

MEL-CIII-TP-01: Point to point connectivity test procedure										
Tester	JD	Date:	10 Oct 2003	Result:	OK					
Comments	Comments:									

5.2 MEL-CIII-TP-02: Electrical isolation

MEL-CIII-TP-02: Electrical isolation							
Tester	XLL / JD	Date:	Result:				
Comments:	:						

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5.3 MEL-CIII-TP-03 Check Interfaces end-to-end

5.3.1 MEL-TC-CIII-0301: Check analogue inputs

TC Ide	entifier	MEL-TC-CIII-0301	Purpose:	Verify that	at analogue inpu	ts are connected, acquired, superv	ised and ranged as specified		
Function	s Tested	Interface between CIII_	CP – CIII_PLC – S	upervision		1 CM 1			
Descri	iption	Known values applied to Values to apply / check	o analogue inputs s	hall be displayed in the Supervis	sion ranged as sp	ecified.			
Special K	tor:	values to apply / check	Indist de detween ui		Date		29/10/2003		
105			3D	Course of	Actions		27/10/2003		
Step no				Description	rectoris		Expected value	OK/NOK	
1	Apply	1 - 1.2 V to AI 01	(CIII_MV_	Dob) and check the d	isplayed va	lue DObot % in the	0-5	OK	
	Superv	ision screen MEI	CIII_GAS.						
2	Apply -	4.8 - 5 V to AI 0	1 (CIII_MV_	Dob) and check the d	lisplayed va	alue DObot % in the	95 - 100	OK	
	Superv	ision screen MEI	CIII_GAS.						
3	Apply	1 - 1.2 V to AI 02	2 (CIII_MV_	Dot) and check the di	splayed va	lue DOtop % in the	0-5	OK	
	Supervision screen MEL_CIII_GAS.								
4	Apply 4.8 – 5 V to AI 02 (CIII_MV_Dot) and check the displayed value DOtop % in the 95 – 100 OK								
	Supervision screen MEL_CIII_GAS.								
5	Apply	1 - 1.2 V to AI 0.	3 (CIII_MV_	NH4) and check the c	lisplayed v	alue NH4 in the	0 – 10	OK	
	Superv	ision screen MEI	CIII_Liqui	d.					
6	Apply	4.8 - 5 V to AI 03	3 (CIII_MV_I	NH4) and check the d	lisplayed va	alue NH4 in the	190 - 200	OK	
	Superv	ision screen MEI	CIII_BP.						
7	Apply	1 - 1.2 V to AI 04	4 (CIII_MV_	NO3) and check the c	displayed v	alue NO3 in the	0 - 50	OK	
	Superv	ision screen MEI	CIII_Liqui	d.					
8	Apply	4.8 - 5 V to AI 04	4 (CIII_MV_I	NO3) and check the d	lisplayed va	alue NO3 in the	950 - 1000	OK	
	Superv	ision screen MEI	CIII_Liqui	d.					
9	Apply	1 - 1.2 V to AI 0.	5 (CIII_MV_	P) and check the disp	layed valu	e P in the Supervision	0 - 50	OK	
	screen	MEL_CIII_Gas.							
10	Apply	4.8 - 5 V to AI 05	5 (CIII_MV_	P) and check the disp	layed value	e P in the Supervision	950 - 1000	OK	
	screen	MEL_CIII_Gas.							
11	Apply	1 - 1.2 V to AI 0	5 (CIII_MV_	PHb) and check the c	lisplayed v	alue pHbot in the	3 – 3.5	OK	

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TC Id	lentifier	MEL-TC-CIII-0301	Purpose:	Verify t	hat analogue inpu	its are connected, acquired, superv	vised and ranged as specified	
Functio	ons Tested	Interface between CIII_	CP – CIII_PLC –	Supervision				
Desci	ription	Known values applied t	to analogue inputs	shall be displayed in the Superv	vision ranged as sp	pecified.		
Special I	Requisites:	Values to apply / check	must be between t	he indicated range				
Tes	ster:		JD		Date:		29/10/2003	
				Course o	f Actions			
Step no				Description			Expected value	OK/NOK
	Superv	ision screen MEI	CIII_pH.					
12	Apply	4.8 - 5 V to AI 00	6 (CIII_MV_	PHb) and check the	displayed va	alue pHbot in the	12.5 – 13	OK
	Superv	ision screen MEI	CIII_pH.					
13	Apply	1 - 1.2 V to AI 0	7 (CIII_MV_	_PHt) and check the	displayed va	alue pHtop in the	1.5 – 2	OK
	Superv	ision screen MEI	CIII_pH.					
14	Apply	4.8 - 5 V to AI 0'	7 (CIII_MV_	PHt) and check the c	lisplayed va	lue pHtop in the	11 - 11.5	OK
	Superv	ision screen MEI	CIII_pH.					
15	Apply	1 - 1.2 V to AI 0	9 (CIII_MV_	Tb) and check the d	isplayed val	ue Temperature in the	0.2 - 7.54	OK
	Superv	ision screen MEI	L_CIII_Tem	р.				
16	Apply	4.8 - 5 V to AI 09	9 (CIII_MV_	Tb) and check the di	splayed valu	ue Temperature in the	139.66 - 147	OK
	Superv	ision screen MEI	L_CIII_Tem	р.		-		
17	Apply	1 - 1.2 V to AI 1	0 (CIII_MV_	Tt) and check the dis	splayed valu	e Temperature in the	0.2 - 7.54	OK
	Superv	ision screen MEI	L_CIII_Tem	р				
18	Apply	4.8 - 5 V to AI 10	0 (CIII_MV_	Tt) and check the dis	splayed valu	e Temperature in the	139.66 - 147	OK
	Superv	ision screen MEI	L_CIII_Tem	р.	-	_		

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5.3.2 MEL-TC-CIII-0302: Check analogue outputs

TC	Identifier	MEL-TC-CIII-0302	Purpose:		Verify that analogue	inputs are connected, acquired and super-	vised as specified	
Funct	ions Tested	Interface between CIII_	<u>CP – CIII_PLC – S</u>	upervision				
Des	cription	Known values applied t will be checked by othe	o Supervision varial r TC.	bles shall be translated to	the analogue outputs v	within the ranges specified. Only outputs	with direct set-points are cl	hecked, the rest
Special	Requisites:	Use a Multimeter to me	asure voltage outpu	ıts				
Т	ester:		JD		Date:	29/10	0/2003	
<i>a</i> .	1			Cou	rse of Actions			0.000
Step no	Set regul	ation mode to MA	N to all loor	Description			Expected value	OK/NOK
2	In the cur	action for a sorroon M	MEL CIII pl	J adit manual ya	luge and got the	value 0 to "CO2 Elow sot	$0 \mathbf{V} + 0 1$	OK
2	In the sup		VIEL_CIII_pr	n euit manuai va	iues and set the	value 0 to CO2 Flow set	$0 V \pm 0.1$	UK
2	point an	a measure AO 01	T output vons		1 1 4 41	1 100 / "CO2 El	EX1 10.1	OV
3	In the sup	pervision screen I	MEL_CIII_pl	H edit manual va	lues and set the	value 100 to "CO2 Flow	$5 V \pm 0.1$	OK
	set point	and measure AC	0 01 output v	olts.				
4	In the sup	pervision screen I	MEL_CIII_G	as edit manual v	alues and set the	e value 0 to "N2 Flow set	$0 V \pm 0.1$	OK
	point" an	d measure AO 02	2 output volts					
5	In the sup	pervision screen I	MEL_CIII_G	as edit manual v	values and set th	e value 150 to "N2 Flow	5 V ±0.1	OK
	set point"	' and measure AC	0 02 output v	olts.				
6	In the sup	pervision screen N	MEL_CIII_G	as edit manual v	alues and set the	e value 0 to "O2 Flow set	0 V ±0.1	OK
	point" an	d measure AO 03	3 output volts					
7	In the sup	pervision screen I	MEL_CIII_G	as edit manual v	alues and set the	e value 100 to "O2 Flow	5 V ±0.1	OK
	set point"	and measure AC	0 03 output v	olts.				
8	Apply a 5	500 ohm resistor	to AO 05					
9	In the sup	pervision screen N	MEL CIII pl	H edit manual va	lues and set the	value 0 to "Acid pump set	2 V ±0.2	OK
	point" an	d check "Enable	Acid pump".	Measure AO 05	output volts.	1 1		
10	In the sup	pervision screen N	MEL CIII pH	H edit manual va	lues and set the	value 100 to "Acid pump	10 V +0.2	OK
	set point	and measure AC	0.05 output v	olts.		1 1	10 + 2012	
11	Apply a 5	500 ohm resistor	to AO 06					
12	In the sur	pervision screen	MEL CIII pl	H edit manual va	lues and set the	value 0 to "Base pump set	2 V +0.2	OK
	point" an	d check "Enable	base pump".	Measure AO 06	output volts.			
13	In the sur	pervision screen N	MEL_CIII pl	H edit manual va	lues and set the	value 100 to "Base pump	10 V ±0.2	OK
	set point"	and measure AC	06 output v	olts.		1 1		
	· · · ·						÷	-
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TCI	Identifier	MEL-TC-CIII-0302	Purpose:	Verify that	analogue inp	uts are connected, acquired and superv	vised as specified	
Functi	ions Tested	Interface between CIII_	_CP - CIII_PLC - S	upervision				
Des	cription	Known values applied t	to Supervision varial	bles shall be translated to the analog	e outputs with	in the ranges specified. Only outputs	with direct set-points are ch	ecked, the rest
		will be checked by othe	er TC.					
Special	Requisites:	Use a Multimeter to me	easure voltage outpu	ts				
T	ester:		JD]	Date:	29/10	0/2003	
				Course of Act	ions			
Step no				Description			Expected value	OK/NOK
14	Apply a :	500 ohm resistor	to AO 07					
15	In the supervision screen MEL_CIII_Liquid edit manual values and set the value 0 to "Liquid							OK
	input pur	np set point" and	measure AO	07 output volts.		_		
16	In the sup	pervision screen l	MEL_CIII_Li	quid edit manual values	and set th	e value 100% to "Liquid	10±0.2 V	OK
	input pur	np set point" and	measure AO	07 output volts.				
17	Apply a :	500 ohm resistor	to AO 08					
18	In the supervision screen MEL_CIII_Liquid edit manual values and set the value 0 to "Liquid							OK
	output pu	mp set point" an	d measure AC	0 08 output volts.		_		
19	In the supervision screen MEL_CIII_Liquid edit manual values and set the value 100 to "Liquid					10±0.2 V	OK	
	output pu	mp set point" an	d measure AC	0 08 output volts.				

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5.3.3 MEL-TC-CIII-0303: Check digital inputs

TC Ide	entifier M	1EL-TC-CIV-0303	Purpose:		Verify that digital in	puts are connected, acquired and superv	ised as specified	
Function	is Tested In	terface between CIII_C	CP – CIII_PLC – S	upervision				
Descri	iption St	atus set to digital input	s shall be translate	d to the supervision as specif	fied.			
Special Re	equisites:					• ••••		
Test	ter:		JD		Date:	29/1	0/2003	
				Course	of Actions		T	
Step no				Description			Expected value	OK/NOK
1	Set DI 01	in open circuit	and check in	n supervision screet	n MEL_CIII_	Liquid, indicator	Disabled	OK
	"Calibrati	ng" in NH4						
2	Set DI 01	in closed circu	it and check	in supervision scre	en MEL CII	I Liquid, indicator	Enabled	OK
	"Calibrati	ng" in NH4		-				
3	Set DI 02	in open circuit	and check in	n supervision scree	n MEL CIII	Liquid, indicator	Disabled	OK
	"Calibrati	'Calibrating'' in NO3						
4	Set DI 02	in closed circu	it and check	in supervision scre	en MEL_CII	I_Liquid, indicator	Enabled	OK
	"Calibrati	ing" in NO3		I		- 1 /		
5	Set DI 03	in open circuit	and check i	n supervision scree	n MEL_CIII_	Liquid, indicator "Level	Enabled	OK
	Low" in I	Level sensor		-		-		
6	Set DI 03	in closed circu	it and check	in supervision scre	en MEL_CII	I_Liquid, indicator "Level	Disabled	OK
	Low" in I	Level sensor		-		-		
7	Set DI 04	in open circuit	and check i	n supervision scree	n MEL_CIII_	Liquid, indicator "Level	Disabled	OK
	High" in I	Level sensor		-		-		
8	Set DI 04	in closed circu	it and check	in supervision scre	en MEL_CII	I_Liquid, indicator "Level	Enabled	OK
	High" in I	Level sensor						

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5.3.4 MEL-TC-CIII-0304: Check digital outputs

TC Ide	ntifier	MEL-TC-CIV-0304	Purpose:	Vei	rify that digital ou	tputs are connected, acquired and superv	vised as specified	
Function	s Tested	Interface between CIII_	CP – CIII_PLC – S	upervision				
Descri	ption	Manual values applied t	o Supervision shall	be translated to the digital out	puts within the ra	nges specified. Only outputs with manual	l values are checked, functi	onal TC will
Special Re	equisites:	Connect lights to 220 V	EF relay outputs to	check status				
Test	er:		JD		Date:	29/1	0/2003	
				Course o	f Actions			
Step no				Description			Expected value	OK/NOK
1	Set reg	ulation mode to N	MAN to all lo	oops.				
2	In the s	supervision screen	n MEL_CIII_	Liquid edit manual	values and e	enable "Output buffer tank	Closed	OK
	pump A	Activation" and cl	heck DO 01 o	connectivity.		-		
3	In the s	supervision screen	n MEL CIII	Liquid edit manual	values and c	lisable "Output buffer tank	Open	OK
	pump A	Activation" and cl	heck $\overline{\text{DO}} 01$	connectivity.		L	1	
4	In the s	supervision scree	On	OK				
	and che	and check DO 02 light status.						-
5	In the s	the supervision screen MEL CIII pH edit manual values and disable "Acid pump activation"					Óff	OK
	and me	and measure DO 02 light status.						-
6	In the s	supervision screen	n MEL_CIII_	pH edit manual valu	es and enat	ble "Base pump activation"	On	OK
	and me	asure DO 03 ligh	t status.	-				
7	In the s	supervision screet	n MEL_CIII_	pH edit manual valu	es and disa	ble "Base pump activation"	Off	OK
	and me	asure DO 03 ligh	it status.	-				
8	In the s	supervision screet	n MEL_CIII_	Temp edit manual v	alues and e	nable "Cooling valve	On	OK
	activati	on" and check D	O 05 light sta	atus.		C		
9	In the s	supervision screen	n MEL_CIII_	Temp edit manual v	alues and di	isable "Cooling valve	Off	OK
	activati	on" and check D	O 05 light sta	atus.		-		
10	In the s	supervision screet	n MEL_CIII_	Temp edit manual v	alues and e	nable "Heater activation"	On	OK
	and che	eck DO 06 light s	tatus.	-				
11	In the s	supervision screen	n MEL_CIII_	Temp edit manual v	alues and d	isable "Heater activation"	Off	OK
	and che	eck DO 06 light s	tatus.	-				

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TC Ide	ntifier	MEL-TC-CIV-0304	Purpose:	Ver	ify that digital ou	tputs are connected, acquired and supervi	sed as specified	
Function	s Tested	Interface between CIII_	_CP - CIII_PLC - S	upervision				
Descri	ption	Manual values applied	to Supervision shall	be translated to the digital outp	outs within the rate	nges specified. Only outputs with manual	values are checked, function	nal TC will
		check the rest.						
Special Re	Special Requisites: Connect lights to 220 VEF relay outputs to check status							
Test	ter: JD Date: 29/10/2003							
	Course of Actions							
Step no				Description			Expected value	OK/NOK
12	In the s	supervision scree	n MEL_CIII_	Gas edit manual val	ues and ena	ble "Enable Pressure safety	On	OK
	valve" and check DO 08 light status.							
13	3 In the supervision screen MEL_CIII_Gas edit manual values and disable "Enable Pressure						Off	OK
	safety v	valve" and check	DO 08 light	status.				

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5.4 MEL-CIII-TP-04 pH Regulation

5.4.1 MEL-TC-CIII-0401: pH Regulation with CO2

TC Id	TC Identifier MEL-TC-CIII-0401 Purpose: Verify that when in pH control mode 1, if pH goes over the set point, CO2 value is opened according to provided parameters.								
Items	Tested	CIII_PLCSW_pH, MEL	_CIII_pH, MEL_	CIII_Main					
Desc	ription	When in control mode 1,	, if pH goes over	the set point, the PI shall open CC	32 valve accordin	ig to parameters provided from the super	v1s10n.		
Special	kequisites:	2 APS are used to simula Check supervision value	s in MEL CIII n	H and MEL_CIII_Main displays					
Те	ster:	Check Super vision value	JD	if and MEE_CHI_Main displays	Date:		30/10/2003		
				•	Course of A	ctions			
Step no				Description			Expected value	OK/NOK	Comments
1	Set pH c	ontrol mode to 1	 CO2 only 	,					
2	Using A	PS 1 set 2.90 – 3.	10 V to AI	06 (CIII_MV_pHb)					
3	In the M	EL_CIII_pH Sup	ervision scr	een check pH bottom	value		8.0±0.1 pH	OK	
4	Using A	PS 2 set 3.50 – 3.	70 V to AI	07 (CIII_MV_pHt)					
5	In the M	EL_CIII_pH Sup	ervision scr	een check pH top valu	e		8.0±0.1 pH	OK	
6	In the M	EL_CIII_MAIN	Supervision	screen check pH valu	e		8.0±0.1 pH	OK	
7	In the M	EL_CIII_pH Sup	ervision scr	een check pH value			8.0±0.1 pH	OK	
8	In the M	EL_CIII_pH chec	ck CO2 valv	ve set point			0±0.1 %	OK	
9	In the M	EL_CIII_pH edit	the PI para	meters (click over Aci	d pump to o	open dialog).			
	Set prop	ortional = 3, Integ	gration $= 0$						
10	In the M	EL_CIII_pH edit	the proport	ional constant for CO	2 valve (clie	ck over CO2 valve to open			
	dialog).								
	Set prop	ortional = 5							
11	Using A	PS 1 set 4.10 – 4.	20 V to AI	06 (CIII_MV_pHb)					
12	Using A	PS 2 set 4.70 – 4.	90 V to AI	07 (CIII_MV_pHt)					
13	Check in	MEL_CIII_pH S	Supervision	display the value of p	Н		11±0.25 pH	OK	
14	Check C	O2 valve control	action value	e			45±3.75 %	OK	
15	Check A	O 01 voltage outp	put				2.3±0.2 V		
16	In the M	EL_CIII_pH Sup	ervision scr	een set pH Ramp para	meter to 0.0)16			
17	In the M	EL_CIII_pH Sup	ervision scr	een set pH set point to	o 11.0.				
	4 3 6557	2220 DD 020 NF				D (0.000)			

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TC Id	TC Identifier MEL-TC-CIII-0401 Purpose: Verify that when in pH control mode 1, if pH goes over the set point, CO2 valve is opened according to provided parameters.								
Items	s Tested	CIII_PLCSW_pH, MEL_CIII_pH, MEL_CIII_Main							
Desc	ription	When in control mode 1, if pH goes over the set point, the PI shall	open CO2 valve accordir	ng to parameters provided from the super-	vision.				
Special I	Requisites:	2 APS are used to simulate the pH sensors.							
		Check supervision values in MEL_CIII_pH and MEL_CIII_Main of	displays						
Те	ster:	JD	Date:		30/10/2003				
	-		Course of A	Actions		. <u>.</u>			
Step no	Step no Description					OK/NOK	Comments		
18	Check th	nat in 3 minutes CO2 valve control action appr	0±5 %	OK					
19	In the M	EL_CIII_pH Supervision screen set pH set pc	45±3.75 %	OK					
	action va	alue is restored.							
20	Using A	PS 1 set 2.90 – 3.10 V to AI 06 (CIII_MV_pH	Ib)						
21	Using A	PS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pH	Ht)						
22	In the M	EL_CIII_pH edit the PI parameters (click ove	er Acid pump to o	open dialog).					
	Set prop	ortional = 1, Integration = 30							
23	Using A	PS 1 set 4.10 – 4.20 V to AI 06 (CIII_MV_pH	Ib)						
24	Using A	PS 2 set 4.70 – 4.90 V to AI 07 (CIII_MV_pH							
24	In the M	EL_CIII_pH annotate CO2 valve control action	ve control action value at 10 seconds and at 40 seconds.			OK			
	Calculat	e the gradient (CO2 at $20 - CO2$ at $10) / 30$							

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5.4.2 MEL-TC-CIII-0402: pH Regulation with CO2 and additional Base medium

TC Id	TC Identifier MEL-TC-CIII-0402 Purpose: Verify that when in pH control mode 2, if pH goes under the set point, Base pump is activated according to provided parameters.									
Items	Tested	CIII_PLCSW_pH, MEL_CIII_pH	ler the set point the DI shall activate	the base pu	nn according to peremeters provided t	From the supervision				
Special 1	ripuon Requisites:	2 APS are used to simulate the pH sensors.	ter tile set politi, tile F1 shall activate	ule base pu	inp according to parameters provided i	ioni me supervision.				
Special	lioquisitest	Check supervision values in MEL_CIII_pH	display							
Те	ster:	JD	Ι	Date:		30/10/2003				
	I.		Co	ourse of A	ctions		-	1		
Step no		<u> </u>	Description			Expected value	OK/NOK	Comments		
1	Set pH c	ontrol mode to $2 - CO2 + Bas$				_	-			
2	Using A	PS 1 set $2.90 - 3.10$ V to AI 0								
3	Using A	PS 2 set 3.50 – 3.70 V to AI 0	7 (CIII_MV_pHt)							
4	Check in MEL_CIII_pH Supervision display the value of pH					8 ±0.25 pH	OK			
5	Check D	O 03 light		Off	OK					
6	Check C	O2 valve and Base pump cont	rol action values			0±0.1 %	OK			
7	In the M	EL_CIII_pH edit the PI paran	neters (click over base pu	imp to c	pen dialog).					
	Set prop	ortional $=$ 3, Integration $=$ 300	0							
8	Using A	PS 1 set 1.70 – 1.90 V to AI 0	6 (CIII_MV_pHb)							
9	Using A	PS 2 set 2.30 – 2.50 V to AI 0	7 (CIII_MV_pHt)							
10	Check in	MEL_CIII_pH Supervision c	lisplay the value of pH			5 ±0.25 pH	OK			
11	In the M	EL_CIII_pH edit the PI param	neters (click over Acid pu	ump to o	open dialog).					
	Set prop	ortional = 3, Integration = 0								
12	Check B	ase pump control action value	during 10 seconds every	/ 30 sec	onds	9±0.75 %	OK			
13	Check D	O 03 light during 10 seconds	every 30 seconds			On				
14	Apply a	500 ohm resistor to AO 06								
15	Check A	O 06 voltage output				2.72±0.1 V	OK	Fixed doc.		
16	In the M	EL_CIII_pH edit the PI param	neters (click over Acid pu	ump to o	open dialog).					
	Set prop	ortional $= 1$, Integration $= 30$								
17	In the M	EL_CIII_pH annotate max. Ba	ase pump control action	value w	ithin the 10 seconds is	0.1±0.01 %	OK			
	active. C	alculate gradient (Base _{t=10} – E	$Base_{t=0}) / 10$							
18	Using A	PS 1 set 2.90 – 3.10 V to AI 0	6 (CIII_MV_pHb)							

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TC Ic	cording to provided J	parameters.					
Items	s Tested	CIII_PLCSW_pH, MEL_CIII_pH					
Desc	ription	When in pH control mode 2, if pH goes under the set point, the PI sha	Ill activate the base pun	np according to parameters provided from	m the supervision.		
Special	Requisites:	2 APS are used to simulate the pH sensors.					
То	store		Data		30/10/2003		
Course of Actions							
Step no		Description	Course of A	ctions	Expected value	OK/NOK	Comments
19	Using A	PS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pHt)		Expected vinue	ON/ITON	Comments
20	Check in	MEL_CIII_pH Supervision display the value of		8 ±0.25 pH	OK		
21	Check C	O2 valve and Base pump control action values	ls)	0±0.1 %	OK		
22	Check D	O 03 light (wait 30 seconds)		Off	OK		
23	Using A	PS 1 set 4.10 – 4.30 V to AI 06 (CIII_MV_pHb)				
24	Using A	PS 2 set 4.70 – 4.90 V to AI 07 (CIII_MV_pHt)				
25	Check in	n MEL_CIII_pH Supervision display the value of	of pH		11 ±0.25 pH	OK	
26	Check C	O2 valve control action value			> 0 %	OK	
27	Using A	PS 1 set 2.90 – 3.10 V to AI 06 (CIII_MV_pHb)				
28	Using A	PS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pHt					
29	Check in	n MEL_CIII_pH Supervision display the value of		8 ±0.25 pH	OK		
30	Check C	O2 valve and Base pump control action values			0±0.1 %	OK	

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5.4.3 MEL-TC-CIII-0403: pH Regulation with Base and Acid additional media

TC Ic	lentifier	MEL-TC-CIII-0403 Purpose: Verify that when in pH control mode 2, if pH goes under the set point, Base pump is activated according to provided parameters.									
Items	s Tested	CIII_PLCSW_pH, MEL_	_CIII_pH	ar/over the est point the DL sh	all activate the he	a /a aid numn raan activaly according	to nonomotors provided from	the supervision			
Special	ripuon Reauisites:	2 APS are used to simulat	te the pH sensors.	er/over the set point, the F1 sh		seracia pump respectively according	to parameters provided nom	i ule supervision.			
~	1	Check supervision values	in MEL_CIII_pH	display							
Те	ster:		JD		Date:		30/10/2003				
	1				Course of A	Actions		1			
Step no	Cot all a	antrol mode to 2	A and L Dag	Description			Expected value	OK/NOK	Comments		
$\frac{1}{2}$	Set pH C	Ontrol mode to $3 - \frac{1}{2}$	- Acid + Bas	e 6 (CIII MV pUb)				+			
2	Using A	PS = 1 set 2.90 - 3.1	$\frac{10 \text{ V to AI 0}}{70 \text{ V to AI 0}}$			+ +					
3	Charle in	PS 2 Set 5.50 - 5.50		/ (CIII_IVI V_pHt)	. T T		0.10.05.11				
4	Спеск п	MEL_CIII_PH S	supervision d	isplay the value of p	DH		8 ±0.25 pH	OK			
5	Check D	O 02, DO 03 ligh	ts (wait 30 s	econds)			Off	OK			
6	Check A	cid and Base pum	p control act	tion values (wait 30	seconds)		0±0.1 %	OK			
7	7 In the MEL_CIII_pH edit the PI parameters (click over Acid pump to open dialog).										
	Set proportional = 3, Integration = 0										
8	Using A	g APS 1 set 4.10 – 4.20 V to AI 06 (CIII_MV_pHb)									
9	Using A	PS 2 set 4.70 – 4.9	90 V to AI 0	7 (CIII_MV_pHt)							
25	Check in	n MEL_CIII_pH S	Supervision d	isplay the value of p	рН		11 ±0.25 pH	OK			
12	Check a	cid pump control a	action value	during 10 seconds ev	very 30 seco	onds	9±0.75 %	OK			
13	Check D	O 02 light during	10 seconds of	every 30 seconds			On	OK			
16	In the M	EL_CIII_pH edit	the PI param	eters (click over Ac	id pump to	open dialog).					
	Set prop	ortional = 1, Integ	ration $= 30$								
17	In the M	EL_CIII_pH anno	otate max. A	cid pump control act	tion value w	ithin the 10 seconds is	0.1±0.1 %	OK			
	active. C	alculate gradient	$(Acid_{t=10} - A)$	$(cid_{t=0})/10$							
18	Using A	PS 1 set 2.90 – 3.1	10 V to AI 0	6 (CIII_MV_pHb)							
19	Using A	PS 2 set 3.50 – 3.7	70 V to AI 0	7 (CIII_MV_pHt)							
20	Check in	n MEL_CIII_pH S	Supervision d	isplay the value of p	рН		8 ±0.25 pH	OK			
21	Check A	cid and Base pum	p control act	tion values (wait 30	seconds)		0±0.1 %	OK			
22	Check D	O 02, DO 03 ligh	ts (wait <u>3</u> 0 s	econds)			Off	ОК			

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TC Id	lentifier	MEL-TC-CIII-0403	Purpose:	Verify that wh	nen in pH control mo	le 2, if pH goes under the set point, Ba	ase pump is activated acc	cording to provided	l parameters.			
Items	s Tested	CIII_PLCSW_pH, MEL_	_CIII_pH									
Desci	ription	When in pH control mode	e 3, if pH goes und	er/over the set point, the PI sh	all activate the base/a	cid pump respectively according to pa	arameters provided from	the supervision.				
Special I	Requisites:	2 APS are used to simulat Check supervision values	APS are used to simulate the pH sensors. Check supervision values in MEL_CIII_pH display									
Te	ster:	T	JD	Date:			30/10/2003					
					Course of Act	ions						
Step no				Expected value	OK/NOK	Comments						
23	Using APS 1 set 1.70 – 1.90 V to AI 06 (CIII_MV_pHb)											
24	Using A	PS 2 set 2.30 – 2.	50 V to AI 0	7 (CIII_MV_pHt)								
25	Check in	n MEL_CIII_pH S	Supervision d	isplay the value of p	эΗ		5 ±0.25 pH	OK				
26	Check B	ase pump control	action value	during 10 seconds e	every 30 secon	ds	>0 %	OK				
27	Using A	PS 1 set 2.90 – 3.	10 V to AI 0	6 (CIII_MV_pHb)								
28	Using APS 2 set 3.50 – 3.70 V to AI 07 (CIII_MV_pHt)											
29	Check in MEL_CIII_pH Supervision display the value of pH						8 ±0.25 pH	OK				
30	Check A	cid and Base pum	p control act	tion values (wait 30	seconds)		0±0.1 %	OK				

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5.4.4 MEL-TC-CIII-0404: pH alarms

TC Id	lentifier	MEL-TC-CIII-0404	Purpose:		Verify that	at when pH value is over the set point during	ng 15 minutes an alarm is	s generated		
Items	Tested	CIII_PLCSW_pH, MEL	_CIII							
Desc	ription	When pH is out of the se	et point for more that	n 15 minutes, a high priority ala	rm shall be ge	nerated.				
Special 1	Requisites:	2 APS are used to simula	ate the pH sensors.							
		Check supervision value	es in MEL_CIII_pH	and MEL_CIII_Main displays						
Те	ster:	JD Date: 30/10/2003								
	Course of Actions									
Step no				Description			Expected value	OK/NOK	Comments	
1	Using A	PS 1 set 4.10 – 4.	20 V to AI 0	6 (CIII_MV_pHb)						
2	Using A	PS 2 set 4.70 – 4.	.90 V to AI 0	7 (CIII_MV_pHt)						
3	Check in MEL_CIII_pH Supervision display the value of pH						11 ±0.25 pH	OK		
4	Wait 15	Wait 15 minutes								
5	Check in	n alarm area pH d	eviation alarr	n status			Alarm	OK		

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5.5 MEL-CIII-TP-05 Liquid Flows Regulation

5.5.1 MEL-TC-CIII-0501: Liquid level control

TC	Identifier	MEL-TC-CIII-0501 Purpose:	Verify that whether the the test of te	hen liquid level	is high output pump flow rate is i	ncreased, when is low, output	pump flow rate is d	ecreased
Iten	ns Tested	CIII_PLCSW_Liquid, MEL_CIII_Liquid, M	EL_CIII_Main			-1		-d - 250/
Des	Cription Requisites:	Check supervision values in MEL CIII Liqu	id level reaches nigh status, outp	but pump now is	increased a 25%, when inquid lev	el reaches low level, output pl	imp now is decrease	ed a 25%.
T	ester:	Under Supervision values in MEE_em_Equ	ind display	Date:		3/11/2003		
				Course of Ac	tions			
Step no			Description			Expected value	OK/NOK	Comments
1	In the MI	EL_CIII_Liquid set control mo	de to AUTO					
2	In the MI	EL_CIII_Liquid set input pump	calibration parameter					
	Paramete	r A = 73.5294	_					
	Parameter	r B = 0.1765						
3	Using Co	ncept tool modify liquid input	safety set point to 0,4	(default)				
4	Check in	MEL_CIII_Liquid supervision	display "Liquid input	t flow rate'	,	0,4 (blinking)	OK	
5	Check in	put pump actuation				29.59±0.1 %	OK	
6	Check Le	evel High indicator				Off	OK	
7	Check Le	evel Low indicator				On	OK	
8	Check ou	tput pump actuation				22.19±0.1 %	OK	
9	Set closed	d circuit to DI 03 (CIII_MV_Llow	/)					
10	Check Le	vel High and Level Low indica	ators			Off	OK	
11	Check ou	tput pump actuation				29.59±0.1 %	OK	
12	Set open	circuit to DI 03 (CIII_MV_Llow)						
13	Check Level Low indicator					On	OK	
14	Check ou	tput pump actuation				22.19±0.1 %	OK	
15	Set close	d circuit to DI03 and DI 04 (CII						
16	Check Le	evel High indicator		On	OK			
17	Check ou	tput pump actuation				36.98±0.1 %	OK	

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TCI	ldentifier	MEL-TC-CIII-0501	Purpose:	Verify that when liquid level	is high output pump flow rate is increase	ed, when is low, output p	oump flow rate is	decreased			
Item	ns Tested	CIII_PLCSW_Liquid, N	AEL_CIII_Liquid, N	/IEL_CIII_Main							
Des	cription	Initially output flow = in	nput flow. When liq	uid level reaches high status, output pump flow is	s increased a 25%, when liquid level reac	ches low level, output pur	np flow is decrea	sed a 25%.			
Special	ecial Requisites: Check supervision values in MEL_CIII_Liquid display										
Т	JD Date: 3/11/2003										
	Course of Actions										
Step no				Description		Expected value	OK/NOK	Comments			
18	Set open	circuit to DI 04 (CIII_MV_Lhigh								
19	Output Off OK										
20	Check ou	tput pump actuat	tion			29.59±0.1 %	OK				

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5.5.2 MEL-TC-CIII-0502: Nitrite estimator

TC Id	lentifier	MEL-TC-CIII-0502	Purpose:			Verify integration of the Nitrite e	stimator algorithm.		
Items	Tested	CIII_PLCSW_Liquid, M	EL_PLCSW_N, N	/EL_CIII_pH, MEL_CIII_pH	I				
Desc	ription Poquisitos:	Firing manually the Nitri	te Estimator contro	ol law, will set the Liquid inpu	ut flow rate set poi	int and NO2 estimation.			
Te	ster:	Check super vision values	.ID		Date:		31/10/2003		
	50010		02		Course of	Actions	01,10,2000		
Step no				Description			Expected value	OK/NOK	Comments
1	In the M	EL_CIII_Liquid	Supervision	display set control 1	mode to AU	ТО			
2	In the M	EL_CIII_Liquid S	Supervision	display set input put	mp calibration	on parameters to:			
	Paramete	er A = 73.5294							
	Paramete	er B = 0.1765							
3	In the M	EL_CIII_Liquid S	Supervision	display set Level 2 l	iquid level s	set point to 0.4			
4	Using C	oncept tool modify	y safety valu	ies for NO3, NH4, I	DO and the l	iquid input set point. Set:			
	NO3 = 3	29 ppm							
	NH4 = 4	.2 ppm							
	DO = 80	% (default value)							
	LIN = 0	.4 l/h							
5	Using iF	ix tool Database N	Manager, set	CIII_SSP_L1IN to	0,4				
6	In the M	EL_CIII_Liquid S	Supervision	display, open Nitrite	e estimator p	arameters dialog.			
7	In the N	itrite estimator par	ameters dial	log, check O2 at liqu	uid output		0,0002 mol/l	OK	Fixed document
8	In the N	itrite estimator par	rameters dial	log, check Required	& Measure	d Liquid input flow rate	0.4 l/h	OK	
9	In the N	itrite estimator par	rameters dia	log, update values u	sing the tabl	e below (MEL-TC-CIII-			
	0502.Ta	ble1)							
10	Using iF	ix Scheduler, set	scheduler pr	operties to "Run in	Foreground'	,			
11	Fire CII	_CTRLLAW_NI	Γ event						
12	In the M	EL_CIII_Liquid S	Supervision	display check Estim	nated NO2 co	oncentration	1.59 ppm	ОК	
13	3 In the MEL_CIII_Liquid Supervision display check Level 1 Liquid Input Flow						0.4 l/h	OK	
14	In the MEL_CIII_Liquid Supervision display check Liquid Input Flow			0.4 l/h	OK				
15	In the M	EL_CIII_Main Su	upervision d	isplay check Liquid	Input Flow		0.4 l/h	OK	
16	In the M	EL_CIII_Main Su	upervision d	isplay check NO2 es	stimation		1.59 ppm	OK	

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Nitrite Estimator parameters table

Index	Description	Values	Unit
0	Measured liquid flow rate or set point of the FRC of the liquid pump	0.4000	l/h
1	O ₂ concentration in the gas input stream	0.0066	mol/l
2	CO_2 concentration in the gas input stream	0.0019	mol/l
3	NH ₃ concentration in the gas input stream	0.0000	mol/l
4	O ₂ concentration in the liquid input stream	0.0004	mol/l
5	total CO ₂ concentration in the liquid input stream	0.0159	mol/l
6	total NH ₃ concentration in the liquid input stream	0.0250	mol/l
7	unused (room for NO ₂ concentration if not null)	0.0000	mol/l
8	NO ₃ concentration in the liquid input stream	0.0000	mol/l
9	PO ₄ concentration in the liquid input stream	0.0016	mol/l
10	SO ₄ concentration in the liquid input stream	0.0040	mol/l
11	O ₂ concentration in the liquid output stream	0.0002	mol/l
12	total CO ₂ concentration in the liquid output stream	0.0564	mol/l
13	total NH ₃ concentration in the liquid output stream	0.0003	mol/l
14	NO ₃ concentration in the liquid output stream	0.0235	mol/l
15	PO ₄ concentration in the liquid output stream	0.0016	mol/l
16	SO ₄ concentration in the liquid output stream	0.0039	mol/l
17	Measured gas flow rate or set point of the FRC of the gas pump	60.0000	l/h
18	'Required' liquid flow rate	0.4000	l/h
19	Maximum constraint of NO ₂	0.0003	mol/l
20	Compensation term for estimator	0.0000	mol/l

MEL-TC-CIII-0502.Table1

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5.5.3 MEL-TC-CIII-0503: Output buffer tank pump activation

TC Id	lentifier	MEL-TC-CIII-0503	Purpose:			Verify buffer tank output pump is activa	ted when level is high				
Items	Tested	CIII_PLCSW_Liquid, M	EL_CIII_Liquid								
Desci	ription	When output buffer liqui	d reaches high leve	l, the output pump is activated	l.						
Special I	Special Requisites: Check supervision values in MEL_CIII_Liquid										
		Use a Multimeter to chec	ck output voltage va	dues.							
Tes	ster:	JD Date: 3/11/2003									
		Course of Actions									
Step no				Description			Expected value	OK/NOK	Comments		
1	Check in	n MEL_CIII_Liqu	id the Buffer	tank Level High in	dicator		Off	OK			
2	Check in	n MEL_CIII_Liqu	id the Buffer	tank output pump s	tatus		Off	OK			
3	Close cir	rcuit in DI 05									
4	Check in MEL_CIII_Liquid the Buffer tank Level High indicator						On	OK			
5	Check in MEL_CIII_Liquid the Buffer tank output pump status On OK										
6	Check D	O 01 relay status					Closed	OK			

5.5.4 MEL-TC-CIII-0504: Liquid level alarms

TC Id	lentifier	MEL-TC-CIII-0504 Purpose:		Verify high liquid level	alarm						
Items	Tested	CIII_PLCSW_Liquid, MEL_CIII_Liquid									
Desci	ription	High level alarm shall be activated when level is high during 15 minutes.									
Special 1	Requisites:	Check supervision values in MEL_CIII_Liquid display									
Te	ster:	JD	JD Date: 3/11/2003								
			Course of Actions								
Step no		Description Expected value OK/NOK Comments									
1	In the M	IEL_CIII_Liquid set Liquid input set point to 0.4 1/	'n								
2	Close cir	rcuit in DI 04									
3	Check L	evel High indicator			On	OK					
4	Wait 15	minutes		Alarm	OK						
5	Check in	Alarm area, the level high alarm has been indicated. On OK									
6	Check L	iquid input flow rate			0 l/h	OK					

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5.6 MEL-CIII-TP-06 Gas Flows Regulation

5.6.1 MEL-TC-CIII-0601: DO regulation

TC	ldentifier	MEL-TC-CIII-0601 Purpos	e: Verify DO regul	ation performed b	y a PID actuating over the N2 and O2 g	gas input flow regulators ad	ccording to provide	ed parameters.
Iten	ns Tested	CIII_PLCSW_DO, MEL_CIII_Gas, I	MEL_CIII_Main	001				
Des	cription Dogwigitogy	When DO grows, O2 valve is closed.	If O2 valve is completely closed and DO sensor	O2 is still over th	e set point, the N2 valve opens.			
Special	Requisites:	Check supervision values in MEL_C	III_Gas and MEL_CIII_Main display	'S				
Т	ester:)	Date:		3/11/2003		
				Course of A	ctions			
Step no			Description			Expected value	OK/NOK	Comments
1	In the ME	EL_CIII_Gas set DO cont	rol action mode to AUTO)				
2	In the MB	EL_CIII_Gas, set DO ram	p parameter to 0.0167					
3	In the MB	EL_CIII_Gas, check DO s	et point (initial value)			80%	OK	
4	In the MB	EL_CIII_Gas Supervision	screen click over the O2	valve to edi	t PID parameters. Set:			
	Proportional = 12							
	Integrativ	e = 30						
	Derivativ	e = 0.033						
	Bias = 0							
5	In the MB	EL_CIII_Gas Supervision	screen click over the N2	valve to set	Proportional constant to			
	0.5							
6	With Con	cept open CIII_PLCSW_	DO and disable EN_I, EN	N_D (only p	roportional part is			
	enabled).							
7	With APS	S set 4.15 – 4.25 to AI 01	(DO bottom)					
8	In the MB	EL_CIII_Gas check DO co	oncentration bottom			80±1.25%	OK	
9	With APS	S set 4.15 – 4.25 to AI 02	(DO top)					
10	In the ME	EL_CIII_Gas check DO co	oncentration top			80±1.25%	OK	
11	With APS	S set $4.15 - 4.25$ V to AI (1 and AI 02 (DO bottom	/top)				
12	In the MI	EL_CIII_Main check DO	concentration			640±1.25 ppm	OK	
13	In the MI	EL_CIII_Liquid check DC	(ppm) concentration			640±1.25 ppm	OK	
14	In the MI	EL_CIII_Gas check DO c	oncentration			80±1.25%	OK	

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TC	Identifier	MEL-TC-CIII-0601 Purpose: Verify DO regulation performed by a PID actuating over the N2 and O2 ga	is input flow regulators a	according to provi	ded parameters.
Iten	ns Tested	CIII_PLCSW_DO, MEL_CIII_Gas, MEL_CIII_Main When DO grows O2 value is closed. If O2 value is completely closed and O2 is still over the set point, the N2 value opens			
Special	Requisites:	1 APS and a FG are used to simulate DO sensor.			
	1	Check supervision values in MEL_CIII_Gas and MEL_CIII_Main displays			
T	ester:	JD Date:	3/11/2003		
Stop po		Course of Actions	Exported value	OK/NOK	Commonts
15	In the MI	EL CIII Gas, modify DO set point to 78%	Expected value	UK/NUK	Comments
16	Check the	at in 2 minutes O2 Set Point moved to expected value (effect of ramp parameter applied	24+1.25%	OK	
_	to DO se	t point):			
17	In the MI	EL_CIII_Gas, modify DO set point to 80%			
18	Check the	at in 2 minutes O2 Set Point moved to expected value (effect of ramp parameter applied	0±1.5%	OK	Fixed document
	to DO set	t point):			
19	With APS	S set 3.95 – 4.05 V to AI 01 and AI 02 (DO bottom/top)			
20	In the M	EL_CIII_Gas check DO concentration	75±1.25%	OK	
21	In the MI	EL_CIII_Gas check O2 flow controller set point (SP)	60%	OK	
22	With APS	S set 4.35 – 4.45 V to AI 01 and AI 02 (DO bottom/top)			
23	In the MI	EL_CIII_Gas check DO concentration	85±1.25 %	OK	
24	In the MI	EL_CIII_Gas check N2 flow controller set point (SP)	30±1.25 %	OK	
25	With APS	S set 4.15 – 4.25 V to AI 01 and AI 02 (DO bottom/top)			
26	In the MI	EL_CIII_Gas check DO concentration	80±1.25%	OK	
27	In the MI	EL_CIII_Gas check N2, O2 flow controllers set point	0±1.25%	OK	
28	With Cor	cept open CIII_PLCSW_DO and disable EN_P, EN_D and enable EN_I (only			
	integrativ	e part is enabled).			
29	With APS	S set 3.95 – 4.05 V to AI 01 and AI 02 (DO bottom/top)			
30	In the MI	EL_CIII_Gas annotate O2 valve control action value within the 10 seconds is active.	2±0.15%	OK	
	Calculate	gradient $(O2_{t=10} - O2_{t=0}) / 10$			
31	With Cor	ncept open CIII_PLCSW_DO and disable EN_P, EN_I and enable EN_D (only derivative			
	part is en	abled).			
32	With a F	G apply a triangular wave Freq=0.1 Hz, A=0.8 V, Offset=3.8 V (3.8 – 4.6 V / 70 – 80%)			
33	In the MI	EL_CIII_Gas check O2 flow controller set point (SP) MAX	4±0.5%	OK	

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5.6.2 MEL-TC-CIII-0602: Pressure valve activation

TC	Identifier	MEL-TC-CIII-0602	Purpose:		Veri	fy that safety valve is opened when pro	essure goes over the set po	int	
Iten	ns Tested	CIII_PLCSW_P, MEL_C	CIII_Gas, MEL_C	II_Main					
Des	cription	When pressure goes over	the set point, the	afety pressure valve shall be o	ppened until the pres	ssure returns under the set point.			
Special	Requisites:	1 APS is used to simulate	e Pressure sensor.	a and MEL_CIII. Main diaplay					
т	octor.	Check supervision values		s and MEL_CIII_Main displa	ys Data:		//11/2003		
	cster.		3D		Course of Ac	tions	7/11/2003		
Step no				Description	Course of the		Expected value	OK/NOK	Comments
1	1 In the MEL_CIII_Gas set control mode to AUTO							1	
2	In the MI	EL_CIII_Gas Supe	ervision scre	en set Pressure Set p	oint to 100 m	ıb			
3	Apply 1.30 – 1.40 V to AI 05 (CIII_MV_P)								
4	4 In the MEL_CIII_Main Supervision screen check Pressure value						87.5±12.5 mb	OK	
5	5 In the MEL_CIII_Gas Supervision screen check Pressure value						87.5±12.5 mb	OK	Fixed document
6	In the MEL_CIII_Gas Supervision screen check safety valve status					Closed	OK		
7	Apply a l	ight to DO 08 (CII	I_AC_Safe in	CIII_AC_OUT)					
8	Check lig	ht status					Off	OK	
9	Apply 1.9	95 – 2.05 V to AI	05						
10	In the MI	EL_CIII_Gas Supe	ervision scre	en check Pressure va	alue		250±12.5 mb	OK	
11	In the MEL_CIII_Gas Supervision screen check safety valve status						Open	OK	
12	2 Check light status					On	OK		
13	3 Apply 1.30 – 1.40 V to AI 05 (CIII_MV_P)								
14	In the MEL_CIII_Gas Supervision screen check Pressure value					87.5±12.5 mb	OK		
15	In the MI	EL_CIII_Gas Supe	ervision scre	en check safety valv	e status		Closed	OK	
16	Check lig	t status					Off	OK	

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5.6.3 MEL-TC-CIII-0603: DO and Pressure alarms

TC	Identifier	MEL-TC-CIII-0603	Purpose:			Verify that DO and pressur	e alarms are notified		
Iten	ns Tested	CIII_PLCSW_P, MEL_	CIII_Gas, MEL_C	III_Main					
Des	cription	When pressure goes ove	r the set point, the	safety pressure valve shall be o	pened until the pre	ssure returns under the set point.			
Special	Requisites:	1 APS is used to simulat	te Pressure sensor.	and MEL CIII Main diamlar					
т		Check supervision value	s in MEL_CIII_Ga	is and MEL_CIII_Main display	Datas		4/11/2002		
I	ester:		JD		Date:		4/11/2003		
<i>a</i> .	1				Course of A	ctions		o v prove	~
Step no				Description	100	1	Expected value	OK/NOK	Comments
1	In the MI	EL_CIII_Gas Sup	ervision scre	en set Pressure Set p	oint to 100 n	16			
2	Apply 1.9	95 - 2.05 V to AI	05 (CIII_M	V_P)					
3	In the MEL_CIII_Gas Supervision screen check Pressure value						250±12.5 mb	OK	
4	Wait 15 minutes.								
5	Check in the Alarm Area the pressure alarm status						Alarm	OK	
6	In the MI	EL_CIII_Gas Sup	ervision scre	en set DO set point t	o 80%				
7	Apply 4.6	65 – 4.75 V to AI	01 and AI 0	2 (CIII_MV_DO top.	/bottom)				
8	In the MI	EL_CIII_Gas Sup	ervision scre	en check DO value			92.5±1.25 %	OK	
9	Check in	the Alarm Area th	he DO alarm	status			Alarm	OK	
10	Apply 4.15 – 4.25 V to AI 01 and AI 02 (CIII_MV_DO top/bottom)								
11	In the MEL_CIII_Gas Supervision screen check DO value						80±1.25 %	OK	
12	2 Check in the Alarm Area the DO alarm status					OK	OK		
13	Apply 3.6	55 - 3.75 V to AI	01 and AI 0	2 (CIII_MV_DO top)	/bottom)				
14	Check in	the Alarm Area th	he DO alarm	status			Alarm	OK	

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5.7 MEL-CIII-TP-07 Temperature regulation

5.7.1 MEL-TC-CIII-0701: Temperature regulation

TC	ldentifier	MEL-TC-CIII-0701 Purpos	ose: V	erify that when tempera	ture goes under the	set point the heater is	activated with a p	ulse action and when is o	ver the set point	the cooling valve is opened		
Iten	ns Tested	CIII_PLCSW_Temp, MEL_CIII_Te	emp, MEL_C	CIII_Main								
Des	cription	When temperature goes under the se	et point, the h	neater is activated with a	pulse action and co	oling valve is opened.						
Special	Requisites:	1 APS is used to simulate Temperatu Check supervision values in MEL.	ture sensors. CIII Temp a	nd MEL CIII Main disr	alays							
Т	ester:		em_remp u		Date:							
	Course of Actions											
Step no				Description				Expected value	OK/NOK	Comments		
1	In the ME	EL_CIII_Temp set contro	ol mode t	to AUTO								
2	Apply a li	ght to DO 06 and DO 05	5 (CIII_AC	C_Heat, CIII_AC_C	CV in the CIII_	AC_CP)						
3	In the ME	EL_CIII_Temp, set Temp	o ramp pa	arameter to 30 se	conds.							
4	4 In the MEL_CIII_Temp, check Temp set point (initial value) 28° C							OK				
5 Apply 1.70 – 1.80 V to AI 09 (Temperature bottom)												
6	6 In the MEL_CIII_Temp, check Temperature bottom value						27.725±1.8° C	OK				
7	Apply 1.7	70 – 1.80 V to AI 10 (Ten	mperature	e top)								
8	In the ME	EL_CIII_Temp, check Te	emperatu	re top value				27.725±1.8° C	OK	Fixed document		
9	Apply 1.7	0 − 1.80 V to AI 09, AI	10 (Tem	perature bottom/	ťtop)							
10	In the ME	EL_CIII_Temp, check Te	emperatur	re value				27.725±1.8° C	OK			
11	Apply 1.8	80 – 1.90 V to AI 09, AI	10 (Tem	perature bottom/	ťtop)							
12	In the ME	EL_CIII_Temp, check Te	emperatur	re value				31.935±1.8° C	OK			
13	13 Check DO 05 light (CIII_AC_CV)						On	OK				
14	4 In the MEL_CIII_Temp check cooling valve status Open OK											
15 Apply 1.60 – 1.70 V to AI 09, AI 10 (Temperature bottom/top)												
16	16 In the MEL_CIII_Temp, check Temperature value							24.04±1.8° C	OK			
17	Check DO	0 05 light (CIII_AC_CV))					Off	OK			

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TC	Identifier	MEL-TC-CIII-0701	Purpose:	Verify that when temperat	ure goes under th	he set point the heater is activated with a p	oulse action and when is o	ver the set point the	he cooling valve is opened	
Item	ns Tested	CIII_PLCSW_Temp, M	EL_CIII_Temp, MI	EL_CIII_Main						
Des	cription	When temperature goes	under the set point,	the heater is activated with a p	oulse action and c	cooling valve is opened.				
Special	al Requisites: 1 APS is used to simulate Temperature sensors. Check supervision values in MEL_CIII_Temp and MEL_CIII_Main displays									
Т	ester:	ster: Date:								
	Course of Actions									
Step no	Step no Description Expected value OK/NOK Comments								Comments	
18	Check DO	O 06 light (CIII_A	AC_Heater) s	tatus every 5 second	s (shall be :	5 seconds blinking, 5	On	OK		
	seconds of	off)								
19	Apply 1.70 – 1.80 V to AI 09 (Temperature bottom)									
20	20 In the MEL_CIII_Temp, check Temperature bottom value 27.725±1.8° C OK									
21	21 Check DO 05, DO 06 lights (CIII_AC_CV, CIII_AC_Heater) Off OK									

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5.7.2 MEL-TC-CIII-0702: Temperature alarms

TC	ldentifier	MEL-TC-CIII-0702 Purpos	se: Verify that when temperat	ure goes under the	set point the heater is activate	d with a pulse action and when is o	over the set point the	e cooling valve is opened
Iten	ns Tested	CIII_PLCSW_Temp, MEL_CIII_Te	emp, MEL_CIII_Main					
Des	cription	When temperature goes under the se	et point, the heater is activated with a p	pulse action and co	oling valve is opened.			
Special	Requisites:	1 APS is used to simulate Temperatu	Ire sensors.	EL CIII Main dis	Jave			
Т	ester•		D	Date:	лауз	4/11/2003		
	cotti i			Course of A	rtions	4/11/2005		
Step no			Description	course of fi		Expected value	OK/NOK	Comments
1	1 In the MEL_CIII_Temp set control mode to AUTO							
2	In the MB	EL_CIII_Temp, check Te	mp set point (initial value		28° C	OK		
3	In the ME	EL_CIII_Liquid, set Liqu						
4	Apply 1.4	5 – 1.55 V to AI 09 (Ter	nperature bottom)					
5	In the MB	EL_CIII_Temp, check Te	mperature bottom value		18.55±1.8° C	OK		
6	In the MB	EL_CIII_Temp, check Te	mperature value	20.44±1.8° C	OK			
7	Check in the Alarm Area the Temperature deviation alarm status					Alarm	OK	
8	Check in	the MEL_CIII_Liquid, th	ne Liquid input flow rate			0±0.1 l/h	OK	
9	Apply 1.7	0 – 1.80 V to AI 09 (Ter	nperature bottom)					
10	In the ME	EL_CIII_Temp, check Te	mperature value			27.725±1.8° C	OK	
11	Check in	the Alarm Area the Temp	perature deviation alarm s	status		ОК	OK	
12	Apply 2.4	5 – 2.55 V to AI 10 (Ter	nperature top)					
13	In the ME	EL_CIII_Temp, check Te	mperature top value			55.25±1.8° C	OK	
14	In the MEL_CIII_Temp, check Temperature value					33.45±1.8° C	OK	
15	Check in the Alarm Area the Temperature deviation alarm status					Alarm	OK	
16	Apply 1.7	10 - 1.80 V to AI 10 (Ter	nperature top)					
17	In the ME	EL_CIII_Temp, check Te	mperature value		27.725±1.8° C	OK		
18	Check in	the Alarm Area the Temp	perature deviation alarm s	status		OK	OK	

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5.8 MEL-CIII-TP-08: Initial Values

TC Identifier	AET-CIII-LD-08	Purpose	Check that	correct initial values are used at PLC restart		
Tester: JD		Date:	5/11/2003			
Variable name	Туре	Address	Init. Value	Description	OK	
CIII_CNS_CO2Kp	real	400522	5	Additional proportional constant for CO2	OK	
CIII_CNS_DOBias	real	400518	0	Disturbance variable (Feed_fw) for DO PID	OK	
CIII_CNS_DOKd	real	400516	0.0033	Derivative constant for DO PID	OK	
CIII_CNS_DOKi	real	400514	3000	Integrative constant for DO PID	OK	
CIII_CNS_DOKp	real	400512	12	Proportional constant for DO PID	OK	
CIII_CNS_Doramp	real	400588	0.016	DO supervision set point ramp coefficient	OK	
CIII_CNS_LinA	real	400584	73.5294	04 Input pump calibration constant parameter A		
CIII_CNS_LinB	real	400586	0.1765	5 Input pump calibration constant parameter B		
CIII_CNS_LoA	real	400598	0	Output pump calibration constant parameter A	OK	
CIII_CNS_LoB	real	400600	0	Output pump calibration constant parameter B	OK	
CIII_CNS_N2Kp	real	400614	0.5	Proportional constant for N2 regulation	OK	
CIII_CNS_OpModeD	O int	int 400568 0 DO control operational mode (0=Off, 1=Auto, 2=Manual)		DO control operational mode (0=Off, 1=Auto, 2=Manual)	OK	
CIII_CNS_OpModeGa	as int	400566	0	Gas control operational mode (0=Off, 1=Auto, 2=Manual)	OK	
CIII_CNS_OpModeL	int	400565	0	Liquid control operational mode (0=Off, 1=Auto, 2=Manual)	OK	
CIII_CNS_OpModep	H int	400612	0	pH control operational mode (0=Off, 1=Auto, 2=Manual)	OK	
CIII_CNS_OpModeT	int	400567	0	Temperature control operational mode (0=Off, 1=Auto, 2=Manual)	OK	
CIII_CNS_pHKi	real	400510	3000	Integration constant for Acid/Base PI	OK	
CIII_CNS_pHKp	real	400508	3	Proportional constant for Acid/Base PI	OK	
CIII_CNS_pHMode	int	400554	1	PH regulation mode variable (1=CO2 only, 2=CO2+Base, 3=Base+Acid)	OK	
CIII_CNS_pHramp	real	400560	0.005	pH supervision set point ramp coefficient	OK	
CIII_CNS_Tramp	real	400556	0.0083	Temperature supervision set point ramp coefficient	OK	
CIII_MAN_Ac	real	400570	0	Manual acid pump set point	OK	
CIII_MAN_Bs	real	400572	0	0 Manual base pump set point		
CIII_MAN_CO2	real	400574	0	0 Manual CO2 flow controller set point		
CIII_MAN_EnAc	Bool	000190	0	0 Manual enable of acid pump		

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TC Identifie	er 🛛	MEL-CIII-TP	-08 Purpose	Check that	correct initial values are used at PLC restar	t
Tester: JI	D		Date:	5/11/2003		
Variable na	me	Туре	Address	Init. Value	Description	OK
CIII_MAN_E	nBs	Bool	000191	0	Manual enable of base pump	OK
CIII_MAN_E	nCV	Bool	000192	0	Manual enable of the cooling valve	OK
CIII_MAN_E	InHT	Bool	000193	0	Manual enable of the heater	OK
CIII_MAN_E	nlobt	Bool	000195	0	0 Manual enable of buffer output pump	
CIII_MAN_E	ΞnΡ	Bool	000194	0	Manual enable of pressure safety valve	OK
CIII_MAN_L	in	real	400576	0	0 Manual liquid input pump set point	
CIII_MAN_L	0	real	400578	0	Manual liquid output pump set point	OK
CIII_MAN_N	12	real	400580	0	Manual N2 flow controller set point	OK
CIII_MAN_C)2	real	400582	0	Manual O2 flow controller set point	OK
CIII_SSP_D	0	real	400520	80	DO Supervision set point	OK
CIII_SSP_L	1Lin	real	400524	0	Level 1 liquid input supervision set point	OK
CIII_SSP_L2	2Lin	real	400542	0	Level 2 liquid Input supervision set point	OK
CIII_SSP_P)	real	400526	80	Pressure supervision set point	OK
CIII_SSP_pl	Н	real	400504	8	8 pH supervision set point	
CIII_SSP_T		real	400500	28	Temperature supervision set point	OK

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5.9 MEL-CIII-TP-09: Check Sensor / Actuator Link Errors

5.9.1 MEL-TC-CIII-0901: Check Link Errors on Analogue Inputs

TC Ide	ntifier	MEL-TC-CIII-0901	Purpose:		Verify that	when a current analogue	e input connection i	is broken is notified to su	pervision	
Functions	s Tested	CIII_PLCSW								
Descri	otion	Errors on sensor links are	e displayed in the s	upervision as alarms and safety	values are displa	ayed blinking in the supe	ervision screens.			
Special Re	equisites:	All current inputs shall b	e disconnected							
Test	er:				Date:					
	1				Course of A	Actions				
Step no				Description				Expected value	OK/NOK	Comments
1	In the M	MEL_CIII_Temp	supervision of	lisplay set Temperati	ure set poin	t to 28				
2	In the M	In the MEL_CIII_Temp supervision display check Temperature bottom value						28 (Blinking)	OK	
3	In the MEL_CIII_Temp supervision display check Temperature top value							28 (Blinking)	OK	
4	In the M	MEL_CIII_Gas su	pervision dis	splay set DO(%) set p	point to 80					
5	In the MEL_CIII_Gas supervision display check DO(%) bottom value						80 (Blinking)	OK		
6	In the MEL_CIII_Gas supervision display check DO(%) top value					80 (Blinking)	OK			
7	In the MEL_CIII_Gas supervision display check Pressure value					80 (Blinking)	OK			
8	In the M	MEL_CIII_Liquid	supervision	display check NH4 v	value			0.0 (Blinking)	OK	
9	In the M	MEL_CIII_Liquid	supervision	display check NO3 v	value			0.0 (Blinking)	OK	
10	In the M	MEL_CIII_pH suj	pervision dis	play check pH bottor	n value			8.0 (Blinking)	OK	
11	In the M	MEL_CIII_pH suj	pervision disp	olay check pH top va	lue			8.0 (Blinking)	OK	
12	In the M	MEL_CIII_Main s	supervision d	isplay check Pressure	e value			80 (Blinking)	OK	
13	In the M	MEL_CIV_Main	supervision d	isplay check DO val	ue			640 (Blinking)	OK	Fixed doc
14	In the MEL_CIV_Main supervision display check NH4 value				0.0 (Blinking)	OK				
15	In the M	MEL_CIV_Main	supervision d	isplay check NO3 va	lue			0.0 (Blinking)	OK	
16	In the M	MEL_CIV_Main	supervision d	lisplay Temperature	value			28.0 (Blinking)	OK	
17	In the M	MEL_CIV_Main s	supervision d	isplay pH value				8.0 (Blinking)	OK	

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TC Ide	ntifier	MEL-TC-CIII-0901	Purpose:	Verify that when a current analogue input connection	is broken is notified to supe	rvision				
Function	s Tested	CIII_PLCSW								
Descri	ption	Errors on sensor links ar	Errors on sensor links are displayed in the supervision as alarms and safety values are displayed blinking in the supervision screens.							
Special Re	equisites:	All current inputs shall b	All current inputs shall be disconnected							
18	Check	following alarms	are fired:			OK				
	- Ala	Alarm to notify Temperature sensor link error								
	- Ala	arm to notify DO	sensor link e	TOT						
	- Ala	arm to notify NO3	3 sensor link	error						
	- Ala	Alarm to notify NH4 sensor link error								
	- Ala	Alarm to notify pressure sensor link error								
	- Ala	arm to notify pH s	ensor link er	ror						

5.9.2 MEL-TC-CIII-0802: Check Link Errors on Analogue Outputs

TC Ide	ntifier	MEL-TC-CIII-0802 Purpose:	Verify that	when a current analogue output connection	n is broken is notified to sur	pervision	
Functions	s Tested	CIII_PLCSW					
Descri	ption	Errors on actuator links are displayed in the supervision as alar	ms				
Special Re	equisites:	All current outputs shall be disconnected					
Tester: Date:							
Course of Actions							
Step no		Descript	Expected value	OK/NOK	Comments		
1	Check	following alarms are fired:				OK	
	- Ala	rm to notify acid pump link error					
	- Ala	rm to notify base pump link error					
	- Ala	rm to notify liquid input link error					
	- Ala	rm to notify liquid output link error					

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6 HMI DISPLAYS

6.1 MEL-HMI-TP-01 Check CIII HMI Displays 6.1.1 MEL-TC-HMI-0101: Check CIII_HMI_Temp

TC Ide	ntifier	MEL-TC-HMI-0101 Purpose:	Verify t	nat values in CIII_HMI_Te,mp are displ	layed according to specifica	tions.	
Function	s Tested	Interface between HMI - CIII_PLC, CIII_HMI_Main, CIII_HMI_Temp					
Descri	ption	Known values applied to PLC variables shall be displayed in the display a	s specified.				
Special Re	equisites:	Use an APS to generate voltages.	Deter		10/11/2002		
1 est	er:	JCM	Date:		10/11/2003		
Stor as	<u>r</u>	Description	Course of A	ctions	Ermanted volue	OK/NOK	Commente
5tep no	A mmlax /	Description	diamlaria di su	lue Terrerereture in the	Expected value		Comments
1	Apply .	$2.9 - 3.1$ v to AI 09 (CIII_IVIV_ID) and check the	displayed va	aue Temperature in the	$/3.6\pm4.3$ mbar	OK	
	Superv	ision screen CIII_HMI_Temp.					
2	2 Apply 2.9 – 3.1 V to AI 10 (CIII_MV_Tt) and check the displayed value Temperature in the					OK	
	Superv	ision screen CIII_HMI_Temp.					
3	Apply 29 – 31 V to AL09 AL10 (CIII MV Th CIII MV Tt) and check the displayed value				73 6+4 3 mbar	OK	
C	Tomporature in the Supervision screen CIII HML Tomp				75.0±4.5 mbai	011	
4						OV	
4	Спеск	temperature value in the CIII_HMI_Main display.			73.6 ± 4.3 mbar	OK	
5	In the I	MEL_CIII_Temp Supervision display change the t	emperature s	set point to 27 ° C			
6	Check	the Temperature set point in the CIII_HMI_Temp	display (not	e ramp action)	down to 27° C	OK	
7	In the I	MEL_CIII_Temp Supervision display change the c	ontrol mode	to AUTO			
8	Check	the operational mode changed accordingly in the G	CIII_HMI_T	emp display	AUTO	OK	
9	In the I	MEL_CIII_Temp Supervision display change the c	ontrol mode	to MAN			
10	Check the operational mode changed accordingly in the CIII_HMI_Temp display				MAN	OK	
11	In the I	MEL_CIII_Temp Supervision display edit manual	values and s	et:			
	- Hea	ater enabled.					
	- Co	oling valve enabled.					
12	Check	in the CIII_HMI_Temp display status of Heater an	d the Coolir	ig Valve.	Enabled	OK	

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6.1.2 MEL-TC-HMI-0102: Check CIII_HMI_pH display

TC Ide	ntifier	MEL-TC-HMI-0102	Purpose:		Verif	fy that values in CIII_HMI_pH are displ	ayed according to specificati	ions.	
Functions	Tested	Interface between HMI -	- CIII_PLC, CIII_H	IMI_Main, CIII_HMI_pH, CI	II_HMI_Gas				
Descrip Special Re	otion anisites:	Known values applied to	PLC variables sha	ill be displayed in the display a	as specified.				
Test	er:	obe un mi bito generate	JCM		Date:		11/11/2003		
			00112		Course of	Actions	11/11/2000		
Step no				Description			Expected value	OK/NOK	Comments
1	Apply 2	2.9 - 3.1 V to AI	06 (CIII_MV	_PHb) and check the	ne displayed	l value pHbot in the	8.0±0.25 pH	OK	
	Supervi	ision screen CIII_	_HMI_pH.				-		
2	Apply 2	2.9 - 3.1 V to AI	07 (CIII_MV	_PHt) and check the	e displayed	value pHtop in the	6.5±0.25 pH	OK	
	Supervi	ision screen CIII_	HMI_pH.				1 I		
3	Apply 2	2.9 – 3.1 V to AI	06 and AI 07	(CIII_MV_PHb, C	III_MV_PF	Ht) and check the displayed	7.85±0.25 pH	OK	
	value p	H in the HMI scr	een CIII_HM	II_pH.			1		
4	Check	pH value in the H	IMI screen C	III_HMI_Main			7.85±0.25 pH	OK	
5	In the M	/IEL_CIII_pH Su	pervision dis	play change the pH	set point to	9			
6	Check	the pH set point in	n the CIII_H	MI_pH display (not	e ramp actio	on) in 3 minutes	up to 9 pH	OK	Fixed doc.
7	In the M	/IEL_CIII_pH Su	pervision dis	play change the con	trol mode to	o AUTO			
8	Check	the operational m	ode changed	accordingly in the (CIII_HMI_f	pH display	AUTO	OK	
9	In the M	/IEL_CIII_pH Su	pervision dis	play change the pH	operation n	node to 2=CO2+Base			
10	Check	the pH operation	mode change	ed accordingly in the	e CIII_HMI	[_pH display	2	OK	
11	In the M	/IEL_CIII_pH Su	pervision dis	play change the pH	operation n	node to 3=Acid+Base			
12	Check	the pH operation	mode change	ed accordingly in the	e CIII_HMI	[_pH display	3	OK	
13	In the M	/IEL_CIII_pH Su	pervision dis	play change the con	trol mode to	o MAN			
14	Check	the operational m	ode changed	accordingly in the (CIII_HMI_f	pH display	MAN	OK	
15	In the M	/IEL_CIII_pH Su	pervision dis	play edit manual va	lues and set	t:			
	- Aci	d pump enabled							
	- Aci	d pump control a	ction 10%.						
	- Bas	e pump enabled							
	- Bas	e pump control a	ction 20%.						
	- <u>C</u> O	2 valve at 30%							

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TC Ide	ntifier	MEL-TC-HMI-0102 Purpose:		Verify	that values in CIII_HMI_pH are display	yed according to specification	ons.	
Function	s Tested	Interface between HMI – CIII_PLC, CIII_H	IMI_Main, CIII_HMI_pH, CI	II_HMI_Gas				
Descri	ption	Known values applied to PLC variables sha	ll be displayed in the display a	as specified.				
Special Re	equisites:	Use an APS to generate voltage values.						
Tester: JCM Date:						11/11/2003		
Course of Actions								
Step no			Description			Expected value	OK/NOK	Comments
16	Check	in CIII_HMI_pH acid pump co		10%	OK			
17	Check	in CIII_HMI_pH base pump c		20%	OK			
18	Check	in CIII_HMI_pH CO2 valve c	ontrol action			30%	OK	
19	Check	in CIII_HMI_Gas CO2 valve	control action			30%	OK	
20	Check a	acid and base pump status				Enabled	OK	
21	In the N	MEL_CIII_pH Supervision dis	play change the con	OFF				
22	Check	the operational mode changed	accordingly in the (H display	OFF	OK		
23	Check a	acid, base, CO2 control actions	5		0.0	OK		
24	Check a	acid, base pumps status				Disabled	OK	

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6.1.3 MEL-TC-HMI-0103: Check CIII_HMI_Liquid display

TC Ider	ntifier	MEL-TC-HMI-0103	Purpose:		Verify	that values in CIII_HMI_Liquid are dia	splayed according to specifica	ations.	
Functions	s Tested	Interface between HMI –	CIII_PLC, CIII_H	IMI_Main, CIII_HMI_Liquid	, MEL_HMI_Ma	in			
Descrip Special Re	ption quisites:	Known values applied to Use an APS to generate w	PLC variables sna	ill be displayed in the display a	as specified.				
Test	er:	Use an Ai 5 to generate v	JCM		Date:		11/11/2003		
			00112		Course of	Actions	11/11/2000		
Step no				Description			Expected value	OK/NOK	Comments
	In the M	MEL_CIII_Liquid	Supervision	display change the	Level 2 Liq	uid Input set point to 0,4			
1	Check]	Level 2 Liquid inp	out set point	value in the HMI sc	reen CIII_H	HMI_Liquid	0,4	OK	
2	Using i	Fix Database Man	ager change	the Level 1 Liquid	Input set po	pint to 0,4			
3	Check]	Level 1 Liquid inp	out set point	value in the HMI sc	reen CIII_H	HMI_Liquid	0,4	OK	
4	Check	in the CIII_HMI_I	Liquid displa	ay the Liquid Level	Low indicat	tor status	Enabled	OK	
5	Apply a	a resistance to DI (04 (Level H	igh)					
6	Check	in the CIII_HMI_I	Liquid displa	ay the Liquid Level	High indica	ntor status	Enabled	OK	
7	In the M	MEL_CIII_Liquid	Supervision	display change the	control mod	de to AUTO			
8	Check	in the CIII_HMI_I	Liquid displa	ay the control mode	value		AUTO	OK	
9	Check]	Liquid input flow	rate value ir	the HMI screen CI	II_HMI_Lic	quid	0,4	OK	
10	Check	Liquid input flow	rate value in	the HMI screen CI	II_HMI_Ma	ain	0,4	OK	
11	Check]	Liquid input flow	rate value in	the HMI screen MI	EL_HMI_M	Iain	0,4	OK	
12	Check]	Liquid input pump	o control act	ion in the HMI scree	en CIII_HM	II_Liquid	29.59%	OK	
13	Check]	Liquid output pum	np control ac	tion in the HMI scre	een CIII_HN	MI_Liquid	36.99%	OK	
14	Apply a	a resistance to DI	05 (CIII_M	VO_Lbt)					
15	Check	in the CIII_HMI_I	Liquid displa	ay the Buffer tank le	evel high inc	dicator	Enabled	OK	
16	Check i	in the CIII_HMI_I	Liquid displa	ay the Buffer tank ou	utput pump	status	ON	OK	
17	In the M	MEL_CIII_Liquid	Supervision	display change the	control mod	de to MAN			
18	Check	in the CIII_HMI_I	Liquid displa	ay the control mode	value		MAN	OK	
19	In the N	MEL_CIII_Liquid	Supervision	ı display edit manua	l values and	l set:			
	- Liq	uid input pump co	ontrol action	10%					
	- Liquid output pump control action 20%.								
	- Buf	fer output pump e	nabled						

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TC Ide	ntifier	MEL-TC-HMI-0103 Purpose:	Verify t	nat values in CIII_HMI_Liquid are	e displayed according to specification	ations.	
Function	s Tested	Interface between HMI - CIII_PLC, CIII_HMI_Main, CIII_HMI_Liquid	l, MEL_HMI_Mair				
Descri	ption	Known values applied to PLC variables shall be displayed in the display	as specified.				
Special R	equisites:	Use an APS to generate voltage values.					
Test	ter:	JCM	Date:		11/11/2003		
			Course of A	ctions			
Step no		Description			Expected value	OK/NOK	Comments
20	Check	in the CIII_HMI_Liquid display the Liquid input	pump contro	l action	10%	OK	
21	Check	in the CIII_HMI_Liquid display the Liquid outpu	t pump contr	ol action	20%	OK	
22	Check	in the CIII_HMI_Liquid display the Buffer tank p	ump status		ON	OK	
23	Apply	2.9 – 3.1 V to AI 03 (CIII_MV_NH4) and check]	NH4 value in	the HMI display	100±5 ppm	OK	
	CIII_H	MI_Liquid					
24	Check	NH4 value in the HMI screen CIII_HMI_Main			100±5 ppm	OK	
25	Apply	2.9 – 3.1 V to AI 04 (CIII_MV_NO3) and check	NO3 value in	the HMI display	500±25 ppm	OK	
	CIII_H	MI_Liquid					
26	Check	NO3 value in the HMI screen CIII_HMI_Main			500±25 ppm	OK	
27	Using i	Fix Data Manager set 5 to CIII_SMV_NO2			30%	OK	
28	Check	in the CIII_HMI_Liquid display the NO2 value			5	OK	
29	Check	in the MEL_HMI_Main display the NO2 value			5	OK	
30	Check	NO2 value in the HMI screen CIII_HMI_Main			5	OK	
31	In the I	MEL_CIII_Liquid Supervision display change the	control mod	e to OFF			
32	Check	the operational mode changed accordingly in the	CIII_HMI_L	iquid display	OFF	OK	
33	Check	input and output pump control action values			0.0	OK	
34	Check	buffer pump status			Disabled	OK	

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6.1.4 MEL-TC-HMI-0104: Check CIII_HMI_Gas display

TC Ide	ntifier	MEL-TC-HMI-0104	Purpose:		Verify	that values in CIII_HMI_Gas are disp	played according to specificat	ions.		
Function	s Tested	Interface between HMI	– CIII_PLC, CIII_I	HMI_Main, CIII_HMI_Gas						
Descri Special Re	ption equisites:	Use an APS to generate	voltage values.	in be displayed in the display	as specified.					
Test	Tester: JCM Date: 11/11/2003									
		•			Course of A	Actions				
Step no				Description			Expected value	OK/NOK	Comments	
1	In the I	MEL_CIII_Gas S	upervision di	splay change the DC	D set point to	o 85%				
2	Check	in the CIII_HMI_	Gas display	the DO set point val	ue (note ran	np action) in 5 minutes	up to 85%	OK		
3	Apply	2.9 – 3.1 V to AI	01 (CIII_MV_	Dob) and check DO	bottom valu	e in CIII_HMI_Gas	50±2.5%	OK		
	display	•								
4	Apply 2	2.9 - 3.1 V to AI	02 (CIII_MV_	Dot) and check DO	top value in	CIII_HMI_Gas display.	50±2.5%	OK		
5	Apply 2	2.9 - 3.1 V to AI	01 and AI 02	CIII_MV_Dob, CIII_	MV_Dot) and	l check DO value in	50±2.5%	OK		
	CIII_H	MI_Gas display.								
6	Check	in the CIII_HMI_	Main display	the DO value			50±2.5%	OK		
7	Check	in the MEL_HMI	_Main displa	y the DO value			50±2.5%	OK		
9	In the I	MEL_CIII_Gas S	upervision di	splay change the DO	Control mo	ode to AUTO				
10	Check	in the CIII_HMI_	Gas display	the DO control mod	e value		AUTO	OK		
11	In the I	MEL_CIII_Gas S	upervision di	splay change the DC	D control mo	ode to MAN				
12	Check	in the CIII_HMI_	Gas display	the DO control mod	e value		MAN	OK		
13	In the I	MEL_CIII_Gas S	upervision di	splay edit manual v	alues and se	t:				
	- O2	control action to	10%							
	- N2	Liquid output put	mp control a	ction 20%.						
14	Check	O2 valve control	action in the	HMI screen CIII_H	MI_Gas		10%	OK		
15	Check	N2 valve control	action in the	HMI screen CIII_H	MI_Gas		20%	OK		
16	Apply 2	2.9 – 3.1 V to AI	05 (CIII_MV_	P) and check P value	e in CIII_HN	MI_Gas display.	500±2.5 mbar	OK		
17	Check	in the CIII_HMI_	Main display	the P value						
18	In the I	MEL_CIII_Gas S	upervision di	splay change the Ga	as control mo	ode to MAN				
19	Check	in the CIII_HMI_	Gas display	the Gas control mod	le value		MAN	OK		
20	In the I	MEL_CIII_Gas S	upervision di	splay change the Ga	as control mo	ode to AUTO				
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TC Ide	ntifier	MEL-TC-HMI-0104 Purpose:		Verify that v	alues in CIII_HMI_Gas are display	ed according to specification	ons.			
Function	s Tested	Interface between HMI – CIII_PLC, CIII_	HMI_Main, CIII_HMI_Gas							
Descri	ption	Known values applied to PLC variables sha	all be displayed in the display	as specified.						
Special Re	equisites:	Use an APS to generate voltage values.								
Test	er:	JCM	JCM Date: 11/11/2003							
			Course of Actions							
Step no			Description			Expected value	OK/NOK	Comments		
21	Check	in the CIII_HMI_Gas display		AUTO	OK					
22	In the M	MEL_CIII_Gas Supervision d	isplay change the P	set point to 200 r	nbar					
23	Check	in the CIII_HMI_Gas display	the Pressure set poin	nt		200 mbar	OK			
24	Check	in the CIII_HMI_Gas display	the Safety Pressure		OPEN (green)	OK				
25	In the M	MEL_CIII_Gas Supervision display change the P set point to 500 mbar								
26	Check	in the CIII_HMI_Gas display	the Safety Pressure	Valve status		CLOSED (red)	OK			

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6.2 MEL-HMI-TP-02 Check CIV_HMI_Displays

DEVIATION NOTICE

A deviation on the execution of the defined test procedures was needed due to the fact that the verification of HMI displays belonging to compartment IV was performed in the Pilot Plant at UAB and the test procedures were designed to be executed in NTE premises. Therefore it was not needed to use external signals to provide meaningful values to display variables. In addition, set point values were not manipulated in order to not interfere with the process. The verification was performed checking that the values displayed in the supervision displays, which were already validated, were the same that in HMI displays. Hence, steps not executed are erased.

6.2.1 MEL-TC-HMI-0201: Check CIV_HMI_pH display

TC Ide	TC Identifier MEL-TC-HMI-0201 Purpose: Verify that values in CIV_HMI_pH are dis							ns.	
Function	s Tested	Interface between HMI - CIV_H	PLC, CIV_H	MI_Main, CIV_HMI_pH, CI	V_HMI_Gas				
Descri	ption	Known values applied to PLC v							
Special Re	equisites:	Use an APS to generate voltage							
Test	Tester: JD Date:								
					Course of A	Actions			
Step no				Description			Expected value	OK/NOK	Comments
1	Apply 2.9 3.1 V to AI 05 (CIV MV pH) and check the displayed value pH in the HMI scree						7.0±0.35 pH	N/A	See Deviation Notice above.
	CIV_H	MI_pH.		•		-	1		
2	Check	pH value in the HMI s	screen Cl	V_HMI_Main			7.0±0.35 pH	OK	Actual supervision value was 9.35
3	In the M	AEL_CIV_pH Supervi	ision dis	play change the pH	set point to	9			See Deviation Notice above.
4	Check the pH set point in the CIV_HMI_pH display						9 9.50	OK	Actual supervision value was 9.50
5	In the M	MEL_CIV_pH Supervi	ision dis	AUTO					
6	Check	the operational mode c	H display	AUTO	OK				
7	In the M	MEL_CIV_pH Supervi	ision dis	play change the con	trol mode to	MAN			

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TC Ide	ntifier	MEL-TC-HMI-0201 Purpose:	Verif	y that values in CIV_HMI_pI	H are displayed according to specification	ons.	
Function	s Tested	Interface between HMI - CIV_PLC, CIV_HMI_Main, CIV_HMI_pH, CIV	/_HMI_Gas				
Descri	ption	Known values applied to PLC variables shall be displayed in the display as	s specified.				
Special Re	equisites:	Use an APS to generate voltage values.		1			
Test	er:	JD	Date:		14/04/2004		
	-		Course of A	Actions		-	
Step no		Description			Expected value	OK/NOK	Comments
8	Check	the operational mode changed accordingly in the C	IV_HMI_I	oH display	MAN	OK	
9	In the I	MEL_CIV_pH Supervision display edit manual val	ues and set	÷		N/A	See Deviation Notice above
	——Aci	d pump control action 10%					
	-Bas	e pump control action 20%.					
	- CO	2 valve control action 2,5 nLm					
10	Check	in CIV_HMI_pH acid pump control action			10 0.0%	OK	Actual supervision value was 0.0%
11	Check	in CIV_HMI_pH base pump control action			20 0.0%	OK	Actual supervision value was 0.0%
12	Check	in CIV_HMI_pH CO2 valve control action			2,5 0.125 nLm	OK	Actual supervision value was 0.125 nLm
13	Check	in CIV_HMI_Gas CO2 valve control action			2,5 0.125 nLm	OK	Actual supervision value was 0.125 nLm
14	In the M	MEL_CIV_pH Supervision set CO2 offset to 1,5 nl	-m			N/A	See Deviation Notice above.
15	Check	the CO2 offset changed accordingly in the CIV_H	MI_pH dis	play	1,5	N/A	See Deviation Notice above.
16	In the M	MEL_CIV_pH Supervision set pH control mode to	2 = CO2 + I	Base			
17	Check	the pH control mode changed accordingly in the C	IV_HMI_p	H display	2	OK	
18	In the M	MEL_CIV_pH Supervision set pH control mode to					
19	Check	the pH control mode changed accordingly in the C	IV_HMI_p	H display	3	OK	
20	In the M	MEL_CIV_pH Supervision display change the open	e to OFF				
21	Check	the operational mode changed accordingly in the C	IV_HMI_F	oH display	OFF	OK	
22	Check	acid, base and CO2 control actions			0.0	OK	

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6.2.2 MEL-TC-HMI-0202: Check CIV_HMI_BP display

TC Ide	ntifier	MEL-TC-HMI-0202	Purpose:		Verif	y that values in CIV_HMI_BP are	e displayed according to specificat	ons.	
Function	s Tested	Interface between HMI -	CIV_PLC, CIV_I	HMI_Main, CIV_HMI_BP, M	EL_HMI_Main				
Descri	ption	Known values applied to	PLC variables sha	all be displayed in the display a	as specified.				
Special Re	equisites:	Use an APS to generate v	oltage values.		r				
Test	er:		JD		Date:		14/04/2004		
	-				Course of A	Actions			
Step no				Description			Expected value	OK/NOK	Comments
1	Apply 2	2.9 3.1 V to AI 0) 2 (CIV_M∖	(_M1) and check the	e displayed l	level for input Tank 1 i	in 75±3.751	N/A	See Deviation Notice above.
	the HM	H screen CIV_HM	H_BP.			-			
2	Apply 2	2.9 3.1 V to AI 0) 3 (CIV_M∖	(M2) and check the	e displaved l	level for input Tank 2 i	in 75+3.751	N/A	See Deviation Notice above.
	the HM	Loreen CIV HM	II BD	_ ,	I J	I			
2		$\frac{11}{2} \frac{11}{2} \frac$	$\frac{1}{1} \frac{1}{1} \frac{1}$.1 1 1	1 1 6 0		NT/A	See Deviation Notice above
3	Apply .	2.9 3.1 V to AI 0)1 (CIV_IVIV	(k the display	ed value for Biomass	3.0±0.5 g/l	IN/A	
	concen	tration in the HMI	screen CIV	<u>_HMI_BP.</u>					
4	In the M	HEL CIV BP Sur	pervision dis	splay change the Lev	vel 2 Bioma	ss Production Set point	t to		See Deviation Notice above.
	12	1				1			
5	Check	the Level 2 Bioma	ss productio	on set point changed	accordingly	in the CIV HMI BP	$\frac{1.7}{1.7}1.00$	OK	Actual supervision value was
5	display		iss production	in set point enanged	uccordingiy		1,2 1.00	0 II	1.00
6	Uispiay	Ein Data Managan	h	(CIV CCD I 1DD) I	aval 1 Dias	mana Duadwatian Cat na		-	See Deviation Notice above
0	Using 1	Fix Data Manager	change the	(CIV_SSP_LIBP) I	Level I Bloi	nass Production Set pe)INI		See Deviation Notice above.
	t o I,I								
7	Check	the Level 1 Bioma	ss productio	on set point changed	accordingly	in the CIV_HMI_BP	$\frac{1,1}{1,1}$ 1.00	OK	Actual supervision value was
	display		•	1 0	01				since value was initially
	unsping								wrong.
8	In the M	MEL CIV BP Sur	pervision dis	splay change the Lev	vel 2 Liquid	input flow rate Set poi	int to		
-	07			·····					
0	Chapler	the Level O Liewid	linner flore	note ant maint all an ar	d according	the CIV LIMI D	D 07050	OV	Actual supervision value was
9	Спеск	the Level 2 Liquid	i input now	rate set point change	according	gly in the CIV_HMI_B	$\frac{0,7}{0.50}$	UK	0.50
	display								
10	Using i	Fix Data Manager	change the	(CIV_SSP_L1LiFr)	Level 1 Lic	uid input flow rate Set	ŧ		See Deviation Notice above.
	point to	0.6	C	/					
11	Check	the Level 1 Liquid	input flow	rate set point change	ed according	ly in the CIV HMI B	P 0.60.55	OK	Actual supervision value was
11	dienlow	ine Dever i Diquid	input now	rate set point endinge			. 0,00.55		0.55
	uispiay								

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TC Ide	ntifier	MEL-TC-HMI-0202 Purpose:		Verif	y that values in CIV_HMI_F	BP are displayed a	according to specification	ns.	
Functions	s Tested	Interface between HMI – CIV_PLC, CIV_HM	II_Main, CIV_HMI_BP, MEL_H	MI_Main					
Descri Special Re	ption cauisites:	Use an APS to generate voltage values	be displayed in the display as spe	cified.					
Test	er:	JD		Date:			14/04/2004		
			С	ourse of A	Actions				
Step no			Description				Expected value	OK/NOK	Comments
12	Check	the Biomass production rate in	the CIV_HMI_BP disp	olay		θ	,66 1.00	OK	Actual supervision value was 1.00
13	Check	the Biomass production rate in	the CIV_HMI_Main d	isplay		θ	,66 1.02	OK	Actual supervision value was 1.02
14	Check	Check the Biomass production rate in the MEL_HMI_Main display					,66 1.00	OK	Actual supervision value was 1.00
15	Check	the Liquid input flow rate in the	e CIV_HMI_BP displa	У		0	,6 0.78	OK	Actual supervision value was 0.78
16	Check	the Liquid input flow rate in the	e CIV_HMI_Main disp	olay		θ	,6- 0.78	OK	Actual supervision value was 0.78
17	Check	the Liquid input flow rate in the	e MEL_HMI_Main dis	play		θ	,6 0.78	OK	Actual supervision value was 0.78
18	Using i	Fix Data Manager change the (CIV_SSP_LightWm)	Light int	ensity to 150				See Deviation Notice above.
19	Check	the Light intensity set point in t	he CIV_HMI_BP disp	lay		4	50 40 W/m2	OK	Actual supervision value was 40
20	Check	the Light intensity set point in t	he CIV_HMI_Main di	splay		1	50 40 W/m2	ОК	Actual supervision value was 40
21	In the M	MEL_CIV_BP Supervision disp	lay change the operation	onal mo	de to AUTO				
22	Check	the operational mode in the CIV	/_HMI_BP display			A	UTO	OK	
23	In the M	MEL_CIV_BP Supervision disp	lay change the operati	onal mo	de to MAN				
24	In the I	MEL_CIV_BP Supervision disp	lay edit manual values	and set	Ħ				See Deviation Notice above.
	<u> </u>	ble Biomass sensor aeration va	lve						
	<u> </u>	ble Liquid input pump 1							
	— Ena	ble Liquid input pump 2							
	-Ena	ble Liquid output pump							
	Set	liquid input pump 1 set point to) 10%						
	-Set	liquid input pump 2 set point to) 20%						
	Set	liquid output pump set point to	-30% -						
	- Set	light supply regulator set point	to 40%						
25	Check	in CIV_HMI_BP liquid input p	ump 1 control action			4	0 26.00%	OK	Actual supervision value was 26.00

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TC Ide	ntifier	MEL-TC-HMI-0202	Purpose:		Verify t	hat values in CIV_HMI_BP are display	ed according to specification	ns.		
Function	s Tested	Interface between HMI -	CIV_PLC, CIV_H	MI_Main, CIV_HMI_BP, ME	EL_HMI_Main					
Descri	ption	Known values applied to	Xnown values applied to PLC variables shall be displayed in the display as specified.							
Special Re	equisites:	Use an APS to generate v	oltage values.							
Test	ter:		JD		Date:		14/04/2004			
					Course of Ac	ctions				
Step no				Description			Expected value	OK/NOK	Comments	
26	Check	in CIV_HMI_BP	liquid input p	pump 2 control actio	n		20 0.00%	OK	Actual supervision value was 0.00	
27	Check	in CIV_HMI_BP	liquid output	pump control action	n		30 25.90%	OK	Actual supervision value was 25.90	
28	Check	in CIV_HMI_BP	light supply	control action			40 10%	OK	Actual supervision value was 10	
29	Check	in CIV_HMI_BP	liquid output	flow rate			2,6 0.59 l/h	OK	Actual supervision value was 0.59	
30	Check	in CIV_HMI_Mai	n liquid outp	ut flow rate			2,6 0.59 l/h	OK	Actual supervision value was 0.59	
31	Check	in CIV_HMI_BP l	liquid input p	ump 1 status			Enabled (green)	OK		
32	Check	in CIV_HMI_BP l	liquid input p	oump 2 status			Enabled	OK	Supervision status was	
				-			Disabled (red)		uisableu	
33	Check	in CIV_HMI_BP	liquid output	pump status			Enabled (green)		Supervision status was enabled	
34	Check	in CIV_HMI_BP	Biomass sens	sor aeration valve			Open Disabled		Supervision status was disabled	
							(red)		aloabloa	
35	In the N	MEL_CIV_BP Sup	pervision dis	play change the oper	rational mode	e to OFF				
36	Check	the operational mo	ode in the CI	V_HMI_BP display			OFF	OK		
37	Check	liquid input/output	t, and light su	pply control actions			0,0	OK		

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6.2.3 MEL-TC-HMI-0203: Check CIV_HMI_Gas display

TC Ide	ntifier	MEL-TC-HMI-0203	Purpose:		Verify	that values in CIV_HMI_Gas are displa	yed according to specificatio	ns.	
Function	s Tested	Interface between HMI – C	CIV_PLC, CIV_H	/II_Main, CIV_HMI_Gas, M	IEL_HMI_Main				
Descri	ption	Known values applied to Pl	LC variables shall	be displayed in the display a	s specified.				
Special Re	equisites:	Use an APS to generate vol	itage values.		D (
Test	ter:				Date:	- 4 •			
Stor no	<u>г</u>			Description	Course of A	Actions	Free sets d such as	OV/NOV	Commente
Step no	A mmlay /	20 21 V_{42} $AI 0/$		D) and also als the a	lian larva d' mus	active in the UNI	Expected value		See Deviation Notice above
1	screen	2.9 3.1 v to A1 04 CIV_HMI_Gas.	+ (GTV_IVIV_	<u>_F) and check the c</u>	iispiäyeu pit		0.75 ± 0.375 bar	N/A	
2	Check	in CIV HMI Main	e value		0.75+0.375 0.07	OK	Actual Supervision value was		
_				bar	011	0.07			
3	Apply 2.9 3.1 V to AI 07 (CIV_MGO_O2) and check the displayed O2 flow rate value in HMI screen CIV_HMI_Gas.						12.5±0.7 nLm	N/A	See Deviation Notice above.
4	Check	in CIV_HMI_Main	the O2 valu	e			12.5±0.7 21.53 nLm	OK	Actual Supervision value was 21.53
5	Check	in MEL_HMI_Main	n the O2 val	ue			12.5±0.7 21.53 nLm	OK	Actual Supervision value was 21.53
6	Apply 2 value	2.9 3.1 V to AI 08	3 (CIV_MG (O_CO2) and check	the display	ed CO2 at gas output	250±15 ppm	N/A	See Deviation Notice above.
7	Check	in CIV_HMI_Main	the CO2 at	output value			250±15 0.67 % ppm	OK	Actual Supervision value was 0.67%
8	Apply 2 HMI se	2.9 3.1 V to AI 09 reen CIV_HMI_Ga) (CIV_MV_ as.	_DO) and check the	e displayed I	DO concentration in the	50±2.5 %	N/A	See Deviation Notice above.
9	Apply 2 compar	2.9 3.1 V to AI 13 tment input (FG CI	3 (CIV_MV_ I) in the HM	_FrGas) and check I screen CIV_HMI	the displaye <u>-Gas.</u>	ed gas flow at	18±0.6 nLm	N/A	See Deviation Notice above.
10	Check	in CIV_HMI_Main	the Gas at o	compartment input	flow rate		18±0.6- 1.99 nLm	OK	Actual Supervision value was 1.99
11	Apply 2	2.9 3.1 V to AI 14	1 (CIV_MG	D_FrGas) and che	ck the displa	eyed gas flow at	18±0.6 nLm	N/A	See Deviation Notice above
12	Apply 2	2.9 3.1 V to AI 15	$5 (CIV_MV_)$	FrCO2) and check	the display	ed CO2 flow at	3±0.1 nLm	N/A	See Deviation Notice above

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	ntifier	MEL-TC-HMI-0203 Purpose: Verify that values in CIV_HMI_Gas are display	ed according to specification	ıs.	
Function	s Tested	Interface between HMI – CIV_PLC, CIV_HMI_Main, CIV_HMI_Gas, MEL_HMI_Main			
Descri	ption	Known values applied to PLC variables shall be displayed in the display as specified.			
Special Re	equisites:	Dete-			
1050		Course of Actions			
Step no		Description	Expected value	OK/NOK	Comments
	compar	tment input in the HMI screen CIV_HMI_Gas.			
13	Check	in CIV HMI Main the CO2 input flow rate	$3\pm0.1-0.125$	OK	Actual Supervision value was
			nLm	_	0.125
14	Apply 2	2.9 3.1 V to AI 16 (CIV_MGI_FrGas) and check the displayed Air flow at	18±0.6 nLm	N/A	See Deviation Notice above.
	compar	tment input in the HMI screen CIV_HMI_Gas.			
15	Apply 2	2.9 3.1 V to AI 06 (CIV_MV_T) and check the Temperature value in the HMI screen	75±3.75 ° C	N/A	See Deviation Notice above.
	CIV H	MI-Main.			
16	In the M	MEL_CIV_Gas Supervision display change the Pressure set point to 0,8			See Deviation Notice above.
17	Check	in CIV_HMI_Gas the pressure set point	0,8 0.025 bar	OK	Actual Supervision value was 0.025
18	In the M	MEL_CIV_Gas Supervision display change the Air input set point to 10			See Deviation Notice above.
19	Check	in CIV_HMI_Gas the Air input set point	10 2.00 nLm	OK	Actual Supervision value was 2,00
20	In the M	MEL_CIV_Gas Supervision display change the Gas at compartment input set point to 20			
21	Check	in CIV_HMI_Gas the Gas at compartment input set point	20 1,93 nLm	OK	Actual Supervision value was 1,93
22	In the M	MEL_CIV_Gas Supervision display change the Gas at output set point to 15			See Deviation Notice above.
23	Check :	in CIV_HMI_Gas the Gas at compartment input set point	15 nLm	N/A	See Deviation Notice above.
24	In the M	MEL_CIV_Gas Supervision display change the operational mode to AUTO			
25	Check	in CIV_HMI_Gas the operational mode	AUTO	OK	
26	In the M	MEL_CIV_Gas Supervision display change the operational mode to MAN			
27	Check	in CIV_HMI_Gas the operational mode	MAN	OK	
28	In the M	MEL_CIV_Gas Supervision display edit manual values and set:			See Deviation Notice above.
	- Ena	ible Safety Pressure valve			
29	Check	in CIV_HMI_Gas the Safety pressure valve status	Open-Close (red)	OK	Actual Supervision status was closed
30	In the M	MEL_CIV_Gas Supervision display change the operational mode to OFF			
31	Check	in CIV_HMI_Gas the operational mode	OFF	OK	

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MELISSA Control System Demonstrator System Test Report

TC Ide	ntifier	MEL-TC-HMI-0203 Purpose: Verify that values in CIV_HMI_Gas	are displayed according to specification	ons.			
Function	s Tested	Interface between HMI – CIV_PLC, CIV_HMI_Main, CIV_HMI_Gas, MEL_HMI_Main					
Descri	Description Known values applied to PLC variables shall be displayed in the display as specified.						
Special Re	Requisites: Use an APS to generate voltage values.						
Test	Tester: Date:						
		Course of Actions					
Step no		Description	Expected value	OK/NOK	Comments		
32	Check	in CIV_HMI_Gas the Air input, CO2 input, Gas at compartment input, Gas at outp	out set 0,0	OK			
	points value						
33	Check	in CIV_HMI_Gas the safety pressure valve status	Closed (red)	OK			

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MELISSA

Contract Number: ESTEC/CONTRACT: 15671/01/NL/ND

Technical Note: 72.4 VOLUME IV

Control System Demonstrator Functional Test Results and Evaluation

Version: 1

Issue: 1



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Version	Issue	Date	Observations
Draft	0	15 Apr '04	Reviewed. Updated with last alarm tests
1	0	20 Apr '04	First release for ESA review
1	1	28 July '04	ESA comments dates 21/07/04 implemented
		-	-

Document Change Log	Document Cha	ange	Log
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1 SCOPE

This document contains the test report resulting from the execution of the functional test procedures defined in [R7] for the MELISSA Control System Demonstrator after its connection to the MELISSA Plant at the UAB.

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

- [A1] MELISSA. Adaptation for Space, Phase 1. Statement of Work.TOS-MCT/2000/2977/ln/CL. Issue 5. April 2001.
- [A2] MELISSA. Adaptation for Space-Phase 1. Proposal issued by NTE. MEL-0000-OF-001-NTE. Issue 2. October 2001.
- [A3] Memorandum of Understanding between the UAB and NTE S.A. MEL-0000-SP-007-NTE. Version 1. Issue 0. 21 January 2002.
- [A4] MELISSA Control System Architecture and Trade-off. TN 72.3. Version 1. Issue 0. December 2002.

2.2 Reference Documents

- [R1] Definition of the control requirements for the MELISSA Loop. TN 72.2, v. 1.2, November 2002 (MEL-3100-SP-010-NTE).
- [R2] Photoheterotrophic Compartment Set-up. TN 37.6. UAB, February 1998.
- [R3] Nitrifying Compartment Studies. TN 25.310. UAB, September 1996.
- [R4] Set-up of the Photosynthetic Pilot Reactor. TN. 37.2. UAB, April 1998.
- [R5] Spirulina Controller. TN 72.3.1, v. 1.0, ADERSA, March 2003.
- [R6] Nitrite Controller. TN 72.3.2, v. 1.1, ADERSA, October 2003.
- [R7] Control System Demonstrator Test Plan and Procedure. TN 72.4 VIb, v. 1.1, July 2004 (MEL-3310-PL-039-NTE).
- **[R8] Nitrite Controller Test Plan and Procedure.** TN 72.3.4, v. 1.1, SHERPA, February 2004.
- **[R9] Test Plan and Procedure for the Spirulina Controller.** TN 72.3.3, v. 1.0, ADERSA, October 2003.

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3 INTRODUCTION

This document reports the functional tests carried out on the Control System Demonstrator after its connection to the MELISSA plant at UAB's. Tests were performed during the November 2003 – April 2004 time frame. Firstly, the Compartment IV Rack was integrated into the plant in mid November '03 and the corresponding tests were conducted and ended in mid December'03 when started integration of rack for Compartment III. Tests for Compartment III started on January and lasted until April 2004.

4 CIII FUNCTIONAL TEST RESULTS

4.1 Compartment set up

Connection of sensors and actuators were performed one by one, checking proper connectivity and measured / actuation values. Once a group of sensors and actuators corresponding to a specific loop were checked, the loop was tested end-to-end.

4.1.1 pH control

First test run was performed with pH not in a steady state, due to the transition of the hardware. Therefore, the measured value was below the set point. The loop action was turned on and an over actuation of the base pump was detected. The conclusion was the same parameters of the old PI controller were not appropriate for the new one. A short test session with the old controller was performed to deduce the proper parameters for the new one. After updating the controller with the new parameters, pH was regulated properly.

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Figure 1. pH (Basic) test result (28 Jan'04)



Figure 2. pH (Acid) Test result (5 Feb'2004)

In figures 1 and 2 is detailed the test result. In the figure 1 the set point was 8.0 and measured value was 7.63. The base pump was activated during the programmed periods of time and

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after 3 h pH finally was 7.93 and therefore inside the dead band. Figure 2 shows pH regulation using CO_2 as an acidifying medium. The pH measured value started at 8.51 and due to the addition of CO_2 after 2 h was fixed to 8.12, which is a value inside the dead band.

A specific test for the acid pump was not performed because control action is the same as for the base pump.

Test Data 28 Jan and 5 Eab 2004 Test Decult Success	Test Date 20 Jan and 5 Feb 2004 Test Result Success
---	---

4.1.2 Dissolved Oxygen control

The same process as in pH test was followed to determine the Dissolved Oxygen (DO) controller parameters for the new controller. The response to different inputs was measured and the results applied to set the parameters for the DO control of the new PID. When the test started the set point was fixed to 80% and DO measure was 73.89%. After turning on the control loop the system started adding oxygen, and after 1.5 h the DO measure was increased to 77.02%. Test was considered successful because the measured value's trend was correct and within the set point value +/-5%.

No specific test was performed to check the N_2 valve since the regulation is performed using a proportional control action to the O_2 PID response.



Figure 3. Dissolved Oxygen test result

Test Date	28 Jan 2004	Test Result	Success

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4.1.3 Temperature control

Parameters were obtained from the old controller to regulate heater control action. After setting the parameters to the new controller, it was verified that the response of the new controller was equivalent to the old one. During the test preparation it was detected that the bottom temperature sensor was failing at irregular intervals, therefore only a short test was performed to check the loop control end-to-end. At test start temperature measured value was 26.97 °C and set point was fixed to 28.0 °C. When control loop was turned on, heater action actuated at programmed intervals and temperature was increased to 27.50 °C after 30 minutes. Test result can be observed in figure 4. Test was considered successful because the measured value's trend was correct and within the set point value +/-5%.

No specific test was performed to verify the cooling valve since the control action is regulated by an on/off controller.



Figure 4. Temperature control test result (28 Jan'04)

Tost Data	28 Jan 2004	Tost Posult	Succoss
Test Date	20 Jan 2004	Test Result	Success

4.1.4 Liquid Level control

To test the level sensors, the input pump was stopped manually to induce the low level signal activation, and reduction of the output pump was observed. To check the high level signal, the high level sensor was manipulated to be located more near the low level and activation was induced and the output pump flow rate was increased according to the control action.

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Test Date28 Jan 2004	Test Result Success
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4.1.5 Pressure control

To test the pressure valve, variations on the set point were performed and control action was verified checking the valve status in the compartment.

Test Date 20 Jail 2004 Test Kesuit Success
--

4.2 Alarms

4.2.1 Temperature difference alarm

Temperature difference alarm could be easily verified since the system temperature difference between the two probes was over 5 ° C at test start due to the loop mode was OFF. Therefore it was verified that the liquid input pump was stopped. After the activating the loop setting the mode to AUTO it was observed that the global temperature of the reactor increased and the temperature difference between the probes decreased arriving to be less than the alarm condition, and then was verified that the input pump flow was restored.

Test Date14 April 2004Test ResultSuccess
--

4.2.2 Over temperature alarm

To verify this alarm the set point was decreased more than 1.5 ° C under the current value. Because the variations on the set point are regulated by a ramp, the effect was not immediate and also the cooling system was activated. Therefore to have the temperature set point really 1.5 ° C under the current value it is necessary to wait several minutes. After this waiting time the alarm was activated and the loop mode was set to OFF.

Test Date 14 April 2004 Test Result Success

4.2.3 Liquid level alarm

To test the liquid level alarm a short circuit was performed to the liquid level sensor to indicate that the level is high. After waiting 15 minutes the alarm was notified and the liquid input pump was stopped.

Test Date	14 April 2004	Test Result	Success

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4.3 Nitrite Estimator

4.3.1 Short Test

First short test was performed on 9th February 2004 the goal was a first checking of the data processing itself. At the end of the test, it was quickly discovered that the values of a few Internal Variables (indices 89 to 130 of vector X) were corrupted consequently to a division by zero. The bug was located in the routine 'estim_3.c' and was due to a set of safety statements put at a wrong place. A new version (Version 1.3) of the controller was sent to NTE to rebuild the controller module and repeat a new short test.

The test was therefore repeated the 16th February 2004. In this case each variable of the implemented control was exactly identical to the corresponding variable of the reference control. So the implemented control passed the short test. Plots of the 155 Internal Variables can be found in [R8].

Test Date 6 and 9 Feb 2003 Test Result Success
--

4.3.2 Long Test

The Long test was performed on the 16th February 2004 and consisted in a step of 'requested flow rate' from 0.4 to 0.6 l/h. The 'NO2 constraint' was set to '2.86 10-4 mol/l as in the short test. Variables of the implemented control were exactly identical to the corresponding variables of the reference control. So the implemented control passed the long test and therefore validated.

Even though, it has to be noted that only the implementation (and not the control itself) was validated. As foreseen because of the measurement noise on ammonia and nitrate, the present estimator is inefficient for low concentrations of nitrite.

The Manipulated Variable (control computed flow (blue line) of the bottom graph of the figure 5) is very noisy and tends very slowly to the 'requested flow rate' (green curve). The estimator itself has to be improved.

Test Date To Test Result Success

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Figure 5. Nitrite Controller long test results.

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5 CIV FUNCTIONAL TEST RESULTS

5.1 Set-up

Connection of sensors and actuators were performed one by one, checking proper connectivity and measured / actuation values. Once a group of sensors and actuators corresponding to a specific loop were checked, the loop was tested end-to-end. In addition, due to the compartment was stopped, as part of the set-up test the compartment was started and given to a steady state.

5.1.1 Biomass sensor

Biomass sensor cleaning operation was tested observing the acquired biomass concentration measure during the cleaning operation. No perturbations on the measure were detected. Although, it has to be noted that when air is blown into the sensor conduction, an overpressure is induced during a short period and causes the pressure regulation valve to be opened. Initially air pulse action was 5 seconds long, and due to the overpressure generated pulse was reduced to 1 second.

Test Date 24 New 2003 Test Desult Success

5.1.2 Gas flow control

Set points were set one by one to check every flow controller and actuation was measured using a manual manometer and value displayed by the sensor. Over pressure was induced closing the output gas conduct and modification of set points was verified. Similarly the gas input was closed to cause an under pressure and set points were checked as well. It has to be noted that the compartment is usually under pressure because of the gas leaks.

Test Date 24 Nov 2003 Test Result Success	Test Date	24 Nov 2003	Test Result	Success
	I cot Date		I cot itcouit	Duccess

5.1.3 pH control

The pH control is regulated by a PI. Initially, the parameters were the same as in the old controller but an adjustment was performed to avoid a continuous offset between the set point and the measured value. Firstly, the pH regulation was tested adding CO_2 only, since the compartment behavior caused basification of the medium. The regulation in this mode was enabled during the Biomass Production test. Results can be observed in figure 6. Afterwards, two tests were performed using Acid and Base prepared media.

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Figure 6. pH test result (27 Nov'03)

Test Date	27 Nov 2003	Test Result	Success

5.2 Alarms

5.2.1 Temperature alarm

Temperature alarm was tested decreasing the set point to a value under the current measure. It was observed that immediately the light was set to a very low value and the liquid input and output pumps were stopped.

Test Date27 Nov 2003Test ResultSuccess
--

5.2.2 No Gas alarm

To check this alarm gas input was disconnected and it was checked that immediately the light was set to a very low value and liquid input and output pumps were stopped.

	Test Date	5 Feb 2004	Test Result	Success
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5.3 Biomass Production

5.3.1 Short test

Short test lasted 48 hours. It can be observed in figure 6 that the Controlled Variable (blue line of upper graph of figure) was reaching its set point (red line). The Manipulated Variable (light flux on second graph) was going to its resting value, about 50 W/m². The biomass concentration was maintained within its constraints (third graph).

So far, the control worked as expected. After ADERSA acknowledge, test continued.



Figure 7. Biomass Production short test results

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Test Date	10-12 Dec 2003	Test Result	Success

5.3.2 Long test

The long test lasted 9 days (including the two of the short test). The results can be observed in figure 7. The Controlled Variable reached its set point at time t = 45 h. When a non-measured disturbance moved the CV away at about time t = 70 h, the Manipulated Variable (light flux) increased so that the set point was reached again. No oscillation could be seen. So the control worked correctly.

Remark: a problem occurred on the pilot plant at t = 151 h (on 16^{th} December). It did not affect the control. A few hours after, the test was restarted with a re-initialization of the control. Graphs are separated due to this fact in figure 7 and figure 8.

Detailed results explanation can be found in [R9].

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Figure 8. Biomass Production Long test result (I)

The control behaved as expected. The constraint on the concentration was not trespassed (third graph of figure 3). And the level1 production set point (red curve of the first graph) was reached without bias nor oscillation. The implementation of the control law was validated by ADERSA.

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Figure 9. Biomass Production long test results (II).

Test Date	10-16 Dec 2003	Test Result	Success

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6 TESTS RESULTS EVALUATION

6.1 Compartment IV

Transition to new compartment IV rack was very smooth. An intermediate connector panel between the compartment and the rack was prepared by the UAB and this made quite easy the connection. The fact that the compartment was stopped avoided risks. Only minor problems were found during the integration and tests performance.

Following table states the problems found and corrective actions taken during the integration of the control system to Compartment IV:

Ν	Date	Incidence	Corrective action	Status
1	19/11/03	Pressure sensor not measuring	Power was not correctly connected. An external power supply was provided.	Closed
2	19/11/03	Problems with CO2 and O2 gas sensors	Error signal was inverse logic Calibration and Scale1/Scale2 signals were short circuited	Closed
3	21/11/03	Supervision has CO2 and O2 sensor ranges fixed.	Modified supervision to allow two configurable ranges depending on the scale sensors are using.	Closed
4	24/11/03	Biomass conversion factor is not editable. Light intensity does not show real value when loop in manual mode. Is not possible the edition of the DO range.	Changed supervision.	Closed
5	24/11/03	Wrong biomass value when liquid input flow is 0.	Modified PLC SW to calculate production using the real flow rate.	Closed
6	25/11/03	CO2 offset does not modify CO2 input set point.	Modified PLC SW to add CO2 offset as bias of the CO2 PID.	Closed
7	25/11/03	Balance measures are needed to perform calibration of liquid input pumps.	Measures added to database.	Closed
8	2/12/03	Balances 1,2 switch even when both are full.	Changed PLC SW. Level measure is filtered with a lag filter of 10 seconds.	Closed.
9	2/12/03	pH regulation is not ok.	PID values were adjusted.	Closed
10	2/12/03	Lost initial values when PLC rebooted.	Include in the user manual procedure to follow when PLC logic needs to be updated.	Closed
11	16/12/03	Fix database damaged when updated from the client PC.	Updated MBE driver to version 7.17	Closed
12	17/12/03	Virus MSBLAS found in server computer.	Operative system was updated and a firewall was installed.	Closed.

Other modifications were performed in order to ease the utilisation of the system:

- Break down Fix tasks to allow the change of the configuration of any without affecting the others. Master Controller tasks perform database updates and execute control laws.
- Activate Fix Historical server process, which allow the visualisation of historical data into the supervision graphs. Graphs were configured to display data of two days.

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Finally an additional alarm was programmed to detect when gas supply is externally interrupted.

6.2 Compartment III

Transition to the new control system was more complicated for this compartment due to fact that it had to be maintained operational during the transition phase. The first transition intent was done late in December '03. It was not conclusive as the hardware integration took longer than expected and it was not possible to adjust the pH control parameters adequately. Therefore, the old controller was maintained connected to the reactor for the complete Christmas holiday period. Transition activities were resumed in January '04 and finally the new rack was completely connected to the compartment.

Following table states the problems found and corrective actions taken during the Compartment III integration:

Ν	Date	Incidence	Corrective action	Status
1	15/12/03	Pressure sensor value was wrong.	Reported range was 4-20 mA when sensor is 0-20 mA. Configuration was updated.	Closed
2	16/12/03	Wrong pH control action.	Parameters were obtained experimentally from the old controller.	Closed.
3	16/12/03	Wrong electrical interface of acid and base pumps switches.	Switches were changed to use the two free relays.	Closed.
4	24/12/03	Supervision lost connection with PLC.	Not reproduced. Probably caused by the installation of the firewall.	Closed.
5	26/01/04	Ramps shall actuate on set-point on loop restart.	PLC software updated.	Closed.
6	28/01/04	Level 1 Liquid flow set point cannot be fixed if control law is not running.	Field made modifiable in the supervision.	Closed.
7	29/01/04	Input media pump not working.	Changed ACO 02000 cabling.	Closed.
8	14/04/04	Alarm action not performed.	Fixed PLC program to perform action even when loop mode is MAN.	Closed.

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7 CONCLUSIONS

Following the successful connection of the Control System Demonstrator for Compartments III and IV to the MELISSA pant at UAB functional tests were conducted to verify the proper performance of the new controller.

In a first stage short duration checks were performed and the obtained results were analyzed and verified by SHERPA. Upon obtaining their conformity full functional procedures were run. The analysis of the test results allows drawing the following conclusions.

Four major requirements / concerns were identified in the MELISSA Control System Requirements technical note [R1], driving the design of the new Control System Architecture and, in turn, the definition and implementation of the Control System Demonstrator object of this Test report:

- Capability and performance
- Reliability
- Safety.
- Data Management.

Capability and Performance

The tests checked that the system architecture and performance is suitable for the MELISSA requirements. The implementation allowed the accommodation of control levels easily. The Supervision software provided a soft way of implementing high-level control tasks with optimal performance. The Supervision software programmability (iFix) is flexible enough to incorporate complex tasks and perform complex calculations. The tests performed confirmed that the refreshing rates of variables are fast enough, since during the test not only control law variables were monitored /manipulated but also log files were generated, database values were stored (with a maximum rate of 10 seconds), supervision displays used, historical data generated. All these actions were performed simultaneously for both compartments (CIII and CIV).

<u>Reliability</u>

The hardware and the software have been proven to be reliable. No problems were found that could be attributed to its reliability. Additionally, the alarm tests proved that the system is capable of controlling unexpected events and reacting in order to minimize the risk of malfunction. However, it has to be noted that alarm management could only be performed at compartment level, individually and therefore, global effects have not been assessed.

Also, additional tests should be performed on the hardware and software, especially the ones related to redundancy. On the other hand, it has to be noted that the fact of using a Windows server in the Master Control raises the problem of reboots during maintenance interventions. This problem can be minimised using a secondary backup server.

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<u>Safety</u>

Its still too early to evaluate safety requirements. Despite of that, it is confirmed that the system has a powerful alarm management, allowing the classification of alarms, different ways of alarm reporting and the possibility of programming recovery actions that will help on implementing safety requirements.

Data Management

The tests also confirmed that the system covers widely the requirements on data management. It can be connected to Relational Database Management Systems, can generate logs, provide historical data on charts, save alarm events, etc.

It can be concluded that the tests demonstrate that the architecture concept and implementation that was chosen in the MELISSA Control System trade-off is suitable to cover the requirements stated in the TN 72.2. At this time the Control System Demonstrator is over dimensioned for the current needs, but as the Pilot Plant will increase in number of reactors, intermediate buffers, interconnections and high level control, performance requirements will need to be re-assessed accordingly.

On the other hand no potential problems are envisaged at this stage as new equipment will have to be connected to the existing control system. This is supported by the flexibility of implementing Master Control in a standard PC server.

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