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# SPD LCC

This SPD provides with several procedures the MR service engineer to test, replace parts and troubleshoot the LCC (Liquid Cooling Cabinet). It also includes general background information (e.g. theory of operation).

If you have any remark, question, addition or suggestion regarding this document, please contact me:
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***NOTE***

*The LCC is shipped empty.*
*The Copley gradient amplifiers are already filled with coolant in the factory.*

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***NOTE***

*Pumps must always be primed / vented after (re) filling of the GC and GA circuits, prior to operation!*

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# SPD LCC

## Table of contents

# 1 INTRODUCTION / EXPLANATION

The LCC consists of:

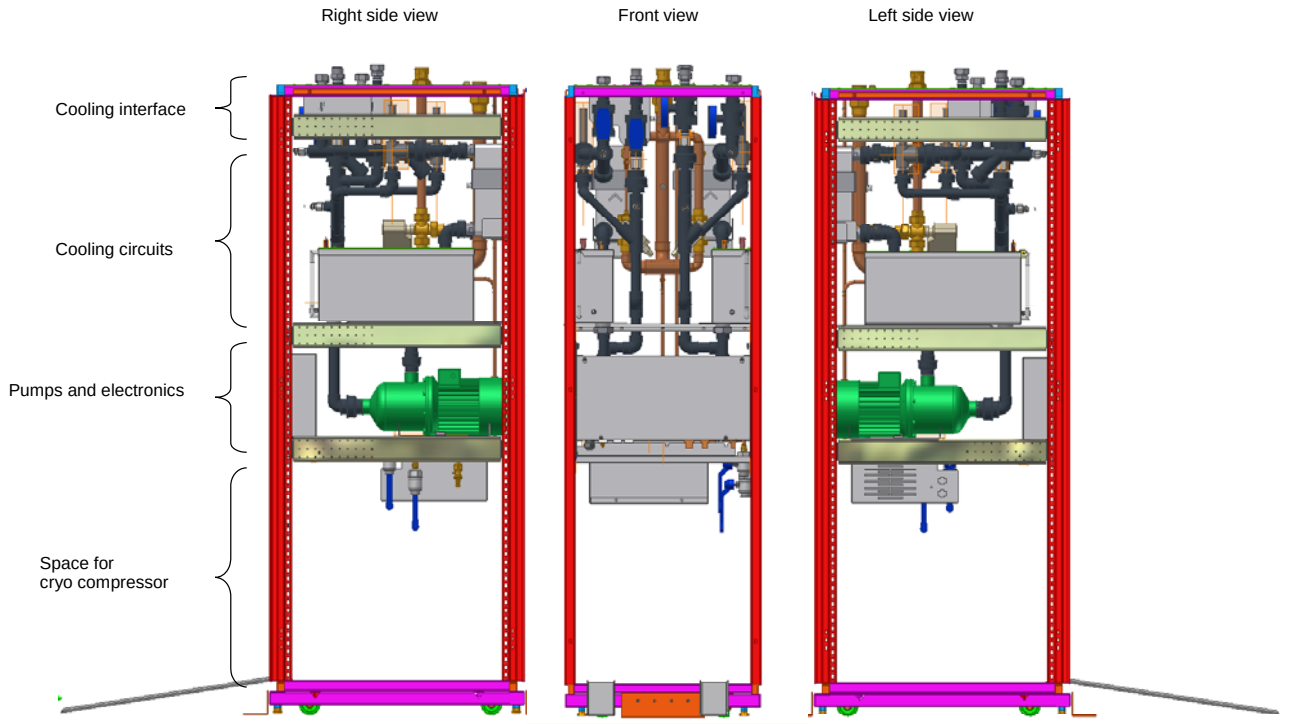
- one primary circuit which is connected to a hospital cooling water system or a chiller.
- a direct connection to the primary circuit for the cryo compressor
- two hydraulically separated secondary liquid cooling circuits; one for cooling the gradient coil and one for the gradient amplifiers.

The cabinet is prepared for cabinet installation of a cryo compressor.
Next cryo compressors are used:

- the APD compressor type HC-8E
- the SHI compressor type CSW-71

From hereon the cryo compressors will be called APD or SHI compressors.

**Figure 1 – Locations of the building blocks**



## 1.1 PRIMARY WATER CIRCUIT

The primary water circuit is made from copper alloys. It delivers the cooling capacity for both secondary cooling circuits and the helium compressor. The piping shall be insulated in order to prevent condensation. The maximum operating pressure for the primary side is limited to 6 bars.

Main components:

3-way-valve

Plate heat exchanger

Flow restrictor for the Helium compressor

Coolant:

Water / Glycol mixture
- maximum Glycol concentration 39 %
- minimum Glycol concentration 25 %

OR

pure water

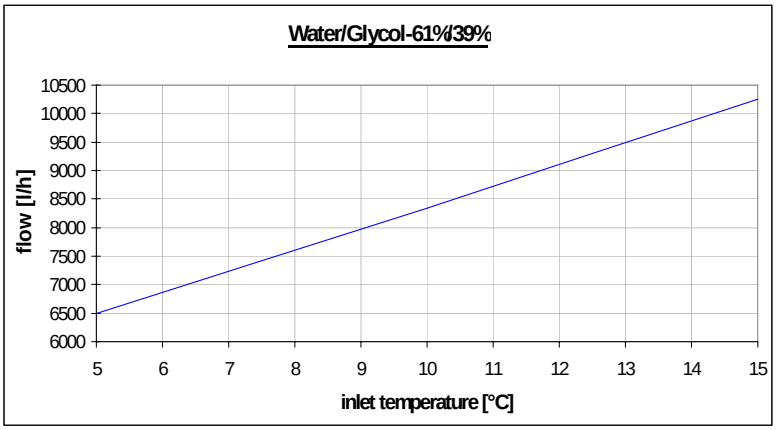
Temperature range:

5 - 15 °C

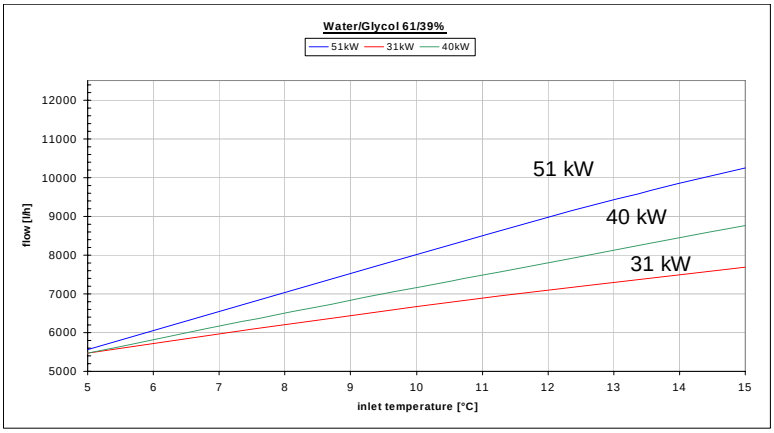
Pressure drop range:

130 – 450 Kpa

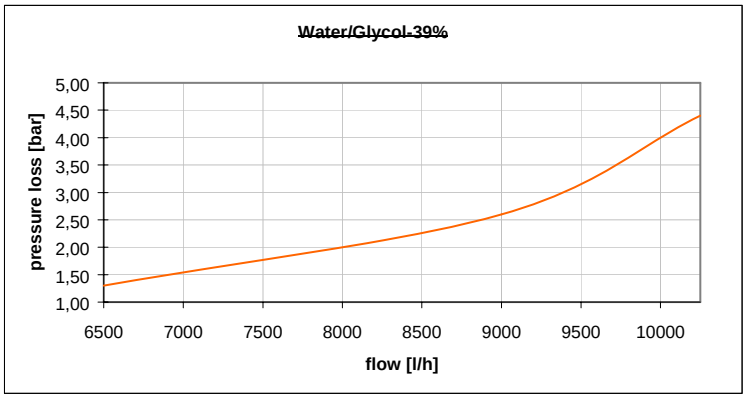
Range of Volume flows:



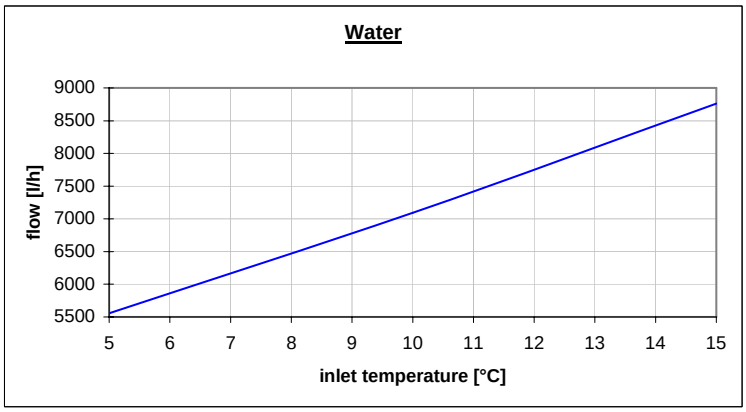

Range of Volume flows for 30/40/50 KW:



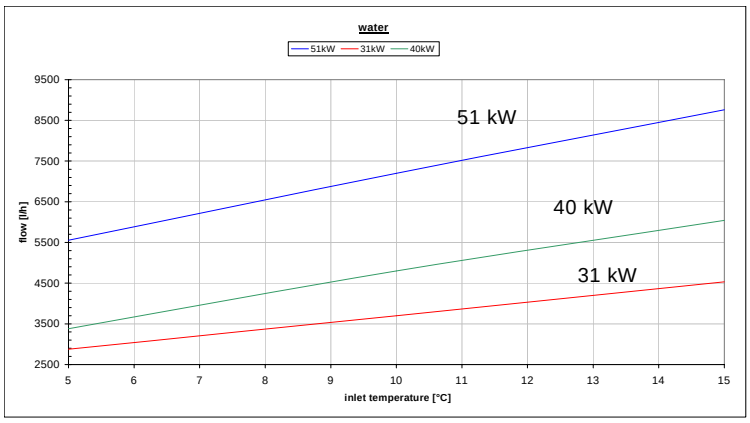
Range of pressure loss:



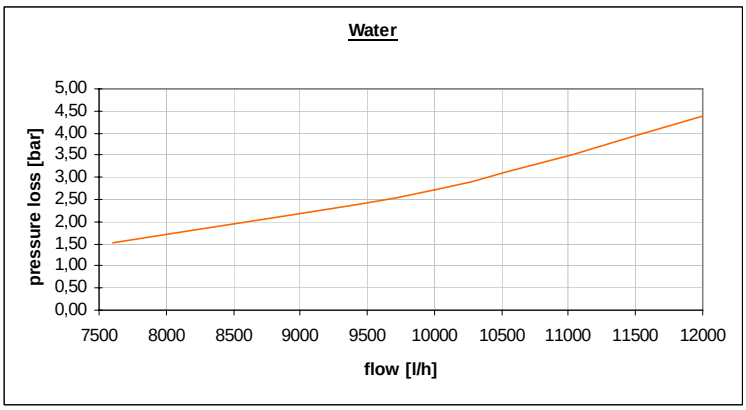

Range of Volume flows:




Range of Volume flows for 30/40/50 KW:




Range of pressure loss:



| | |
|---|---|
| Quality: | pH-value: 6-8 |
| Water hardness: | < 14 Degree of German hardness |
| | < 250 PPM Calcium Carbonate |
| Content of Chlorine: | < 200 PPM |
| Total cooling capacity: | max. 58 kW (incl. Helium compressor load) |
| Facility connection: | Device: LCC<br>▪ Hose DN32<br>▪ max. length of hose 3 m<br>▪ 1 ½" BSP, flat seal<br>▪ gender: male (supply), female (return) |
| Type connection: | Device: APD helium compressor (inside LCC)<br>▪ Hose DN12<br>▪ max. length of hose 2 m<br>▪ hose end APD: ½" straight pipe<br>▪ APD interface: ½", squeeze swagelock fitting |
| Type connection: | Device: SHI helium compressor (inside LCC)<br>▪ Hose DN12<br>▪ max. length of hose 2 m<br>▪ hose end SHI: 3/8" NPT male<br>▪ SHI interface: 3/8" NPT female |

## 1.2 SECONDARY WATER CIRCUIT

The two secondary circuits are made from PVC-U. They are used for delivering the cooling capacity to the Gradient Amplifier(s) (GA) and Gradient Coil (GC).

| | |
|---|---|
| Main components: | Pumps<br>Overflow valves<br>Pressure sensor<br>Water filter<br>Flow restrictor<br>Tanks with air vent<br>Ball valves<br>Control temperature sensor<br>Level switch<br>Level indicator<br>Flow switch only in the gradient coil circuit |
| Coolant: Gradient Coil (GC): | de-ionised water or distilled water with biocide and inhibitor<br>- CAS-Number: 7732-18-5 or<br>- EG-Number: 231-791-2<br>- Biocide NX1164<br>- Inhibitor AZ8104 |
| Gradient Amplifier (GA): | water/ DowTherm SR1-mixture 50/50 % |
| Temperature range: | 15 - 30 °C |
| Cooling power: | 51 kW<br>GA circuit maximum 36 kW (2x18 kW)<br>GC circuit maximum 15 kW |
| Temperature set point: | 25 °C |
| Temperature stability: | ± 2 K |
| Hoses DN19 | - fixed length of the hose to the gradient amplifier 7 m<br>- fixed length of the hose to the gradient coil 15 m |
| Hose connectors: | |
| LCC side supply (GA and GC) | 1“ flat seal male |
| LCC side return (GA and GC) | 1” flat seal female |
| Gradient amplifier side supply (feed) | quick connect female |
| Gradient amplifier side return | quick connect female |
| Gradient coil side supply (feed) | 16 mm straight pipe (Swagelock type connection) |
| Gradient coil side side return | 16 mm straight pipe (Swagelock type connection) |

## 1.3 MAINS POWER

The LCC is either connected to a mains power of 400 V at 50 Hz OR of 480 V at 60 Hz.

**WARNING**

*Mains power to the LCC is not switched off by the main switch of the I-MDU!*
*To switch of the mains power use switch Q3 inside the I-MDU!*
*HAZARD FOR LIFE!*

## 1.4 THE ELECTRONIC BOX

The electrical components of the LCC are installed into a ‘electronic box’. This electronic box contains all necessary components for the automatic control- and regulation of the LCC heat exchanger circuits. The electronic box is located behind the front panel and has an additional cover.

It contains thermal switches F1 through F5 and the PCB with controls the both GC and GA heat exchanger circuits. See Figure 2.

F1 = GC pump
F2 = GA pump
F3 = Cryo compressor
F4 = Transformer (supply for the PCB)
F5 = 24 Vdc to the PCB

**Figure 2 - Overview of the electronic box**

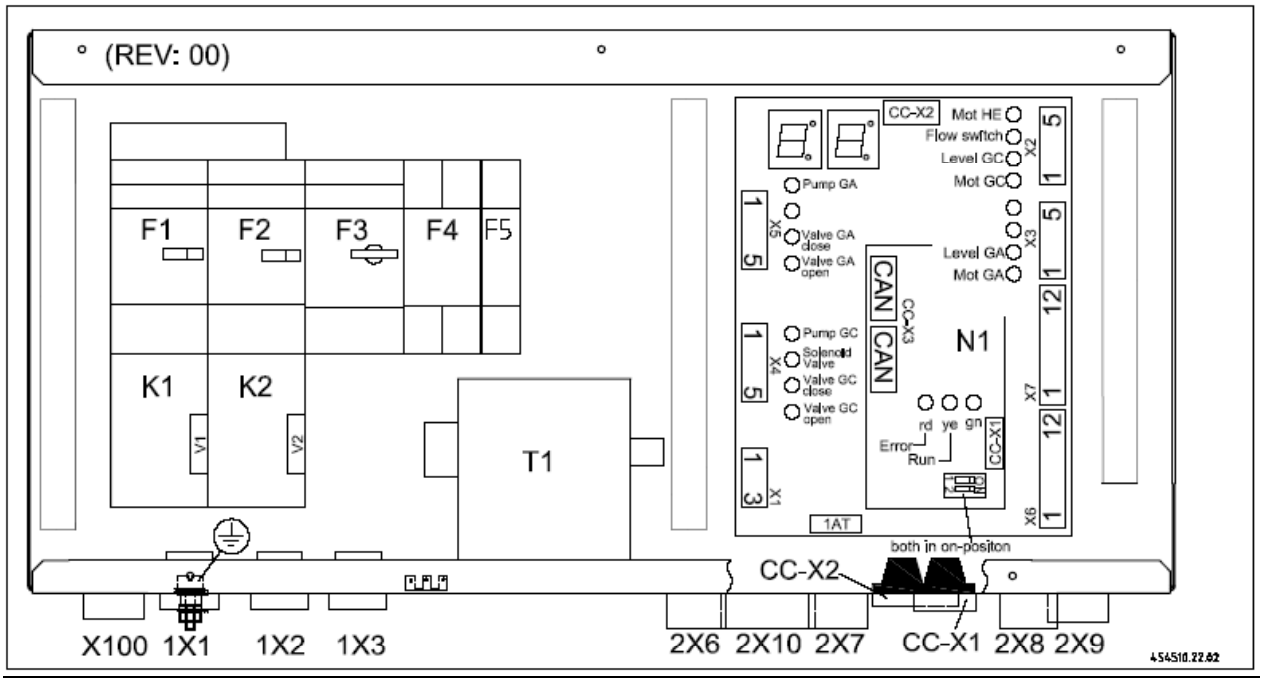



**Figure 3 – Bottom view**

## 1.5 CONTROLLING

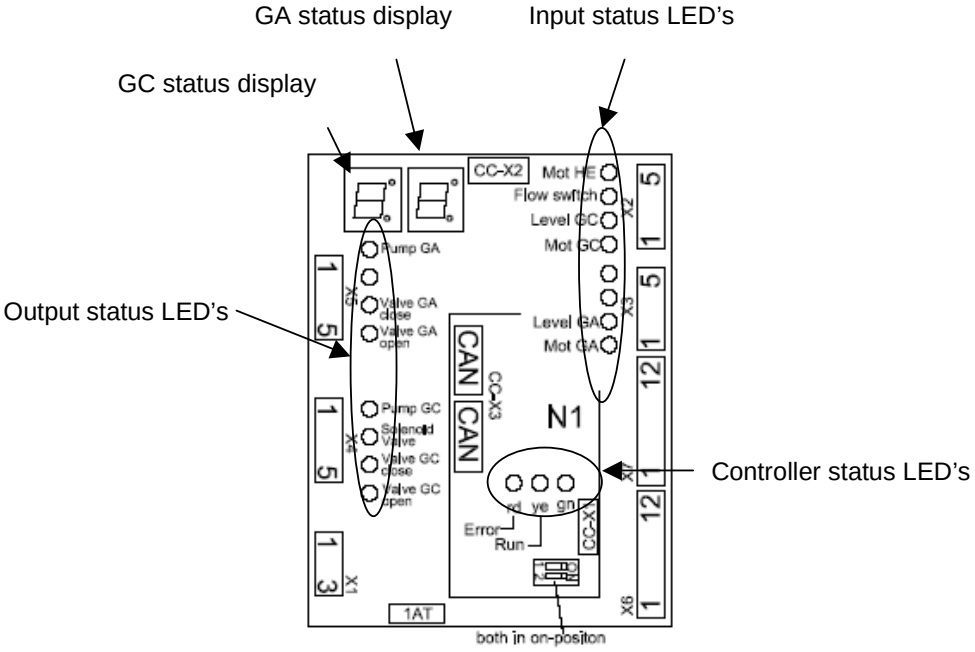
The outlet temperatures of the two secondary cooling circuits are regulated to a nominal value by means of a controller on the printed circuit board (PCB). This controller controls two 3-way valves, which are located in the primary circuit.

The temperature sensors for the secondary circuits are installed in the tank of each circuit.
The controller is equipped with a serial interface RS 232 for (remote) diagnosis and status monitoring (STT).

## 1.6 VISUAL STATUS SIGNALS

Description of the visual status signals on the printed circuit board (PCB).

**Figure 4 – The PCB**




### 1.6.1 GC / GA STATUS DISPLAY (SOFTWARE VERSION < 1.0)

| | |
|---|---|
| " 1 " | Start |
| " 2 " | Normal usage |
| " 3 " | Error |
| " 4 " | Standby mode |
| " 5 " | Reference drive of the 3-way-valves actuator towards close |
| " 9 " | Reference drive of the 3-way-valves actuator towards ope |

### 1.6.2 GC / GA STATUS DISPLAY (SOFTWARE VERSION 1.0 AND HIGHER)

| | |
|---|---|
| " 1 " | Start (initialise) |
| " 2 " | Normal control (Warmed up above the low temperature threshold) |
| " 3 " | Error |
| " 4 " | Standby |
| " 5 " | Start-up flow (Flow switch is ignored now) |
| " 6 " | Normal control (Warming up, low temperature faults are ignored) |
| "7" | Temperature out of range. |

### 1.6.3 CONTROLLER STATUS LED'S

| | |
|---|---|
| "GREEN" | On during NORMAL operation |
| "YELLOW" | Flashing during NORMAL operation |
| "RED" | Error |

***NOTE***

*When these LED's are off, they still remain slightly lit, to ensure that they are not defective.*

### 1.6.4 INPUT STATUS LED'S

| | | |
|---|---|---|
| Mot HE | motor protecting switch HE compressor engaged | LED ON when active |
| Flow switch | Flow switch activated | LED ON when active |
| Level GC | liquid level GC OK | LED ON when active |
| Mot GC | motor protecting switch pump GC engaged | LED ON when active |
| | | |
| Not used | - | - |
| Not used | - | - |
| Level GA | liquid level GA OK | LED ON when active |
| Mot GA | motor protecting switch pump GA engaged | LED ON when active |

### 1.6.5 OUTPUT STATUS LED'S

| | | |
|---|---|---|
| Pump GA | pump GA (relay K2) | LED ON during NORMAL operation |
| Not used | - | - |
| Valve GA close | 3-way-valve GA | LED ON if valve closes |
| Valve GA open | 3-way-valve GA | LED ON if valve opens |
| | | |
| Solenoid valve (optional) | Optional GC valve | LED ON if valve opens |
| Pump GC | pump GC (relay K1) | LED ON during NORMAL operation |
| Valve GC close | 3-way-valve GC | LED ON if valve closes |
| Valve GC open | 3-way-valve GC | LED ON if valve opens |

The LED's will give a rough indication of the status of the LCC and can be helpfully while troubleshooting. More detailed information will be available through the RS 232 port, if connected to a service PC using a hyper terminal program, or through STT diagnostics.

## 1.7 RS 232 INTERFACE

| | |
|---|---|
| Connector type | 9p D connector (female). |
| Protocol | ASCII |
| Baud rate | 9600 |
| Parity check | N, 8, 1, |
| Digital logic: | Control: ±5V RS232 (EIA/TIA-232). |
| | Status: ±5V RS232 (EIA/TIA-232). |

| Pin | Signal name | I/O characteristics | | | | |
|---|---|---|---|---|---|---|
| | | Low level | High level | Current | Impedance | Filter |
| 1 | GND | | | | | |
| 2 | Tx | $V_{OL} \leq$ -5V | $V_{OH} \geq$ +5V | $I_{out} \leq$ 60mA | $R_{out}$ =10E | |
| 3 | Rx | $V_{IL} \leq$ 0.8V | $V_{IH} \geq$ 2,4V | | $R_{in} \geq$ 3K | |
| 4 | | | | | | |
| 5 | GND | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | FAULTN | $V_{IL} \leq$ 0.8V | $V_{IH} \geq$ 2,4V | | $R_{PD\ GND}$ =1K00 | $RC_{IN}$ =22µs |
| 9 | FAULT_ENABLEN | $V_{IL} \leq$ 0.8V | $V_{IH} \geq$ 2,4V | | $R_{PU\ 3V3}$ =10K0 | |

Test cable CC-X1 to service PC

| Label | Serial port PC | CC-X1 |
|---|---|---|
| Connectors | D-Shell, 9 positions | D-Shell, 9 positions |
| Terminations | Socket (Female) | Pin (Male) |
| Connections | Position **1** GND | Position **1** GND |
| | Position **2** TX | Position **2** TX |
| | Position **3** RX | Position **3** RX |
| | Position **5** GND | Position **5** GND |
| | Position **8** FAULTN | Position **8** FAULTN |
| | Position **9** FAULT_ENABLEN | Position **9** FAULT_ENABLEN |

### 1.7.1 GENERAL RS 232 PROTOCOL INFORMATION

- There will be no communication placed on the RS232 port other than requested by the host (interlock status excluded)
- Each command shall end with a CR.
- The command will be echoed in defined format.
- The echo shall end with a CR followed by a LF
- Each reply by the LCC shall be separated by a (CR).
- Replies do not have a fixed length.
- In case of a wrong command received by LCC, “wrong input!” is returned
- In case of a range error received by LCC, “RANGE ERROR” is returned
- Each reply shall start with an “>” as implemented

### 1.7.2 INTERLOCK ERROR STATUS

Under the next listed conditions, applicable for either one or both secondary circuits, the LCC controller circuit will generate an interlock error on the RS 232 port and on the parallel interface.

- Low coolant level
- High coolant temperature (TLOW sec > 30ºC)
- Low coolant temperature (TLOW sec < 15ºC)

Under all these conditions an interlock error will be generated and the cooling circuits (both GA and GC) will be shut down. As soon as the conditions are restored the LCC will automatically get into normal operating mode.

### 1.7.3 DETAILED COMMAND DESCRIPTIONS

| | | HOST | LCC | |
|---|---|---|---|---|
| *Prim. circuit* | *Command description* | *string send* | *string reply* | *description* |
| T1 input | Read T1 primary | #PT␣1 | #PT ␣1␣183<br>(i.e. 18.3 °C) | When broken or disconnected value >108°C |
| T2 output | Read T2 primary | #PT␣2 | #PT␣2␣210<br>(i.e. 21.0 °C) | When broken or disconnected value >108°C |
| Valve GC | Read valve position GC | #VP␣1 | #VP␣1␣1200<br>(i.e. 120.0 sec) | max. value: 170sec @ 50Hz<br>max. value: 135sec @ 60Hz<br>At max value, valve is closed, at 0, the valve is fully opened. This is a SW generated value and invalid when valve has been manually changed. |
| Valve GA | Read valve position GA | #VP␣2 | #VP␣2␣1234<br>(i.e. 123.4 sec) | max. value: 170sec @ 50Hz<br>max. value: 135sec @ 60Hz<br>At max value, valve is closed, at 0, the valve is fully opened. This is a SW generated value and invalid when valve has been manually changed. |
| *Sec. circuit GC* | *Command description* | *string send* | *string reply* | *description* |
| Temperature | Read T-actual GC | #RT␣1 | #RT␣1␣245<br>(i.e. 24.5°C) | When broken or disconnected value >100°C |
| | Read T-set point GC | #RS␣1 | #RS␣1␣250<br>(i.e. 25.0 °C) | Control set point |
| | Set T-set point GC | #SS␣1␣240 | #SS␣1␣240<br>(i.e. 24.0 °C) | Range is 20 ≤ $T_{setpoint}$ ≤ 30°C |
| PI-Control | Control-Output | #RY␣1 | #RY␣1␣-34<br>(i.e. –34%) | Proportional Integral output.<br>0 indicates no cooling<br>-100% max cooling requested |
| Gain | Read gain GC | #RG␣1 | #RG␣1␣500<br>(i.e. 5.00%) | |
| | Set gain GC | #SG␣1␣750 | #SG␣1␣750<br>(i.e. 7.50%) | Range is 1 ≤ Gain ≤ 20% |
| Integration time | Read integration time | #RI␣1 | #RI␣1␣300<br>i.e. 30.0 sec) | Range is 10 ≤ $t_{integration}$ ≤ 50 seconds<br>Range is 0 ≤ $t_{integration}$ ≤ 65 seconds (* |
| | Set integration time | #SI␣1 | #SI␣1␣300<br>(i.e. 30.0 sec) | Range is 10 ≤ $t_{integration}$ ≤ 50 seconds<br>Range is 0 ≤ $t_{integration}$ ≤ 65 seconds (* |
| Pressure | Read pressure GC pump | #RP␣1 | #RP␣1␣34<br>(i.e. 3.4 Bar) | Range for planned maintenance derived from trends in log files |
| Pressure | Read pressure GC filter | #RF␣1 | #RF␣1␣34<br>(i.e. 3.4 Bar) | Range for planned maintenance derived from trends in log files |
| Operating hours pump | Read Opr. hrs pump GC | #RO␣1 | #RO␣1␣44<br>(i.e. 44 hours) | Pump operating hrs |
| | Re-Set Opr. hrs pump GC | #SO␣1 | #SO␣1␣0 | Reset to operating hrs to zero |

| | | | | |
|---|---|---|---|---|
| Read digital | Read digital signals GC | #RD␣1 | (pos ␣1234␣5678)<br>#RD␣1␣xxxx␣yyyy | x - inputs:<br>(1=OK, 0=NOK)<br>pos 1: motor protect pump<br>pos 2: tank level<br>pos 3: reserve<br>pos 4: motor protect He compressor<br>y - outputs:<br>pos 5: pump running<br>pos 6: reserve<br>pos 7: increasing cooling capacity<br>pos 8: decreasing cooling capacity |
| | | #RE␣1 | | 0: no interlock<br>101: Motor switch GC circuit tripped<br>102: Level GC circuit too low<br>110: Tactual GC circuit too low<br>111: Tactual GC circuit too high<br>112: Tactual GC sensor defect (*<br>113: Tactual GC circuit < 15°C (*<br>114: Tactual GC circuit > 40°C (*<br>115: Tactual GC circuit < lower trippoint, t ≥ 30 minutes (*<br>116: Tactual GC circuit > higher trippoint, t ≥ 30 minutes (*<br>120: Pump pressure GC defect<br>121: Filter pressure GC defect |
| | | #RE␣1 | #RD␣1␣x | 1 Start<br>2 Normal Control<br>3 Error<br>4 Standby<br>5 Ref close<br>6 Ref open |
| *Sec. circuit GA* | *Command description* | *string send* | *string reply* | *description* |
| Temperature | Read T-actual GA | #RT␣2 | #RT␣2␣245<br>(i.e. 24.5°C) | When broken or disconnected value >100°C |
| | Read T-set point GA | #RS␣2 | #RS␣2␣250<br>(i.e. 25.0 °C) | Control set point |
| | Set T-set point GA | #SS␣2␣240 | #SS␣2␣240<br>(i.e. 24.0 °C) | Range is 20 ≤ $T_{setpoint}$ ≤ 30°C |
| PI-Control | Control-Output | #RY␣2 | #RY␣2␣-34<br>(i.e. –34%) | Proportional Integral output.<br>0 indicates no cooling<br>-100% max cooling requested |
| Gain | Read gain GA | #RG␣2 | #RG␣2␣500<br>(i.e. 5.00%) | |
| | Set gain GA | #SG␣2␣750 | #SG␣2␣750<br>(i.e. 7.50%) | Range is 1 ≤ Gain ≤ 20% |
| Integration time | Read integration time | #RI␣2 | #RI␣2␣300<br>i.e. 30.0 sec) | Range is 10 ≤ $t_{integration}$ ≤ 50 seconds<br>Range is 0 ≤ $t_{integration}$ ≤ 65 seconds (* |
| | Set integration time | #SI␣2 | #SI␣2␣300<br>(i.e. 30.0 sec) | Range is 10 ≤ $t_{integration}$ ≤ 50 seconds<br>Range is 0 ≤ $t_{integration}$ ≤ 65 seconds (* |
| Pressure | Read pressure GA pump | #RP␣2 | #RP␣2␣34<br>(i.e. 3.4 Bar) | Range for planned maintenance derived from trends in log files |
| Pressure | Read pressure GA filter | #RF␣2 | #RF␣2␣34<br>(i.e. 3.4 Bar) | Range for planned maintenance derived from trends in log files |
| Operating hours pump | Read Opr. hrs pump GA | #RO␣2 | #RO␣2␣44<br>(i.e. 44 hours) | Pump operating hrs |
| | Re-Set Opr. hrs pump GA | #SO␣2 | #SO␣2␣0 | Reset to operating hrs to zero |

| | | | | |
|---|---|---|---|---|
| Read digital | Read digital signals GA | #RD␣2 | (pos ␣1234␣5678)<br>#RD␣2␣xxxx␣yyyy | x - inputs:<br>(1=OK, 0=NOK)<br>pos 1: motor protect pump<br>pos 2: tank level<br>pos 3: reserve<br>pos 4: reserve<br>y - outputs:<br>pos 5: pump running<br>pos 6: reserve<br>pos 7: increasing cooling capacity<br>pos 8: decreasing cooling capacity |
| | | #RE␣2 | | 0: no interlock<br>201: Motor switch GA circuit tripped<br>202: Level GA circuit too low<br>210: Tactual GA circuit too low<br>211: Tactual GA circuit too high<br>212: Tactual GA sensor defect (*<br>213: Tactual GA circuit < 15°C (*<br>214: Tactual GA circuit > 40°C (*<br>215: Tactual GA circuit < lower trippoint, t ≥ 30 minutes (*<br>216: Tactual GA circuit > higher trippoint, t ≥ 30 minutes (*<br>220: Pump pressure GA defect<br>221: Filter pressure GA defect |
| | | #RE␣2 | #RD␣2␣x | 1 Start<br>2 Normal Control<br>3 Error<br>4 Standby<br>5 Ref close<br>6 Ref open |
| *Other* | *Command description* | *string send* | *string reply* | *description* |
| Version SW | | #SV | #SV␣010 | V0.10 |
| Serial number | | #SN | #SN␣234 | 234 |
| Parameter list | Request parameter listing | #LP | #LP<br>#RH␣50 or 60<br>#SV␣1.01<br>#SN␣134<br>#PT␣183␣210<br>#VP␣1200␣1234<br>#RT␣245␣253<br>#RS␣250␣250<br>#RY␣-34␣-50<br>#RG␣500␣300<br>#RI␣300␣200<br>#RP␣34␣27<br>#RF␣34␣27<br>#RO␣44␣75<br>#RE␣0␣<br>#RM | List parameters,<br>net frequency,<br>Software version 1.01<br>Serial number<br>Primary temp 1, 2<br>Valve position 1, 2<br>Temperature 1,2<br>Set point 1, 2<br>Control output 1, 2<br>Gain 1, 2<br>Integration time 1, 2<br>Pressure Pump 1,2<br>Pressure Filter 1, 2<br>Operating hours 1, 2<br>Read error code |
| Mains frequency | Read mains frequency | #RH | #RH␣50 or<br>#RH␣60 | Read mains frequency as input for valve drive time (i.e. 135 or 170 seconds).<br>Only internal by the LCC used. |
| Normal Mode | Normal mode<br>Normal control of set point | #NC | #NC | Normal control mode of set point. One command for both circuits. |

| | | | | |
|---|---|---|---|---|
| Standby Mode | Standby mode | #SB | #SB | After receiving a standby command and subsequently reaching set point the system goes into standby mode (pump shuts down, valve goes to minimum cooling position.<br>One command for both circuits. |
| Standby Mode (* | Standby mode + time | #SB␣xxx<br>(xxx = 0…540 minutes) | #SB␣xxx | Pumps are shut off within xxx minutes + 5 sec if the "Temp out of range" was not entered during xxx minutes, this may lead to an extra delay of 30 minutes. After shutting down the pumps, the 3-way valves are closed this may take up to 170 sec. This command is only accepted in the states "Normal Control" and "Temp out of range" and (re) starts the Standby timer. Applies to both GC and GA circuits.<br>The command "#SB" is also valid and will interpreted as "#SB 0", meaning that if the LCC is in the state "Normal Control" it switches immediately to the "StandBy"state. |
| Temperature upper Trippoint (* | Read T-upper trip point CG and GA | #GT␣1 | #GT␣1␣320<br>(i.e. 32.0 °C) | The temperature trippoint is the value of the LCC output temperature at which the LCC generates an interlock to the MR system, while the pumps keep running. |
| | Write T-upper trip point CG and GA | #ST␣1 | #ST␣1␣320<br>(i.e. 32.0 °C) | |
| Temperature lower Trippoint (* | Read T-lower trip point CG and GA | #GT␣2 | #GT␣1␣180<br>(i.e. 18.0 °C) | |
| | Write T-lower trip point CG and GA | #ST␣2 | #ST␣1␣180<br>(i.e. 18.0 °C) | |

(* only available for LCC software versions 1.0 and higher.

## 1.8 COOLANT SAFETY ISSUES

### 1.8.1 GRADIENT COIL CIRCUIT (GC)

As already mentioned, the coolant for the gradient coil consists of distilled water with inhibitor and biocide as additives.

A inhibitor biocide packaging contains, a small bottle of inhibitor and a small bottle of biocide.

The bottle marked 'Inhibitor' contains 6 ml of inhibitor mixed with water to a volume of 30 ml. This will result in a concentration of 0.2 ml/l when added to the 30 liter distilled water of the gradient coil cooling circuit (further called GC).
The bottle marked 'Biocide' contains 2.7 ml of biocide mixed with water to a volume 30 ml. This will result in a concentration of 0.09 ml/l when added to the 30 liter distilled water of the GC circuit.

Please realize that the inhibitor and biocide are potentially harmful fluids; precautions must be taken when working with these fluids. Refer to Material Safety Data Sheets MSDS#9 'Inhibitor' and MSDS#10 'biocide' for detailed information including safety and disposal instructions.

***NOTE***
*All types gradient coil use all, the same type of coolant.*

_____

### 1.8.2 GRADIENT AMPLIFIER CIRCUIT (GA)

With each LCC, 25 liter coolant will be supplied. The coolant consists of a mix of 50% Dowterm SR1 (inhibited ethylene glycol) and 50% water. The pink colored liquid has a glycol odor. There are no significant immediate hazards for emergency response known.

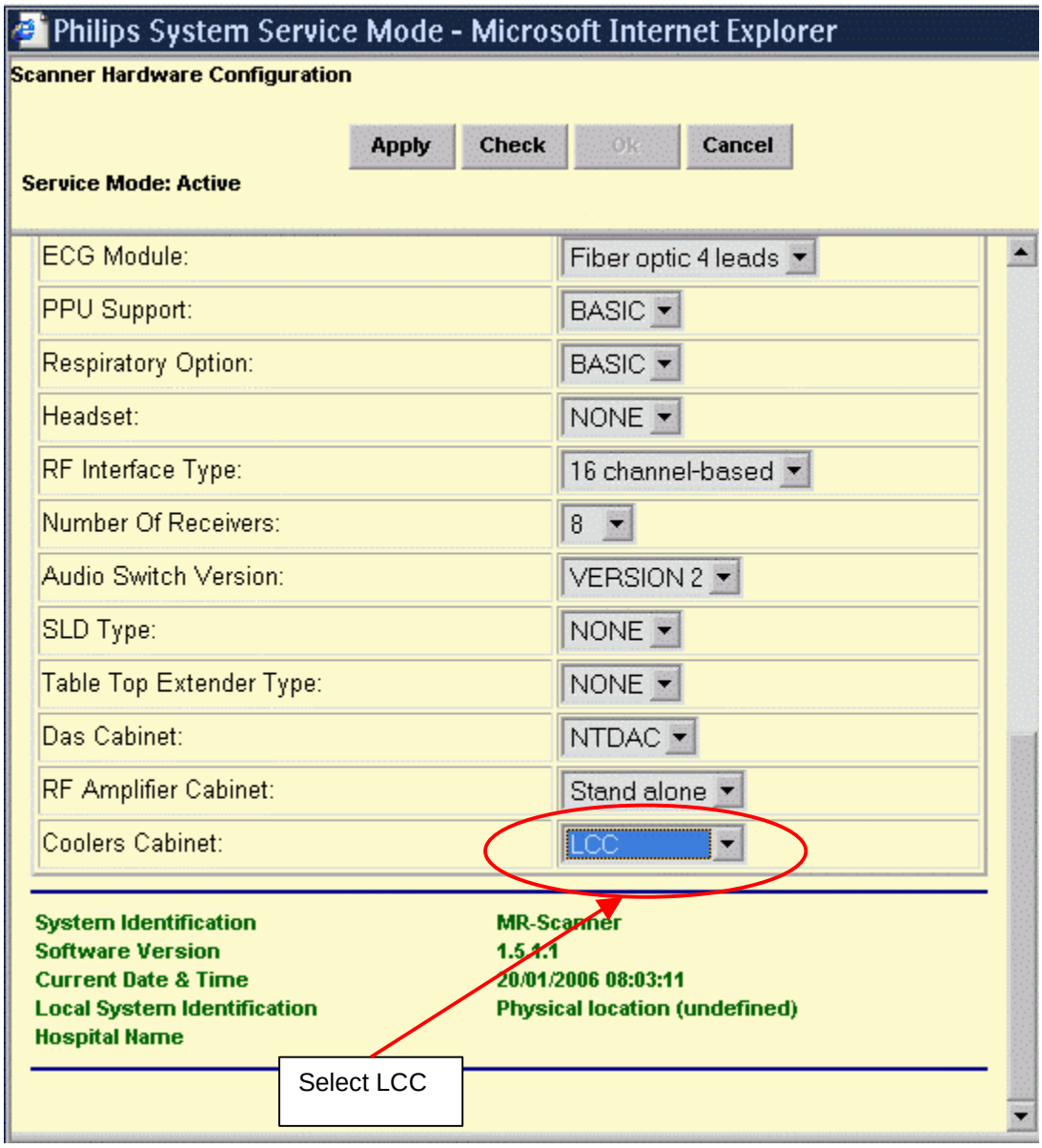
Refer to Material Safety Data Sheets MSDS MR-011 for detailed information including safety and disposal instructions.

# 2 PROGRAMMING

## 2.1 CONFIGURATION IN FSF

Configure the LCC in FSF, if not already done.

**Figure 5 – FSF scanner hardware configuration**

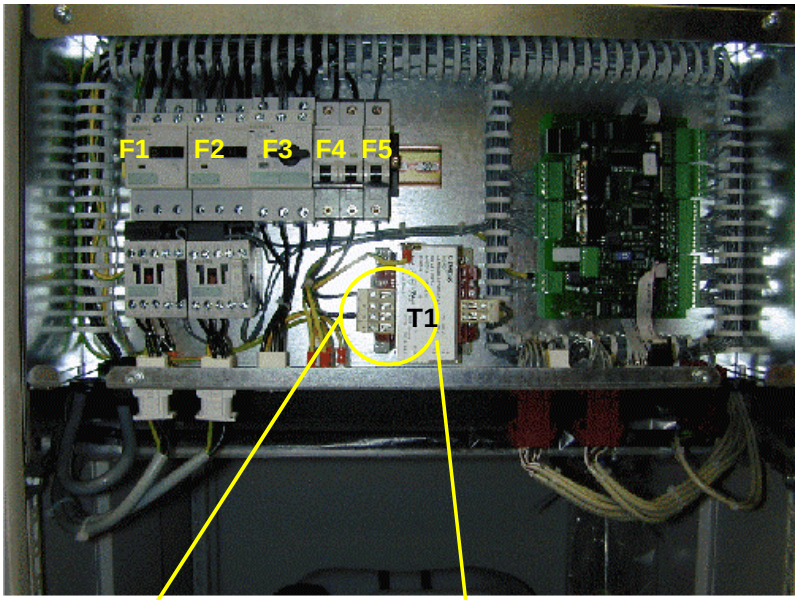


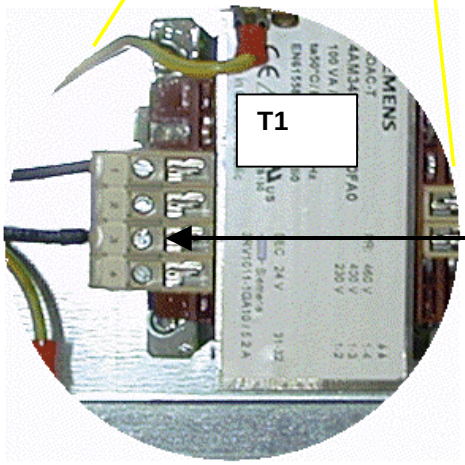

## 2.2 VOLTAGE PROGRAMMING

Ensure that F1 through F5 are switched OFF. (See Figure 6.)
Select the right voltage for the PCB power supply by connecting the loose cable between T1 (transformer) and F4 (circuit breaker primary) to the right voltage taps on the transformer. See Figure 6.

**Figure 6 – Voltage programming for T1**

F1 GC pump
F2 GA pump
F3 Cryo compressor
F4 electronics (transformer for controller)
F5 electronics (controller)



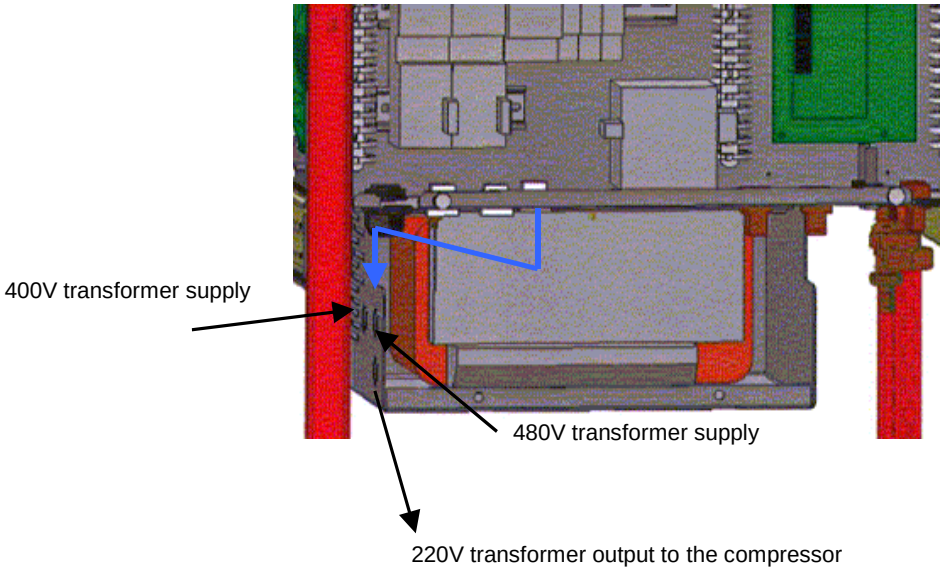



## 2.3 CONNECTING THE APD CRYO COMPRESSOR TO THE RIGHT VOLTAGE

A transformer is pre-installed to adapt of the mains supply in order to meet the power requirements for the APD Helium compressor. The power supply for the transformer is supplied via the control box. The transformer transforms the mains supply 400 V / 50 Hz or 480 V / 60 Hz for the helium compressor to 220 V / 50 Hz or 60 Hz.

See Figure 7.

**Figure 7 – Wiring the mains power for the APD compressor**




Use the supplied mains cable and connect the straight ends to the terminals inside the APD helium compressor before installing the unit inside the LCC. After installation of the compressor plug in the other end of the mains cable to transformer 220V outlet. Connect the mains outlet for the helium compressor on the control box to the 400V or 480V mains inlet on the transformer thus selecting the right voltage.

## 2.4 CONNECTING THE SHI CRYO COMPRESSOR

Use the supplied mains cable and connect the straight ends to the corresponding voltage terminal on the SHI cryo compressor before installing the unit inside the LCC.
Connect the mains power connector to 1X3 at the bottom of the electronic box.

## 2.5 WATER CONNECTIONS

**Figure 8 – Top view of the LCC, the primary connections**

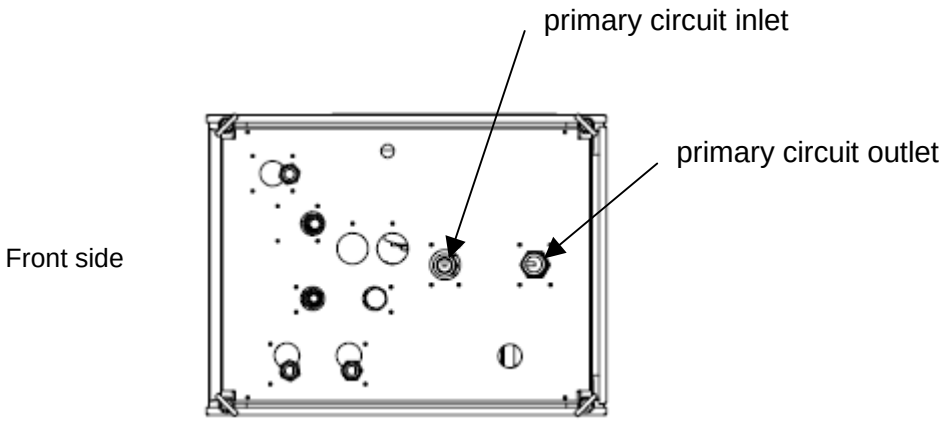
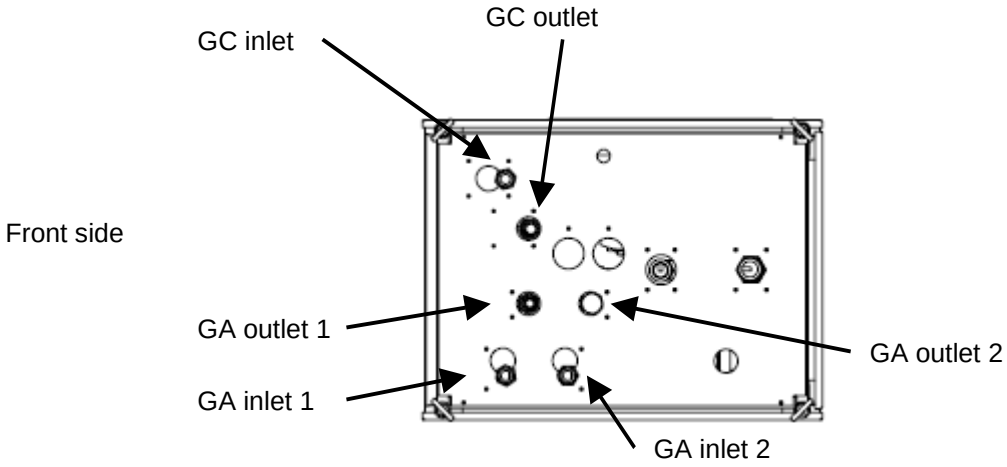



**Figure 9 – Top view of the LCC, the secondary connections**



# 3 SETTING THE LCC TO WORK (SYSTEM EMPTY)

Precondition: All hoses (primary and secondary) must be connected prior to setting to work.

## 3.1 PREPARATION

1. Check all connections to ensure that they are leak tight (i.e. the PVC O-ring seals, hose connections).
2. Check that the blind caps (in case only one amplifier is present) are installed and tightened.
3. Check that all drain valves (3 in total, 2 near the pump and 1 behind the ball valve in the cooling supply for the helium compressor) are closed. The red colored handle to close the drain valves in the secondary circuits are fixed with tie-wrap to the plumbing. To avoid to accidentally opening these valves, remove the handle after closing.

**Figure 10 - The drain valves in the secondary circuit**

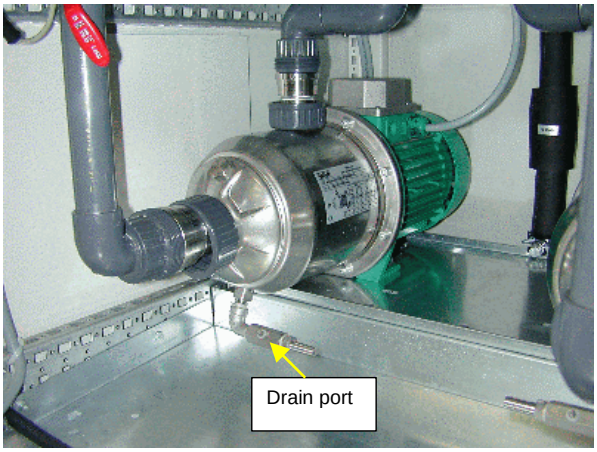
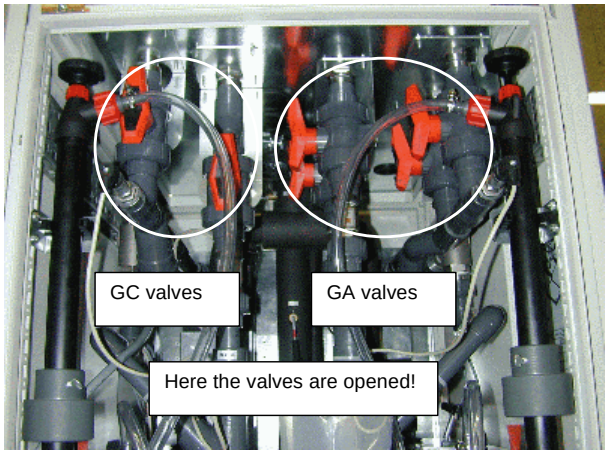



**Figure 11 – The 6 ball valves at top of the LCC**




4. Ensure that all required ball valves in the secondary circuits (at the top of the LCC) are closed. See Figure 11.

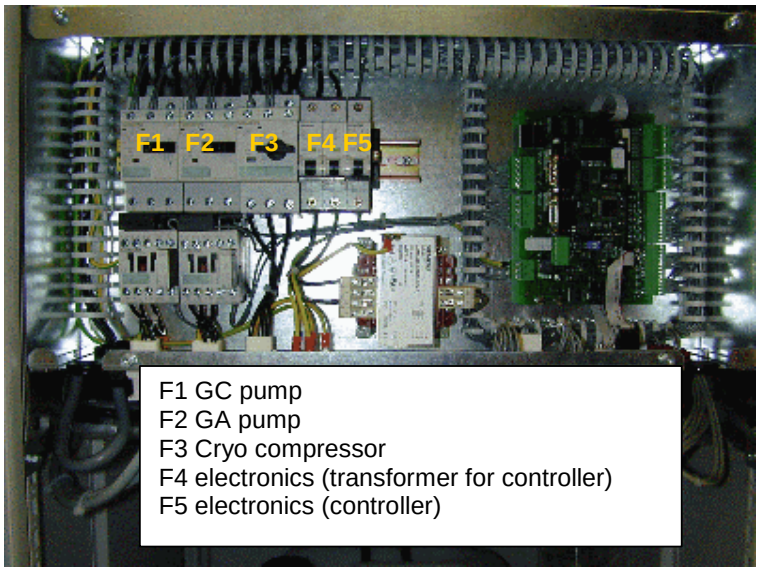
## 3.2 FILLING THE PRIMARY CIRCUIT

1. Slowly open the primary circuit and check the system for leaks (i.e. all connections inside as well as outside the LCC).
2. Open the ball valves to the helium compressor and check for leaks.

## 3.3 CONNECTING TO MAINS VOLTAGE SUPPLY

1. Check that all circuit breakers F1 (gradient coil loop pump), F2 (gradient amplifier loop pump), F4 and F5 (both for the electronics) are switched OFF (default factory setting). See Figure 12.
2. Switch on the LCC mains power inside the Philips I-MDU cabinet, if not already done.
3. F3 (cryo compressor) can be switched on if the cryo cooling system is operational.
4. When all connections are checked and OK, switch ON the mains power.
5. Switch ON circuit breaker F4 and F5 to activate the controller. See Figure 12.

**Figure 12 – Overview of the switches**




## 3.4 SWITCHING ON THE CRYO COMPRESSOR

Switch on F3 to supply mains power to the cryo compressor. If the compressor runs the wrong way around, swap two fase connections at the compressor. The cryo compressor is not controlled any way by the LCC electronics.

## 3.5 FILLING THE GRADIENT COIL COOLING CIRCUIT

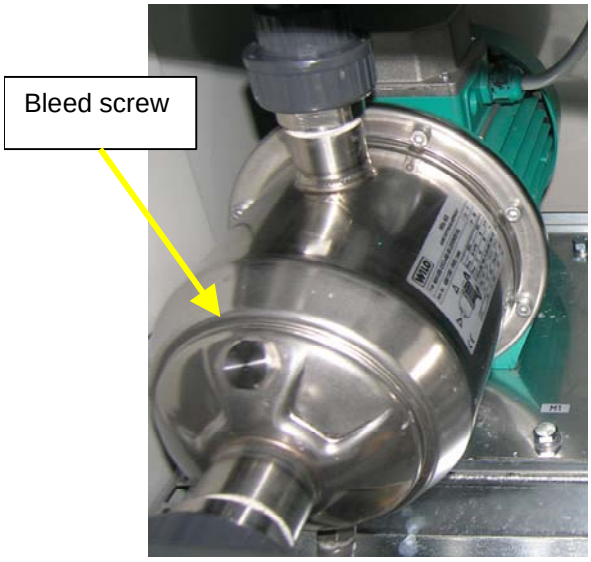
The gradient coil circuit will be filled with distilled water. Afterwards the inhibitor and biocide must be added.

**NOTE**

*The pump switches ON after the system check has been successfully passed and F1 is switched on. This takes approximately 170 seconds (130 seconds at 60Hz), it is actually the maximum time needed for a reference drive of the 3 way valve actuator.*
*As soon as the pump starts, the level will drop fast and the hoses will be filled with liquid until the low level switch is activated. The activated level switch will set an interlock, which stops the pump (the left controller display shows code '3'). To release the interlock, the controller must be reset by toggling F5.*

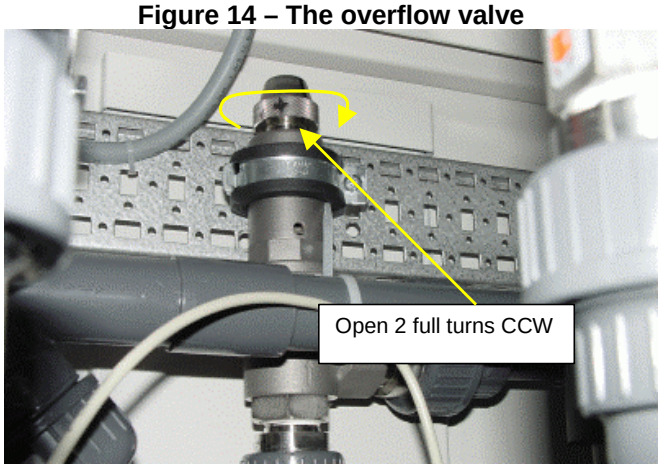
1. Insert the hand pump, which is connected to the GC circuit, in the container filled with distilled water. Screw the hand pump to the container and fill the tank to the maximum level by operating the hand pump.
2. Check for leaks, while filling.
3. Ensure that all required ball valves in the secondary GC circuits (at the top of the LCC) are closed. See Figure 11.
4. Vent the pump by loosening the bleed screw just one full turn, using a 19 mm wrench. See Figure 13.

**Figure 13 – Location of the bleed screw**




5. Tighten the bleed screw (clock wise) when fluid without air leaks out.
6. Open the overflow valve by turning it 2 full turns counter clock wise. See Figure 14. This way air, trapped in the by-pass, will be vented through the heat exchanger into the tank, when the pomp is switched on.

**Figure 14 – The overflow valve**




7. Switch on the GC pump by toggling F5 to reset the LCC electronics and switch ON circuit breaker F1. An 3 minutes calibration run is started, afterwards the pump will start.
8. Switch off the pump with F1 when the tank is **half empty**.
9. Close the overflow valve by turning it fully clock wise.
10. Check for leaks.
11. Now open the ball valves in the secondary circuits (at the top of the LCC). See Figure 11.
12. Top up the tank again by operating the hand pump.
13. Vent the pump by loosening the bleed screw just one full turn, using a 19 mm wrench. See Figure 13.

14. Tighten the bleed screw (clock wise) when fluid without air leaks out.
15. Switch on the GC pump by switching ON circuit breaker F1 for a short while. If the pump does not start, toggle F5 to reset the LCC electronics. A 3 minutes calibration run is started, afterwards the pump starts and must be switched off with F1 when the tank is half empty.
16. Switch off the pump with F1 when the tank is **half empty**.
17. Repeat step 12 to 16 until the level stops dropping.
18. If there are no leaks, switch off the pump by switching off F1.
19. Keep F1 switched off until also the gradient amplifier circuit is filled.

Drain the remaining fluid from the pump and store it in the LCC.

## 3.6 ADD THE INHIBITOR AND BIOCIDE TO THE DISTILLED WATER IN THE GC CIRCUIT

1. Unscrew the 3 bolts that hold the up the tank cover.
2. Take off the cover with level switch.
3. Add the inhibitor and biocide through the tank opening.
4. Install the tank cover with level switch.

## 3.7 FILLING THE GRADIENT AMPLIFIER COOLING CIRCUIT

The gradient amplifier circuit will be filled with a DowTherm SR1 mixture.

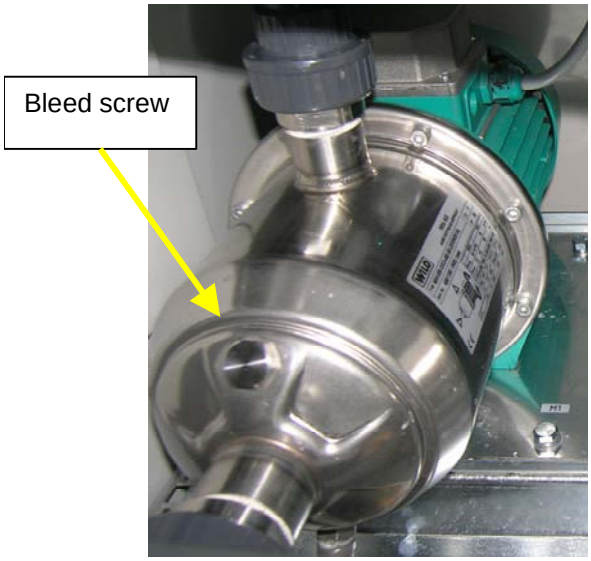
**NOTE**

*The pump switches ON after the system check has been successfully passed and F2 is switched on. This takes approximately 170 seconds (130 seconds at 60Hz), it is actually the maximum time needed for a reference drive of the 3 way valve actuator.*
*As soon as the pump starts, the level will drop fast and the hoses will be filled with liquid until the low level switch is activated. The activated level switch will set an interlock, which stops the pump (the right controller display shows code '3'). To release the interlock, the controller must be reset by toggling F5.*

---

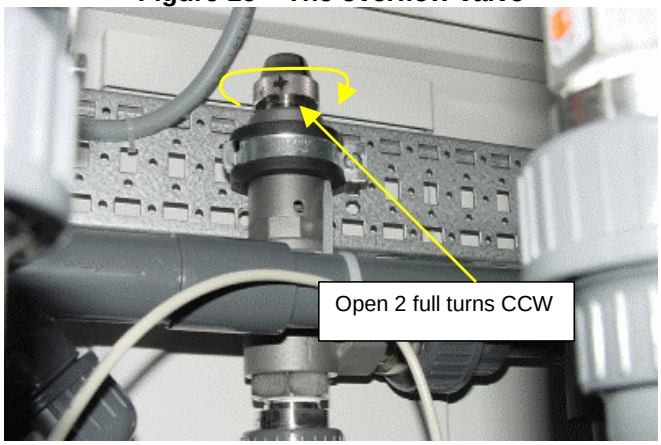
1. Insert the hand pump, which is connected to the GA circuit, in the container filled with the pink DowTherm SR1 mixture. Screw the hand pump to the container and fill the tank to the maximum level by operating the hand pump.
2. Check for leaks, while filling.
3. Ensure that all required ball valves in the secondary GA circuits (at the top of the LCC) are closed. See Figure 11.
4. Vent the pump by loosening the bleed screw **one full turn**, using a 19 mm wrench. See Figure 15.

**Figure 15 – Location of the bleed screw**




5. Tighten the bleed screw (clock wise) when fluid without air leaks out.
6. Open the overflow valve by turning it 2 full turns counter clock wise. See Figure 16. This way air, trapped in the by-pass, will be vented through the heat exchanger into the tank when the pump is switched on.

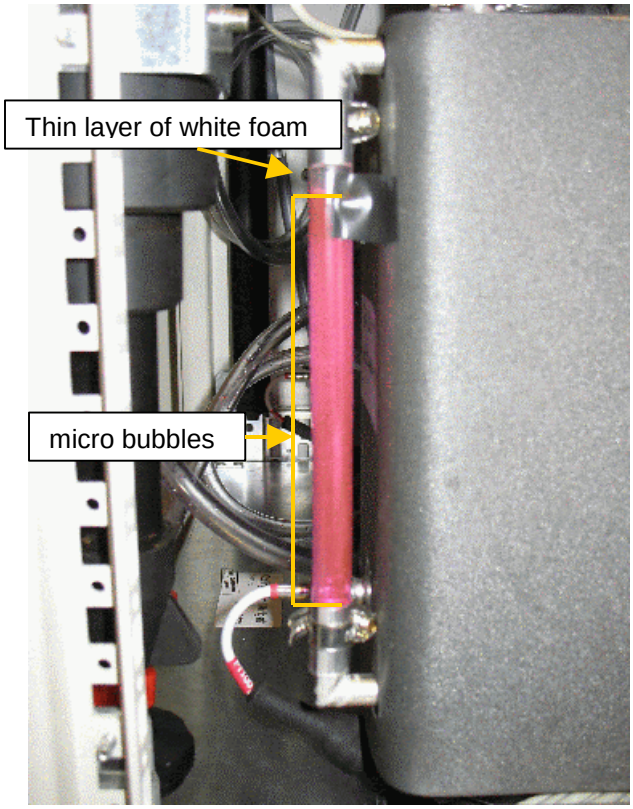
**Figure 16 – The overflow valve**




7. Switch on the GA pump by toggling F5 to reset the LCC electronics and switch ON circuit breaker F2. An 3 minutes calibration run is started, afterwards the pump will start.
8. Switch off the pump with F2 when the tank is **half empty**.
9. Close the overflow valve by turning it fully clock wise.
10. Check for leaks.
11. Now open the ball valves in the secondary circuits (at the top of the LCC) for GA 1 circuit (the first gradient amplifier). See Figure 11.
12. Top up the tank again by operating the hand pump, if required.
13. Switch on the GA pump by toggling F5 to reset the LCC electronics and switch ON circuit breaker F2. An 3 minutes calibration run is started, afterwards the pump will start.
14. Switch off the pump with F2 when the tank is **half empty**.
15. Now close the ball valves for GA 1 circuit (of the first gradient amplifier). See Figure 11.
16. If there are no air bubbles in the level indicator, open the ball valves for GA 2 circuit (of the second gradient amplifier if applicable). If there are air bubbles, refer to paragraph 3.8.
17. Switch on the GA pump by toggling F5 to reset the LCC electronics and switch ON circuit breaker F2. An 3 minutes calibration run is started, afterwards the pump will start.
18. Switch off the pump with F2 when the tank is **half empty**.
19. If there are still no air bubbles in the level indicator the GA 2 circuit is vented. If there are air bubbles, refer to paragraph 3.8.
20. Now open the ball valves for the GA 1 circuit. Now both GA circuits are open.
21. Top up the tank again by operating the hand pump, if required.
22. Vent the pump by loosening the bleed screw **one full turn**, using a 19 mm wrench. See Figure 15.
23. Tighten the bleed screw (clock wise) when fluid without air leaks out.
24. Switch on the GA pump by switching ON circuit breaker F2 for a short while. If the pump does not start, toggle F5 to reset the LCC electronics. A 3 minutes calibration run is started, afterwards the pump starts and must be switched off with F2 when the tank is half empty.
25. Switch off the pump with F2 when the tank is **half empty**.
26. Repeat step 21 to 25 until the level stops dropping.
27. Drain the remaining fluid from the hand pump and store the hand pump in the LCC.
28. Now, switch on F1 and F2. If the pump does not start, toggle F5 to reset the LCC electronics. A 3 minutes calibration run starts, afterwards the pumps start.

The liquid is should look clear, not looking foamy and saturated with large amounts of bubbles. Only very small micro bubbles and a very thin layer of foam are allowed. See Figure 17.

**Figure 17 – The level indicator**



## 3.8 WHAT TO DO WHEN THERE IS AIR / FOAM IN THE CIRCUIT

If the liquid is not transparent, looking foamy and saturated with a large amount of bubbles, continue with next procedure:

1. Allow the DowTherm SR1 mixture in the tank to vent air bubbles for approximately 15 minutes.
2. Open the bleed screw one full turn (counter clockwise), using a 19 mm wrench, at the pump until DowTherm SR1 mixture (without air bubbles) starts leaking out. See Figure 15.
3. Tighten the bleed screw. (clock wise).
4. Switch on the pump (F2) shortly for approximately 40 seconds. The total tank content has been flushed now.
5. Wait again for approximately 15 minutes to vent air bubbles from the DowTherm SR1 mixture in the tank.
6. Repeat 2 to 5 until the level indicator shows clear DowTherm SR1 mixture with just a small amount of micro bubbles.

If there is a **thick layer of foam** (most of the level indicator will be filled with foam) visible in the level indicator, continue with next procedure:

1. Switch off the pump (F2).
2. Unscrew the 3 bolts that hold the tank cover on top of the tank.
3. Take off the cover with level switch.
4. Check the tank for foam.
5. If there is a thick layer of foam in the tank, continue with the draining of the system.
6. Install the tank cover with level switch.
7. Restart the filling procedure with a fresh container of DowTherm SR1 mixture.

***NOTE***

*At first start-up of the cabinet after filling the tank, the pumps can make a **scratching noise**, caused by trapped air in the bypass line. This is normal and this is no problem as long as the noise disappears after a few seconds.*
*If this noise does not disappear, then the trapped air must be vented from the system.*
*Refer to the filling procedure*

---

If there is no way in getting the fluid clear and the air bubbles removed, call the MR helpdesk.

# 4 TEST PROCEDURES

## 4.1 CHECKING THE PUMP ROTATION DIRECTION

1. Switch ON the pumps by switching on F1 and F2. The system will switch into NORMAL control mode (the display shows two times '2". If the pumps do not start, toggle F5 to reset the LCC electronics.
2. Hold the ***rotation*** indicator near the electro-motor housing of the pump. Move it to find the rotating magnetic field of the motor until the red-white disks starts to rotate. Notice that the indicator turns in the opposite direction of the rotating field of the pump motor.

   - Red-white disk rotates clock wise (CW) = OK (seen from the font side of the LCC).
   - Red-white disk rotates counter clock wise (CCW) = Not OK, the wrong direction.

   This means that the phase order of the mains power connection is wrong.
   Swap two phases connections at the LCC connection in the Philips I-MDU cabinet to get the phase right order.
   If the cryo compressor was running correctly already, also two phases connections at the cryo compressor must be changed.

## 4.2 LCC BOARD TEST

Procedure:

1. Logon: **MRService** + password (Case sensitive!)
2. Select: **Intera** in the MR Boot Configuration manager and press Start
3. Select: **Start → MR Applications → Scan Applications → STT application**
4. Select: **Diagnostic procedures**
5. Select: **Gradient**
6. Select: **LCC**
7. Select: **LCC Info board test**
8. Select: <Proceed> After reading the instructions, to start the measurement.
9. An MRL is shown upon completion.
10. Select: **<Proceed>** to return the 'LCC' menu

If required continue with: 6.6 Firmware update

## 4.3 LCC INFO OVERVIEW TEST

Procedure:

1. Logon: **MRService** + password (Case sensitive!)
2. Select: **Intera** in the MR Boot Configuration manager and press Start
3. Select: **Start → MR Applications → Scan Applications → STT application**
4. Select: **Diagnostic procedures**
5. Select: **Gradient**
6. Select: **LCC**
7. Select: **LCC Info overview test**
8. The test shows a list of results as shown in next list:

If a print out of this test is saved upon installation, it can be used as reference upon failure in the future.

```
==================================[Test Results]================================
     Test  : LCC INFO OVERVIEW TEST             Date: 15-JUL-2005 10:39:35.68
     Result: Passed

     Parameter name                  Value       Nominal     Spec
------------------------------------------------------------------------------
     LCC: Board Access               Passed      Passed      Passed
     LCC: Software version/layout    0.1
     LCC: Serial number              15
     LCC: Primary Temperature T1 [D  12.4        10.0        [5 : 15.0]
     LCC: Primary Temperature T2 [D  12.6        10.0
     LCC: GA Valve Position [Sec]    161.5       120.0
     LCC: GA Temperature [DegC]      25.2        24.5        [20.0 : 30.0]
     LCC: GA Setpoint Temp [DegC]    25.0        25.0
     LCC: GA Pump Pressure [Bar]     5.9         6.5
     LCC: GA Filter Pressure [Bar]   1.4         6.5
     LCC: GA Tank Level              OK          OK          OK
     LCC: GA Valve Gain [%]          5.0         5.0
     LCC: GA Valve Int Time [Sec]    20.0        30.0
     LCC: GA Pump Status             ON          ON          ON
     LCC: GA Pump Operating hours    228.0
     LCC: GC Valve Position [Sec]    165.8       120.0
     LCC: GC Temperature [DegC]      25.2        24.5        [20.0 : 30.0]
     LCC: GC Setpoint Temp [DegC]    25.0        25.0
     LCC: GC Pump Pressure [Bar]     6.2         6.5
     LCC: GC Filter Pressure [Bar]   0.6         6.5
     LCC: GC Tank Level              OK          OK          OK
     LCC: GC Valve Gain [%]          5.0         5.0
     LCC: GC Valve Int Time [Sec]    10.0        30.0
     LCC: GC Pump Status             ON          ON          ON
     LCC: GC Pump Operating hours    240.0
```

This information is also displayed in the system log file upon LCC failure. Just look for ‘LCC’ in the log file.

## 4.4 LCC COPY HW PARAMETERS TO LCC

Normally there is no reason to use this test. This test is only to be used when the LCC parameters must be updated.

Procedure:

1. Logon: **MRService** + password (Case sensitive!)
2. Select: **Intera** in the MR Boot Configuration manager and press Start
3. Select: **Start → MR Applications → Scan Applications → STT application**
4. Select: **Diagnostic procedures**
5. Select: **Gradient**
6. Select: **LCC**
7. Select: **LCC Copy HW Parameters to LCC**
8. Select: <Proceed> After reading the instructions, to start the measurement.
9. An MRL is shown upon completion.
10. Select: **<Proceed>** to return the ‘LCC’ menu

## 4.5 LCC RESET HOUR COUNTER GA PUMP

Procedure:

1. Logon: **MRService** + password (Case sensitive!)
2. Select: **Intera** in the MR Boot Configuration manager and press Start
3. Select: **Start → MR Applications → Scan Applications → STT application**
4. Select: **Diagnostic procedures**
5. Select: **Gradient**
6. Select: **LCC**
7. Select: **LCC Reset the hour counter GA pump**
8. Select: <Proceed> After reading the instructions, to start the measurement.
9. An MRL is shown upon completion.
10. Select: **<Proceed>** to return the 'LCC' menu

After resetting the hour counter continue with3.7 Filling the gradient amplifier cooling circuit.

## 4.6 LCC RESET HOUR COUNTER GC PUMP

Procedure:

1. Logon: **MRService** + password (Case sensitive!)
2. Select: **Intera** in the MR Boot Configuration manager and press Start
3. Select: **Start → MR Applications → Scan Applications → STT application**
4. Select: **Diagnostic procedures**
5. Select: **Gradient**
6. Select: **LCC**
7. Select: **LCC Reset the hour counter GC pump**
8. Select: <Proceed> After reading the instructions, to start the measurement.
9. An MRL is shown upon completion.
10. Select: **<Proceed>** to return the 'LCC' menu

After resetting the hour counter continue with 3.5 Filling the gradient coil cooling circuit.

## 4.7 LCC SYSTEM STARTUP

Procedure:

1. Logon: **MRService** + password (Case sensitive!)
2. Select: **Intera** in the MR Boot Configuration manager and press Start
3. Select: **Start → MR Applications → Scan Applications → STT application**
4. Select: **Diagnostic procedures**
5. Select: **Gradient**
6. Select: **LCC**
7. Select: **LCC System startup**
8. Select: <Proceed> After reading the instructions, to start the measurement.
9. An MRL is shown upon completion.
10. Select: **<Proceed>** to return the 'LCC' menu

## 4.8 LCC SYSTEM STANDBY

Procedure:

1. Logon: **MRService** + password (Case sensitive!)
2. Select: **Intera** in the MR Boot Configuration manager and press Start
3. Select: **Start → MR Applications → Scan Applications → STT application**
4. Select: **Diagnostic procedures**
5. Select: **Gradient**
6. Select: **LCC**
7. Select: **LCC System standby**
8. Select: <Proceed> After reading the instructions, to start the measurement.
9. An MRL is shown upon completion.
10. Select: **<Proceed>** to return the 'LCC' menu

# 5 ADJUSTMENT PROCEDURES

Not applicable

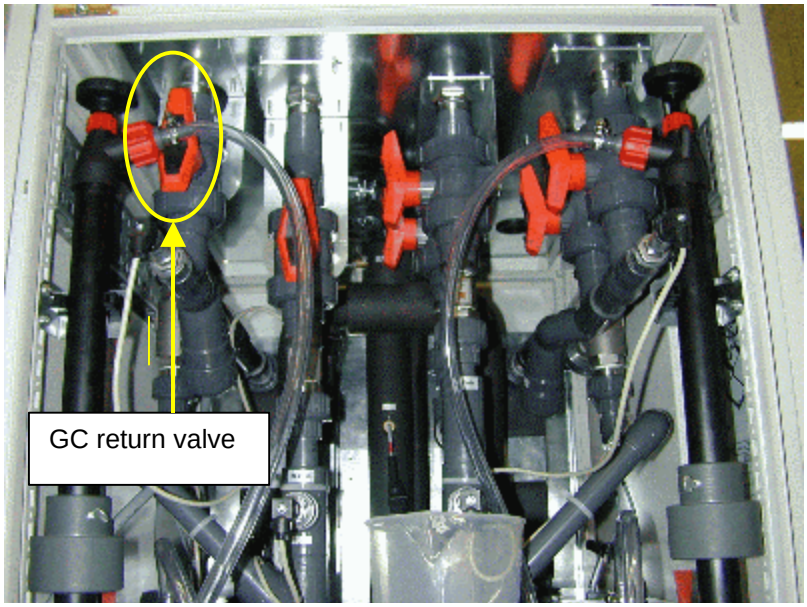
# 6 REPLACEMENT PROCEDURES

## 6.1 GRADIENT COIL COOLANT FLUSHING

Refer to Figure 20 for the coolant flush setup.

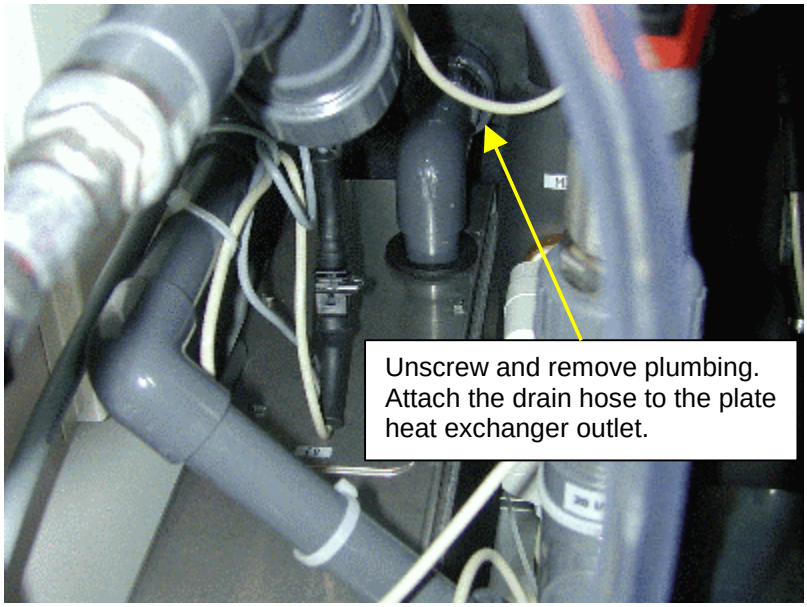
1. Switch OFF the pump by switching OFF F1. Keep the controller switched ON!
2. Close the valve of the return line from the gradient coil. See Figure 18.

**Figure 18 - Location of the GC return valve**



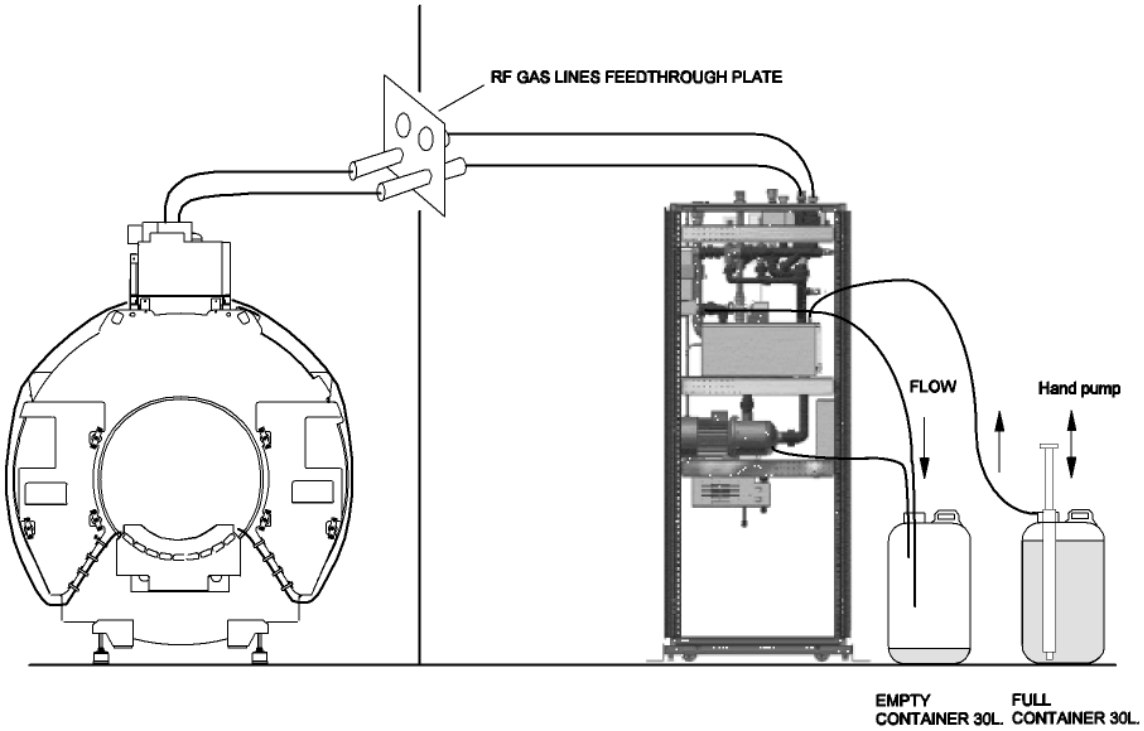

3. Unscrew the outlet of the plate heat exchanger of the gradient coil circuit. And remove the PVC plumbing. See Figure 19.
4. Screw the coolant drain hose to the outlet of the plate heat exchanger and put the other end in an empty container and fasten it somehow to the container. Notice that the water flows with approximately 18 liters per minute.

**Figure 19 – Unscrew and remove plumbing**




5. Connect an additional drain hose to the drain valve of the motor of the gradient coil circuit and put the other end also in the empty container.
6. Open the drain valve at the pump and drain the tank contents into the container.
7. Close the pump drain valve.
8. Insert the hand pump of the gradient coil circuit into the container with the new distilled water.
9. Fill the tank by operating the hand pump.
10. Open the valve of the return line from the gradient coil.
11. Switch ON the pump by switching ON F1.
12. The pump will fill the circuit with the new distilled water and drain the old coolant into the empty container until the low level switch in the LCC tank is activated because of low level.
13. Switch OFF the pump by means of switching OFF F1.
14. Fill the tank again and switch ON the pump by switching ON F1. Repeat this until the wastewater container is filled (25 liter).
15. Switch OFF the pump by means of switching OFF F1.
16. Remove the drain hose and install the PVC plumbing to connect the plate heat exchanger outlet to the tank.
17. Re-fill the tank with the distilled water just below the maximum level.
18. Verify the systems for leaks. If there are no leaks, continue.
19. Add the biocide and inhibitor additives through tank opening for the low level switch.
20. Switch ON the pump by means of switching ON F1.
21. Check the level and if necessary add coolant.
22. Dispose the waste coolant according local regulations.

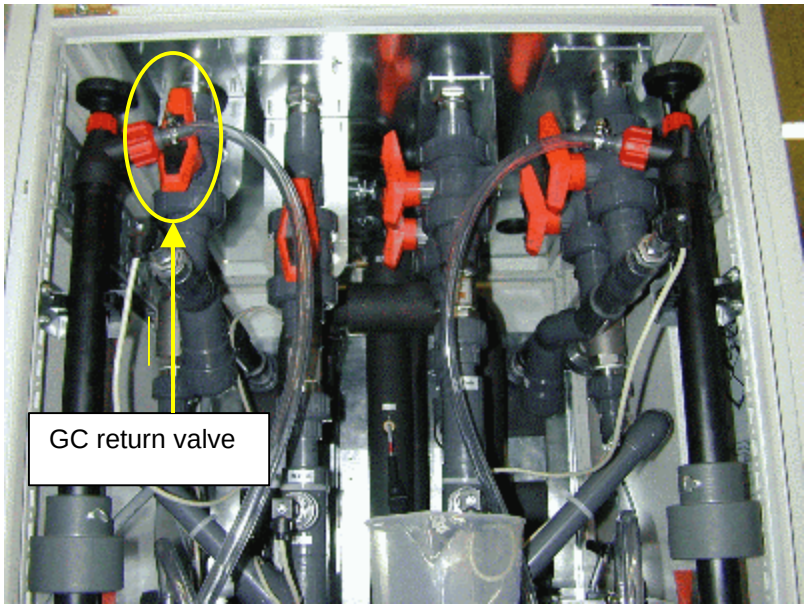
**Figure 20 - The flush setup**



## 6.2 COOLANT DRAINING

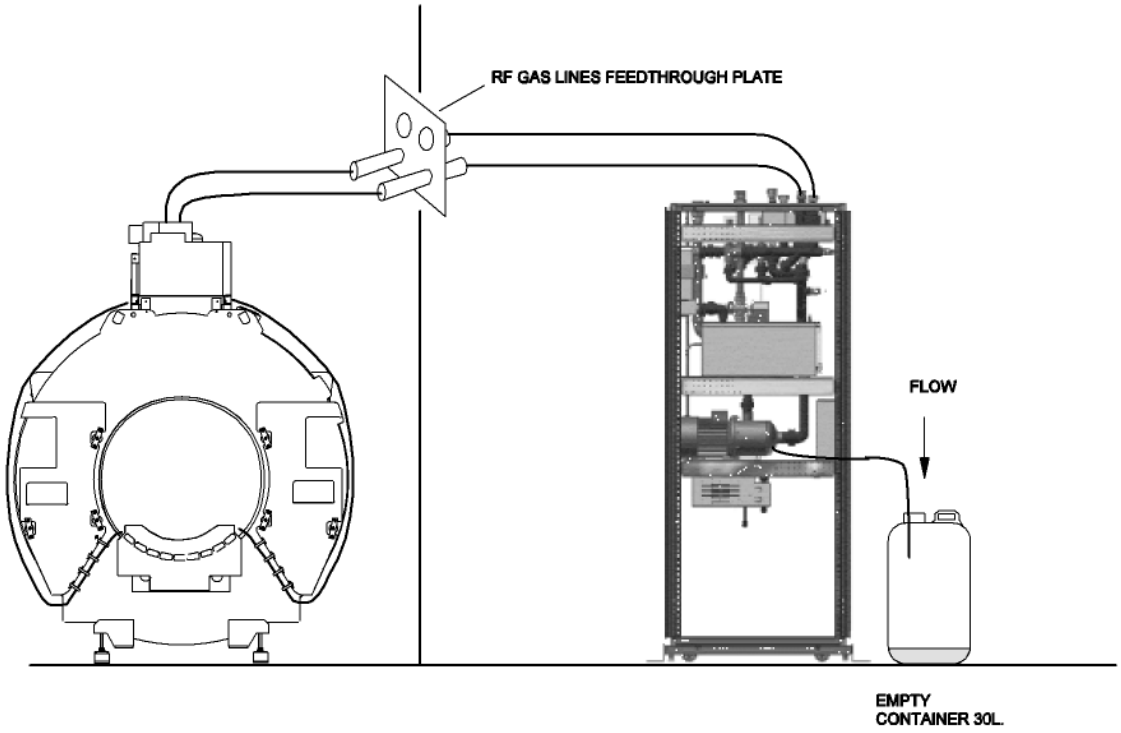
1. Switch OFF the pump by switching OFF F1. Keep the controller switched ON!
2. Close the valve of the return line from the required circuit, if only the LCC needs to be drained. If the secondary hoses needs to be disconnected the valve must be kept open, to allow draining of the coolant which is trapped in the hoses.

**Figure 21 – Location of the GC return valve**




1. Connect a drain hose to the drain valve of the motor of the required circuit and put the other end in the empty container.
2. Open the drain valve at the pump and drain the coolant into the container.
3. Close the pump drain valve.

**Figure 22 – The drain setup**

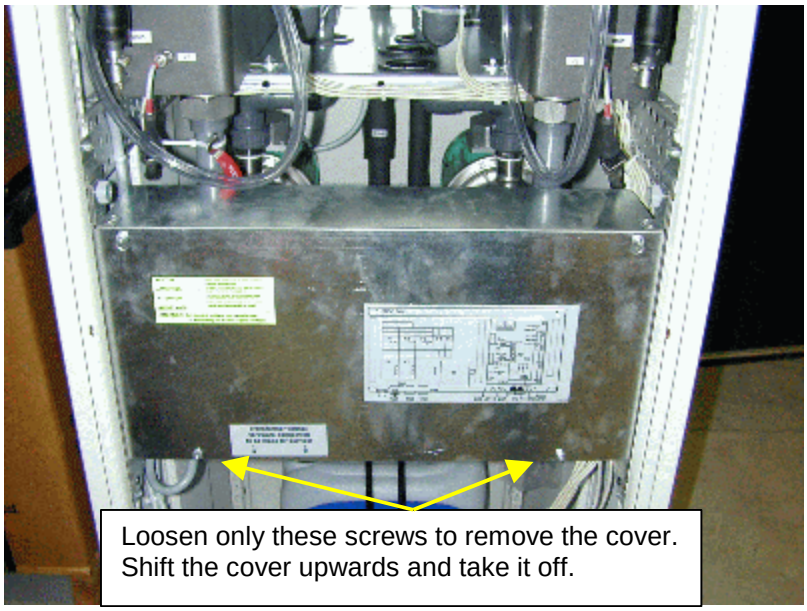



For filling the LCC circuit, refer to the Installation manual paragraph 7 ‘Setting the LCC to work’.

## 6.3 THE PUMP

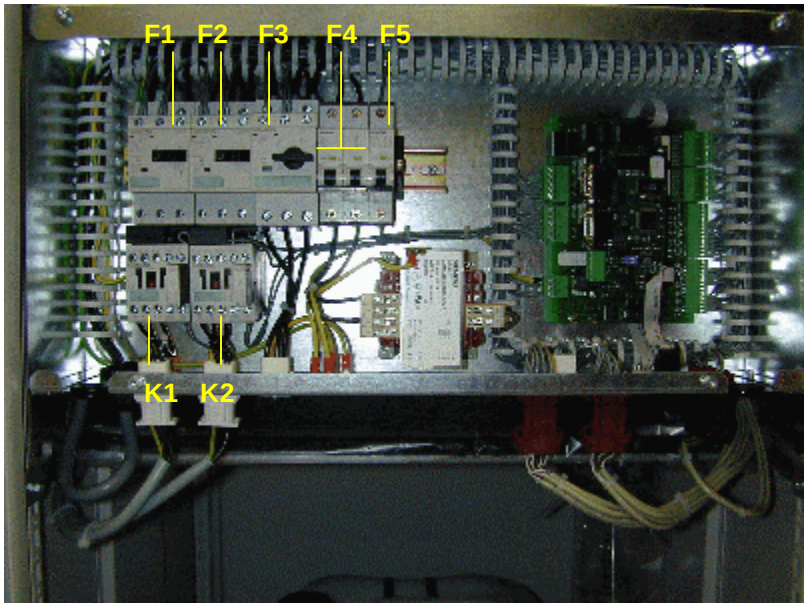
1. Remove the front cover of the LCC cabinet.
2. Remove the front plate of the control box by loosening only the screws at the bottom side.

**Figure 23 - LCC front side**



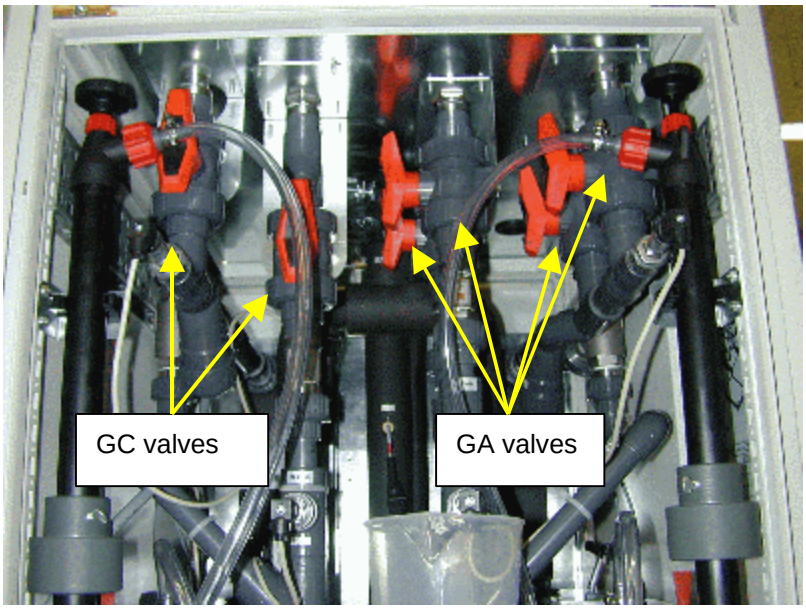

3. Switch OFF the controller by switching OFF F4 and F5.
4. Switch OFF the pumps by switching OFF F1 and F2.

**Figure 24 - Location of the switches**



5. Close the ball valves at the top of the cabinet. See Figure 25.

**Figure 25 – The valves**




6. Loosen the two knurled knobs on top of the control box by 3 turns and tilt the control box outwards until it rests upside down.
7. Protect the connectors from ingress with water by placing a plastic foil (see next picture) over the connectors and empty the circuit via the draining valve at the pump using the appropriate containers.

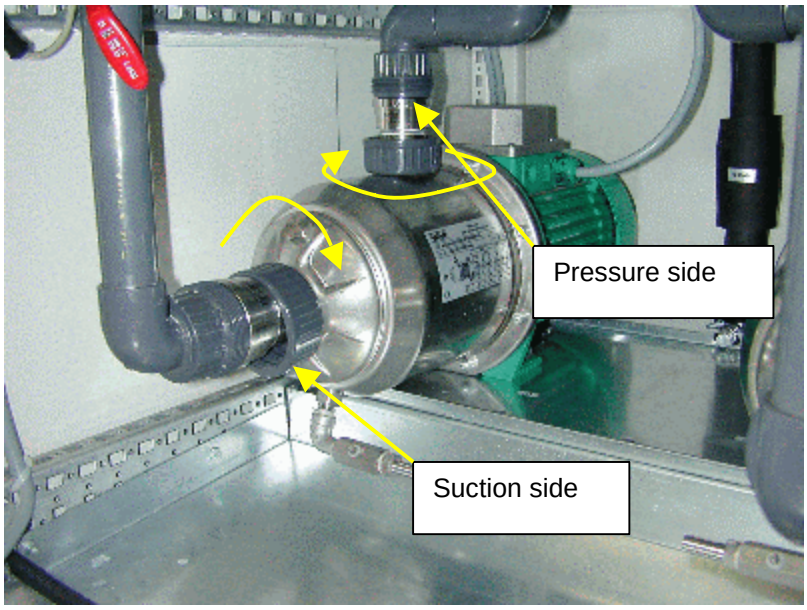
**Figure 26 - The plastic cover**


**Note**

**Do not mix the GC and GA coolants.**

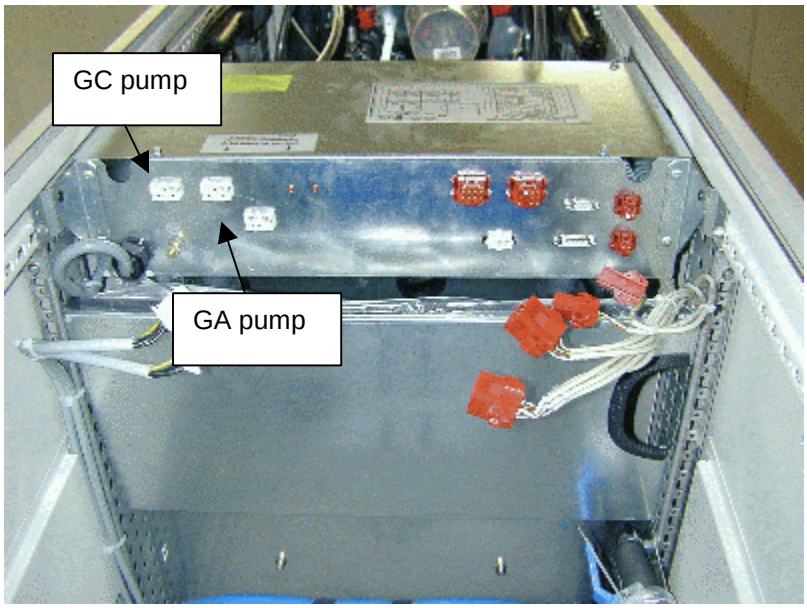
8. Unscrew the fittings on the suction and on the pressure side.

**Figure 27 - Pump fittings**




9. Disconnect the cable of the pump at the control box.

**Figure 28 - Electrical pump connections**




10. Cut the tie-wraps that fixate the cable of the pump to the cabinet

11. Unscrew the bolt that holds the pump to the bottom plate, using a 13mm wrench.

**Figure 29 - Unscrew the bolt**

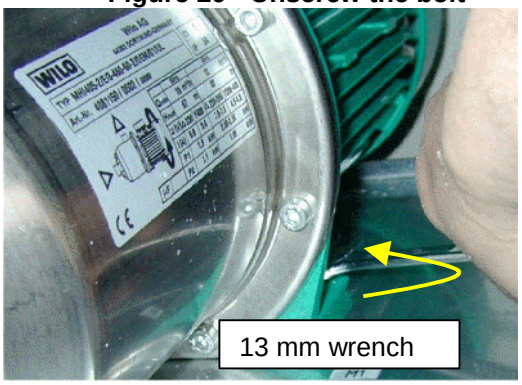
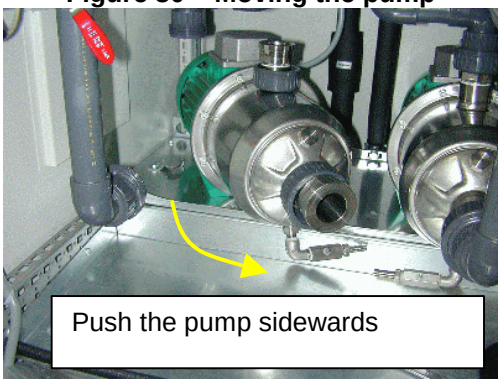



**Figure 30 – Moving the pump**




12. Push the pump sideward to release it (GC to the left, GA to the right) and remove the pump.

**Note**

**The pump weighs 13 kg.**

The new unassembled drain valve and Teflon tape are delivered with each pump.

**Figure 31 – The valve parts and Teflon tape**

For installing the drain valve on the pump follow the instructions showing on the pictures.

13. Install the drain valve including the elbow on the new pump using the Teflon tape supplied to seal the interface. The Teflon tape must be applied along thread of the connection.

**Figure 32 – The valve parts**

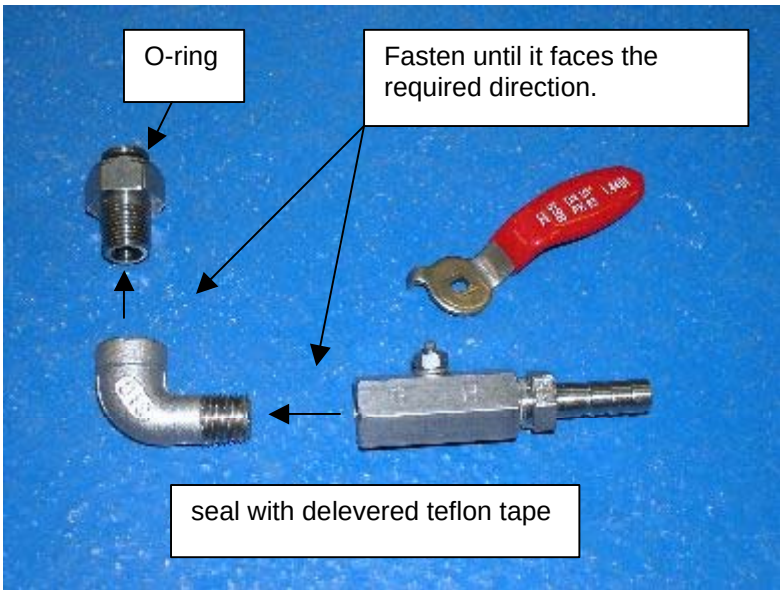
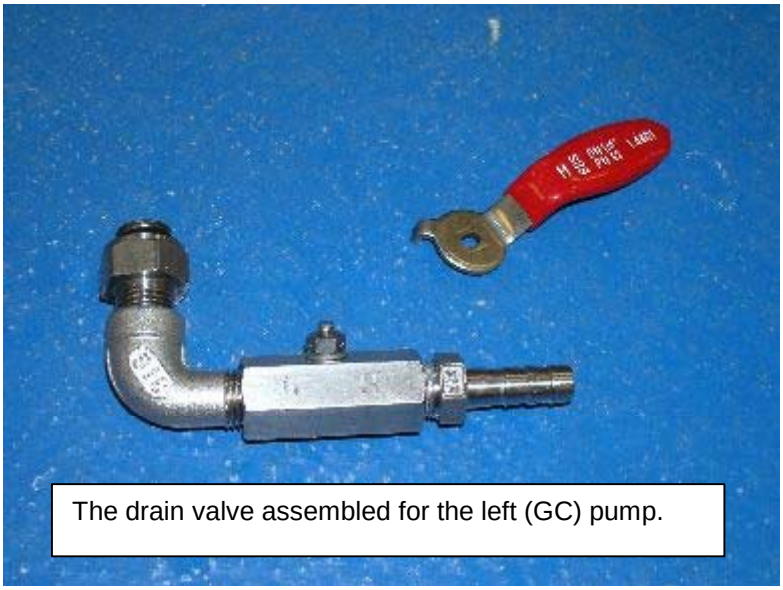


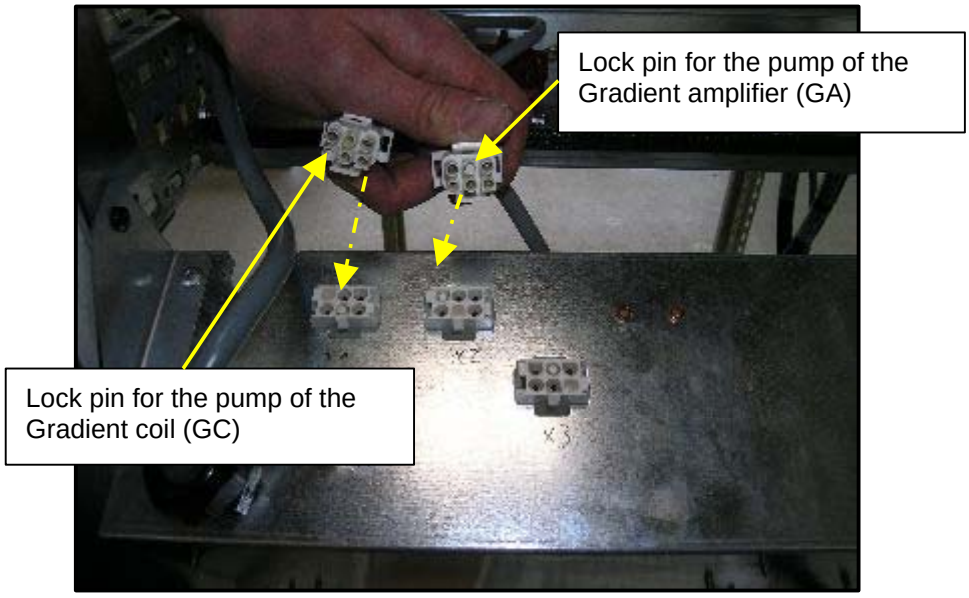

**Figure 33 – The assembled valve**




14. Ensure that the O-rings are installed at the suction and pressure side of the pump.

15. Place the lock pin in the left position of second line of the plug when the pump of the Gradient Coil circuit is replaced. Install the lock pin in the first line in the middle, when replacing the pump in the Gradient Amplifier circuit. See Figure 34.
16. Install the pump following the instructions in reverse order.

**Figure 34 – Install the lock pins in the connector**




17. Switch ON the controller by switching ON F4 and F5.

**CAUTION**

*DO NOT YET RUN THE REPLACED PUMP, until the affected circuit has been filled properly!*

_____

18. Continue depending of which pump has been replaced with:
    - 4.5 LCC Reset hour counter GA pump
    - 4.6 LCC Reset hour counter GC pump

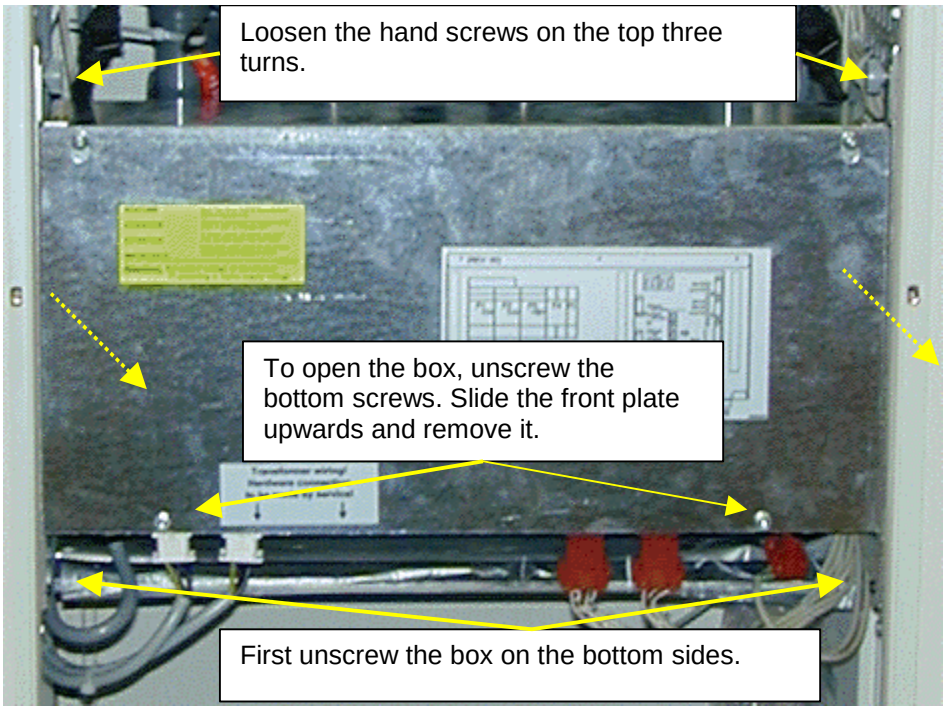
19. After resetting the hour counter continue with filling of the affected circuit.
    - 3.5 Filling the gradient coil cooling circuit
    - 3.7 Filling the gradient amplifier cooling circuit

## 6.4 THE CONTROL BOX

The control box is one FRU.

1. Switch OFF the mains power to the LCC in the mains distribution unit.
2. Remove the LCC cabinet front cover.
3. Disconnect all connectors.
4. First unscrew the box on the bottom sides.
5. Loosen the hand screws on the top three turns.

**Figure 35 - The control box**



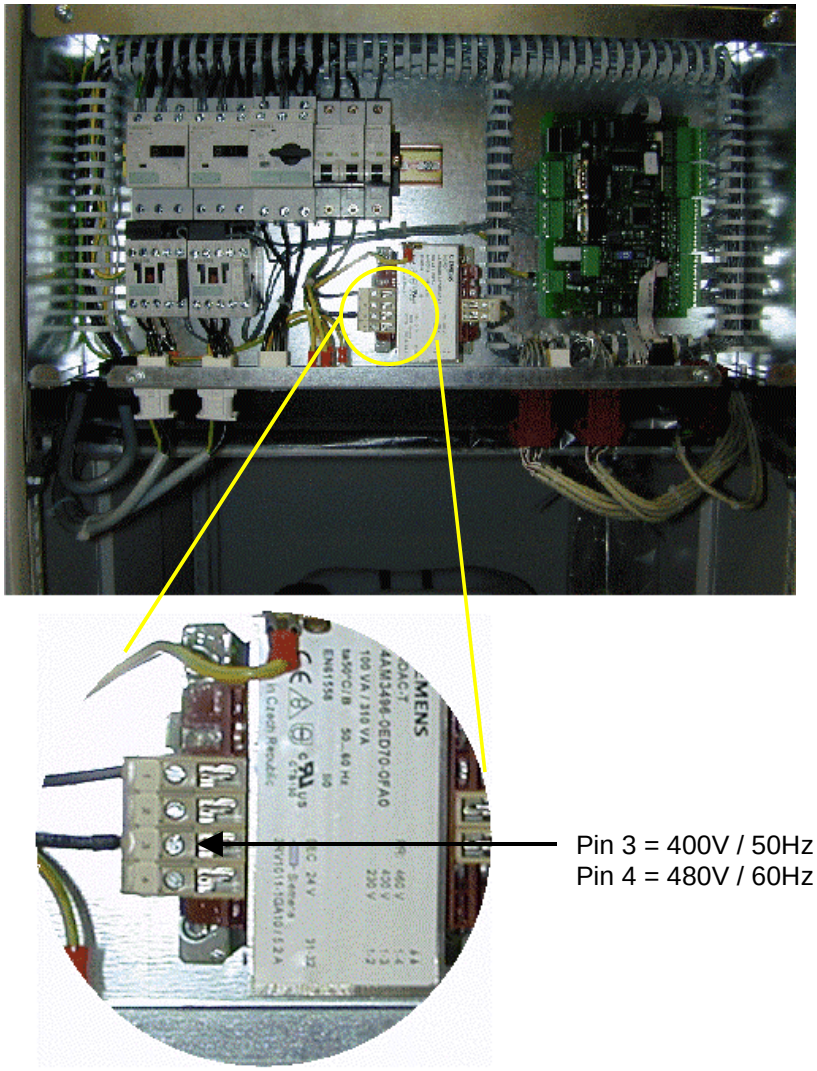

6. Remove the control box and install a new unit.
7. Connect all connectors.

**Note**

**There is only one way to connect the plugs because they have lock pins.**

8. Open the control box
9. Set the voltage programming. Next picture shows 400V / 50 Hz programming. For 480V / 60 Hz the wire must be moved from pin 3 to pin 4.

**Figure 36 - The opened control box**




10. Ensure that all switches are in ON position.
11. Switch on the mains power to the LCC in the mains distribution unit.
12. When the LCC is up and running, close the control box.
13. Install the LCC cabinet front cover.

Continue with:
4.2 LCC board test
And if required:
6.6 Firmware update

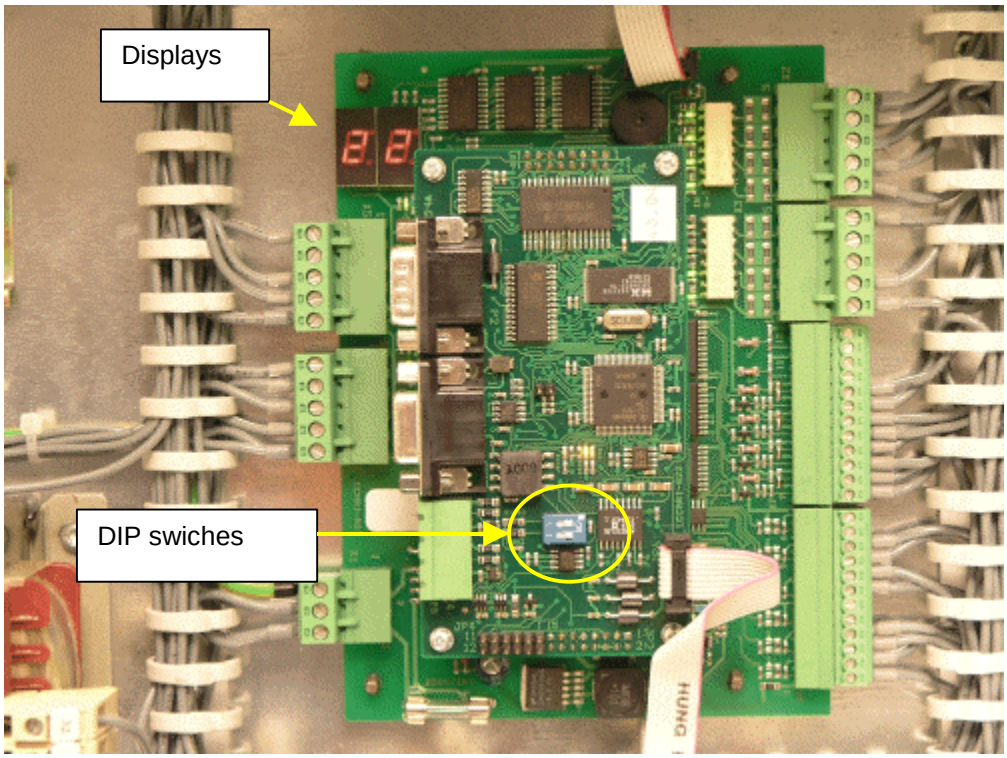
## 6.5 THE PRINTED CIRCUIT BOARD (PCB)

**ESD-P: Electro Static Discharge Protection required!**

**Take the right ESD precautions when working with electronic components.**

1. Remove the LCC cabinet front cover.
2. Open the control box
3. Switch OFF F4 (circuit breaker primary) and F5 (circuit breaker secondary).
4. Connect an ESD-wrist band to your wrist and connect the clamp to the control box.
5. Disconnect the 7 plugs from the PCB.
6. Disconnect the flat communication cables.
7. Squeeze the mounting nuts with flat pliers.
8. Remove the PCB from the back plate of the control box.
9. Install the new PCB.
10. Make sure that the decimal display is located at the top.
11. Connect all plugs and the two flat cables to the PCB.
12. Ensure that the dip switches on the PCB are in the ON position.
13. Switch ON F4 (circuit breaker primary) and F5 (circuit breaker secondary).
14. When the LCC is up and running, close the control box.
15. Install the LCC cabinet front cover.

**Figure 37 – The PCB**




Continue with:

4.2 LCC board test

And if required:

6.6 Firmware update

## 6.6 FIRMWARE UPDATE

Required tools:

- Service laptop
- Cable: CC-X1 to service PC

Procedure:

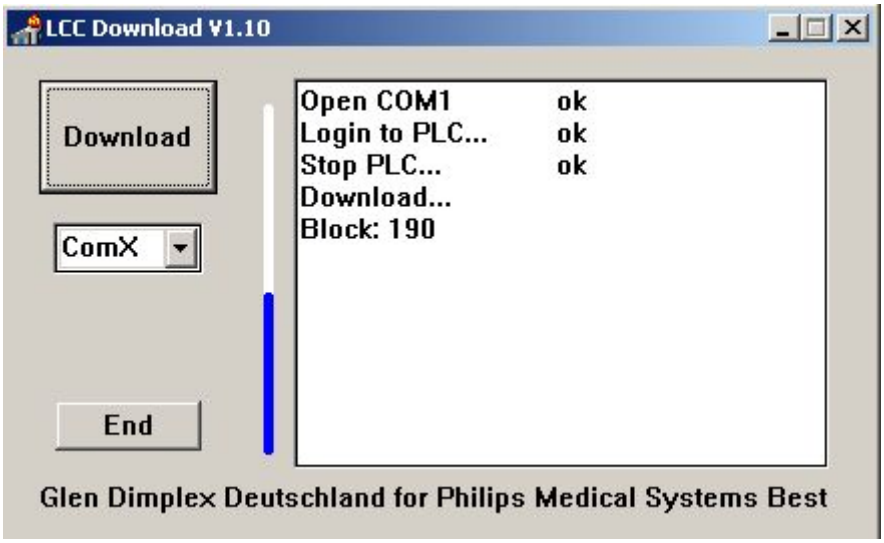
1. Download the LCC firmware update program from InCenter or a CD/DVD to the service laptop.
2. Unpack the ZIP-file in a convenient directory.
3. Next files will become available:
4. - Appl.bin
   - Lccdld.exe
   - Lccdld.ini
5. Disconnect cable CC-X01 from the LCC electronic box. Notice that the gradient axis amplifiers will shut down and the OK LED at the GCI I/O board (DGB) will be off.
6. Connect the serial port of the service laptop directly to CC-X01 of the LCC by a RS232 cable.
7. If there is not yet a cable available in the measurement accessories, a cable must be arranged local. (sub D 9 male / female all 9 pins 1 to 1 will do the job).

Cable: CC-X1 to service PC

| Label | Serial port PC | CC-X1 |
|---|---|---|
| Connectors<br>Terminations<br>Connections | D-Shell, 9 positions<br>Socket (Female)<br>Position **1** GND<br>Position **2** TX<br>Position **3** RX<br>Position **5** GND<br>Position **8** FAULTN<br>Position **9** FAULT_ENABLEN | D-Shell, 9 positions<br>Pin (Male)<br>Position **1** GND<br>Position **2** TX<br>Position **3** RX<br>Position **5** GND<br>Position **8** FAULTN<br>Position **9** FAULT_ENABLEN |

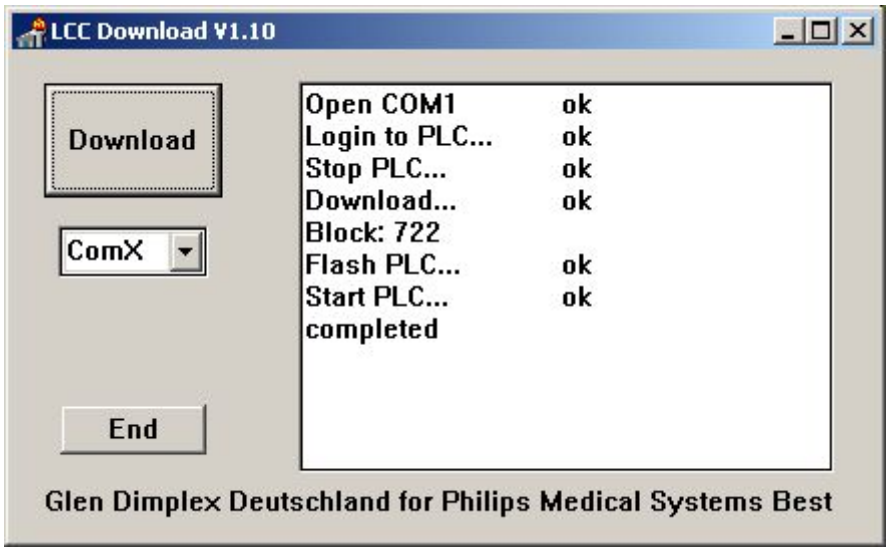
8. Startup Lccdld.exe
9. The window as shown in Figure 38 starts up.
10. Press the download button.
11. A blue process bar will become visible and the white screen in the window displays the performed actions.

**Figure 38 – Download screen in progress**



12. When the last line says ‘completed’, press the ‘end’ button to exit the program.

**Figure 39- Download screen completed**

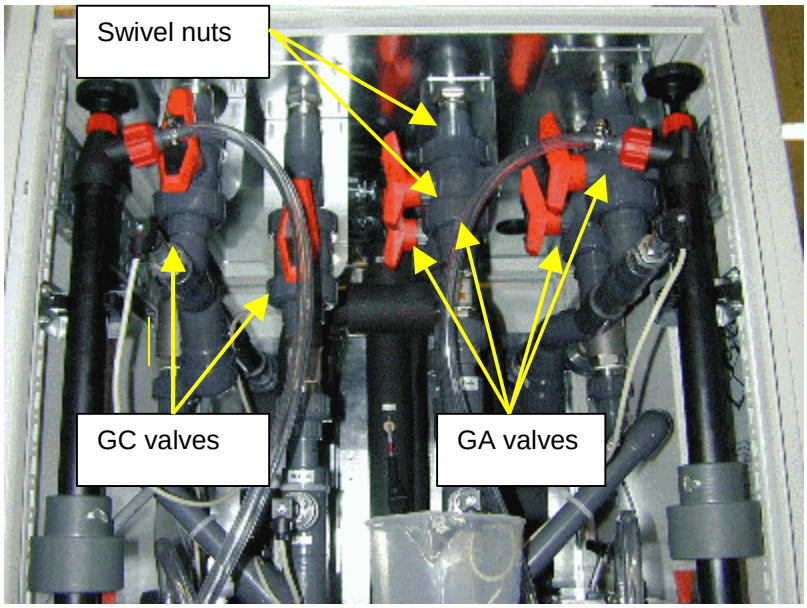



13. Disconnect the RS232 cable.
14. Connect cable CC-X1 coming from DGB-X11 (GCI in the gradient amplifier) to connector CC-X1
15. The gradient axis amplifiers will be powered on at next scan or test.

## 6.7 THE SHUT-OFF SUPPLY AND RETURN VALVE OF THE SECONDARY CIRCUIT

1. Remove the LCC cabinet front cover.
2. Switch OFF the mains power to the LCC in the mains distribution unit.
3. Drain the affected circuit.
4. Loosen the swivel nuts on both sides of the affected valve.
5. Unscrew the two bolts to release the valve from the bracket. Replace the valve.

**Figure 40 – Shut-off valves**




6. Ensure that the seals are between the couplings.
7. Tighten the swivel nuts.
8. Fasten the valve to the bracket with the two bolts.
9. Fill the circuit.
10. Check for leaks.
11. Switch ON the mains power to the LCC in the mains distribution unit.
12. Install the LCC cabinet front cover.

## 6.8 THE PRESSURE SENSORS

1. Remove the LCC cabinet front cover.
2. Switch OFF the mains power to the LCC in the mains distribution unit.
3. Drain the affected circuit.
4. Disconnect the connector from the affected sensor.

**Figure 41 - Unscrew the connector**

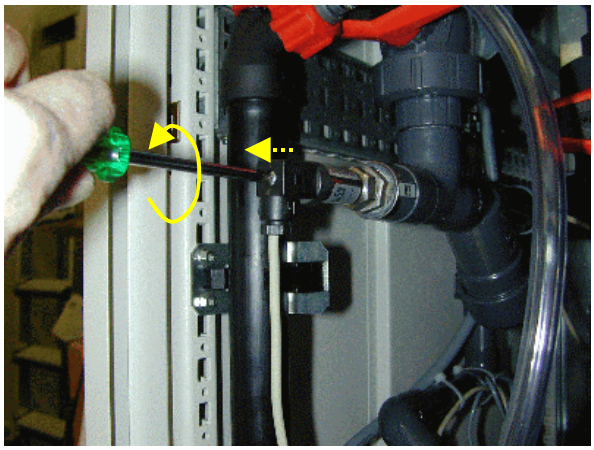
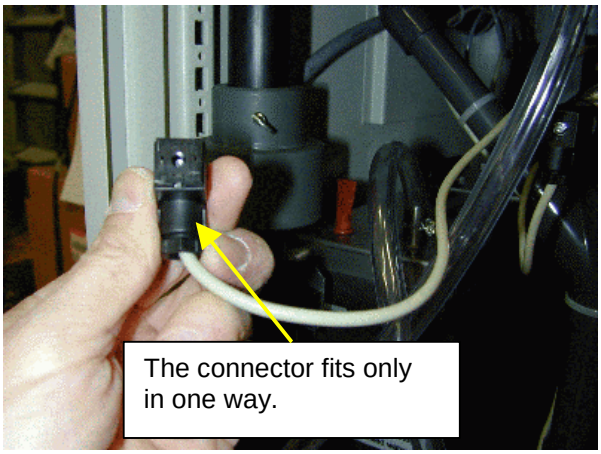
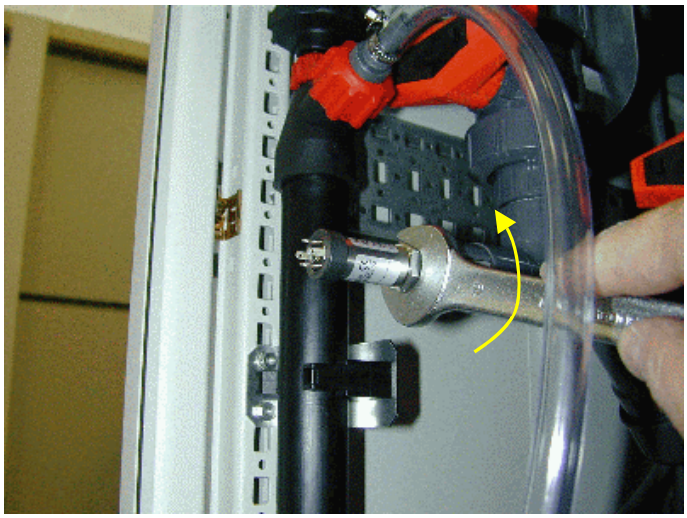


**Figure 42 - The connector**




5. Unscrew the affected sensor using a wrench, size 19.

**Figure 43 - Unscrewing the pressure sensor**



6. Replace the defect sensor with a new one. Put the new O-ring over the threaded end of the sensor.
7. Install the new sensor by hand.
8. Subsequently tighten the sensor with a wrench to a maximum 1 complete turn.

**CAUTION**

**Avoid damaging the PVC threading. Apply only minimum force on the wrench.**

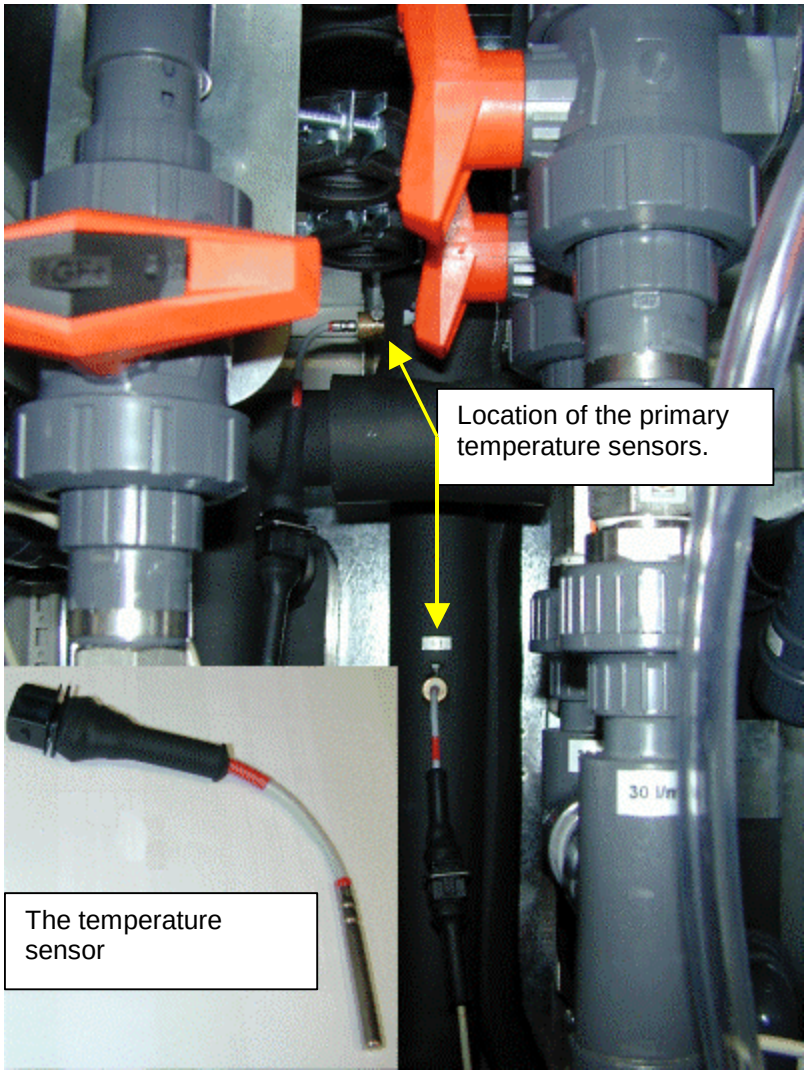
9. Connect the connector to the sensor and fasten the screw. Notice that the connector contacts have different sizes, therefore it fits only in one way. If required, the connector of the sensor can be rotated slightly.

10. Fill the circuit.
11. Check for leaks.
12. Switch ON the mains power to the LCC in the mains distribution unit.

## 6.9 THE TEMPERATURE SENSORS IN PRIMARY CIRCUIT

1. Remove the LCC cabinet front cover.
2. Switch OFF the mains power to the LCC in the mains distribution unit.
3. You don't need to drain the primary circuit because the sensor is inserted into a closed chamber in the plumbing.
4. Disconnect the connector of the sensor (do not loose the seal) and release locking screw with a wrench size 7.

**Figure 44 - The primary temerature sensors**



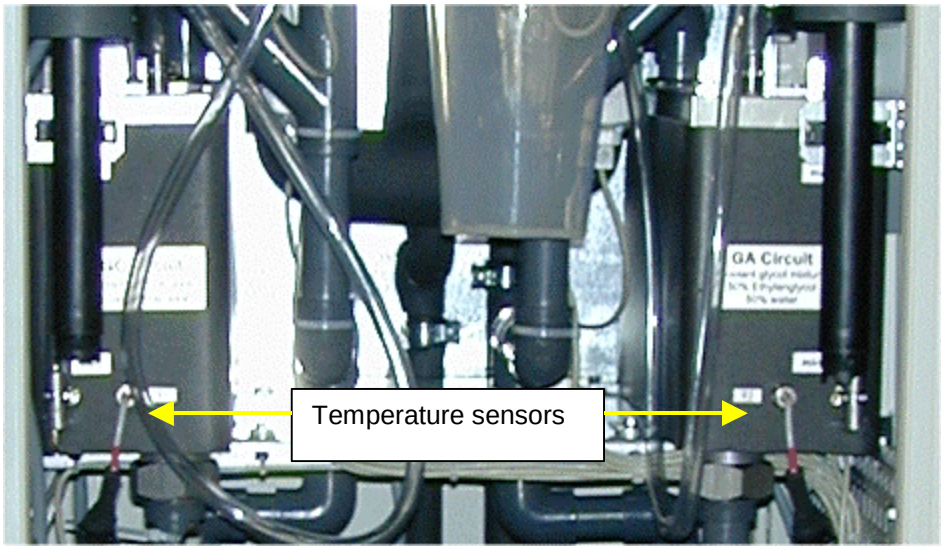

5. Pull out the sensor and put in a new.
6. Push in the sensors as far as it will go. Fasten the locking screw hand tight.
7. Connect the connector to the cable and ensure that the seal is still in. The connector fits only in one way.
8. Switch ON the mains power to the LCC in the mains distribution unit.
9. Install the LCC cabinet front cover.

## 6.10 THE TEMPERATURE SENSORS OF SECONDARY CIRCUITS

The temperature sensors of the secondary circuits are inserted through the tank wall into the coolant.

1. Remove the LCC cabinet front cover.
2. Switch OFF the mains power to the LCC in the mains distribution unit.

**Figure 45- locations of the temperature sensors**




3. Drain the affected circuit.
4. Disconnect the sensor connector from the cable.
5. Unscrew the nut. (See next figure.)
6. Pull out the temperature sensor.

**Figure 46 – Installed temperature sensor**

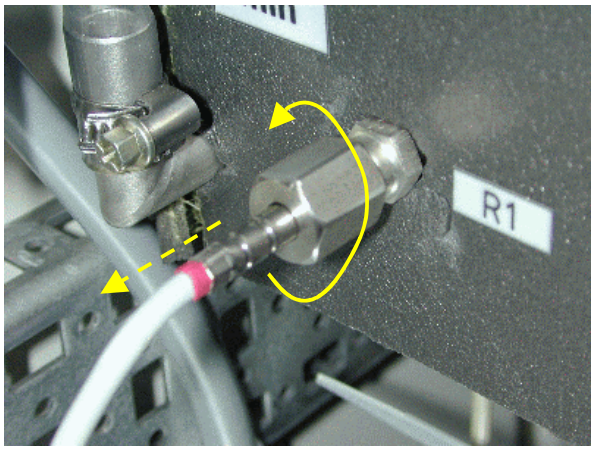
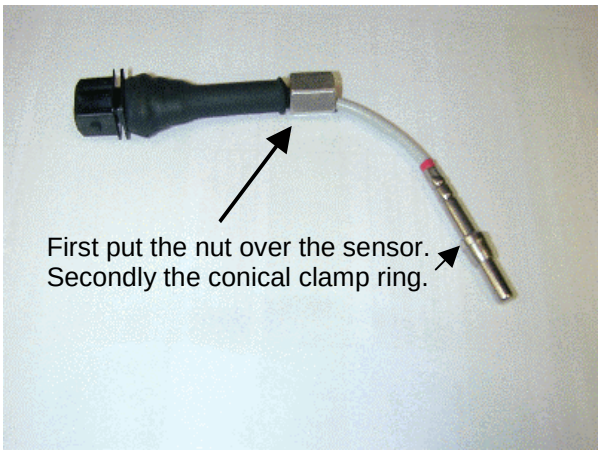



**Figure 47 – The temperature sensor**

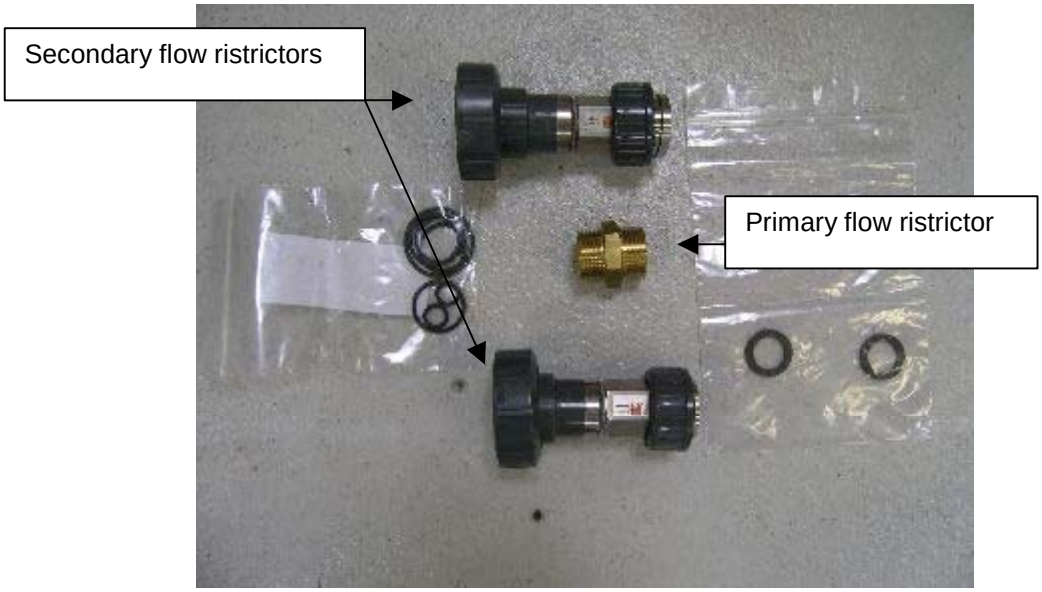



7. Put the new nut and new conical clamp ring over the new sensor.
8. Insert the sensor as shown in above figure and fasten the nut.
9. Fill the tank.
10. Check for leaks.
11. Switch ON the mains power to the LCC in the mains distribution unit.

12. Install the LCC cabinet front cover.

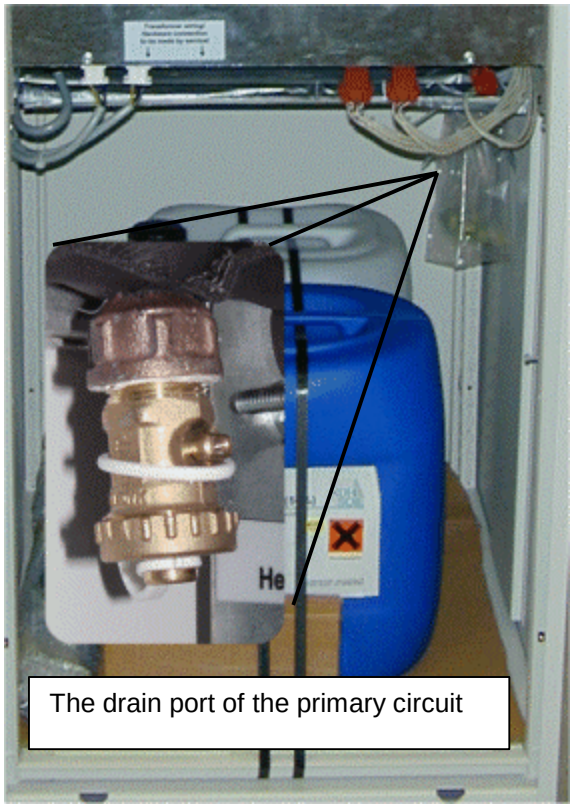
## 6.11 THE FLOW RESTRICTOR IN PRIMARY CIRCUIT

**Figure 48 - flow restrictors as FRU**



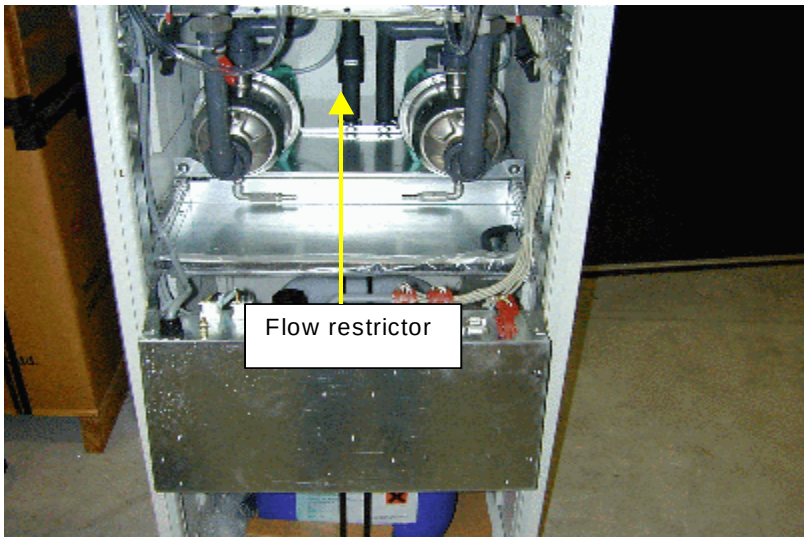

1. Remove the LCC cabinet front cover.
2. Switch OFF the mains power to the LCC in the mains distribution unit.
3. Close the supply and return of primary circuit at the hospital side.
4. Close the ball valves and drain the primary circuit.

**Figure 49- The primary drain port**



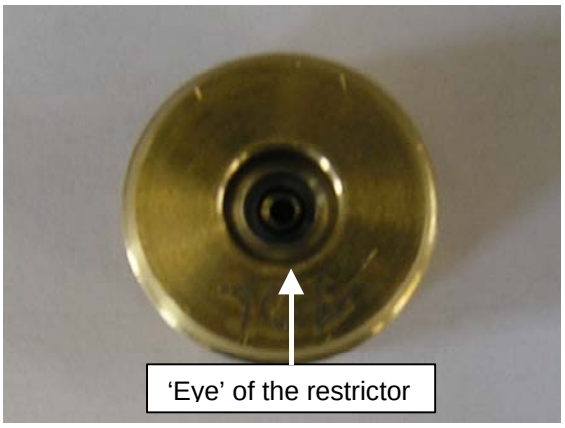

5. Release the control box by loosening the two hand screws and tilt it forward to gain better access to the flow restrictor.

**Figure 50 - Location of the flow restrictor**




6. Loosen the insulation gently.
7. Loosen the swivel nut on the top by holding the middle tight with a wrench size 36.
8. Screw off the restrictor of the middle fitting and take out the flow restrictor.
9. Put in a new flow restrictor, such way that the ‘eye’ of the restrictor is at the top (the star is at the bottom).

**Figure 51 - The flow restrictor**




10. Install the reassembled fitting, apply Teflon tape along the thread.
11. Glue the insulation back to the plumbing. (Get glue locally.)
12. Fill the circuit by opening the primary water / coolant supply and return at the hospital side.
13. Check for leaks.
14. Switch ON the mains power to the LCC in the mains distribution unit.
15. Install the LCC cabinet front cover.

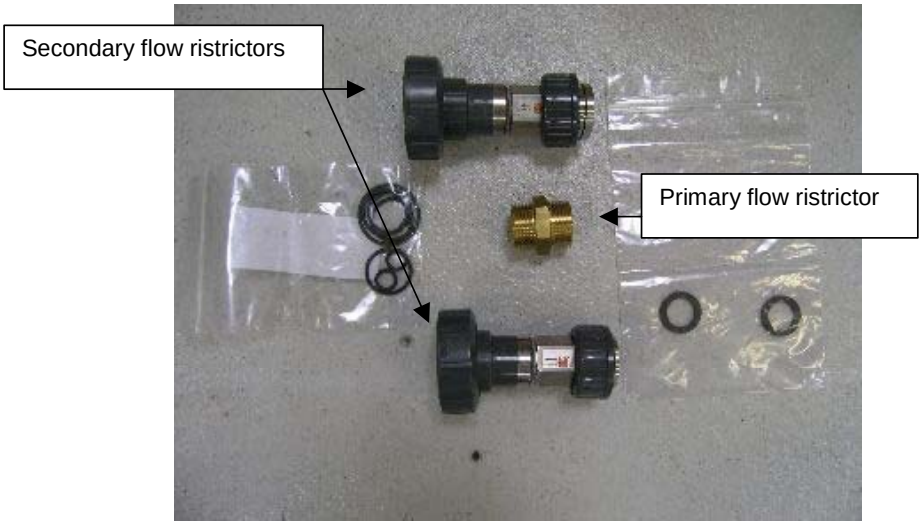
## 6.12 THE FLOW RESTRICTOR IN SECONDARY CIRCUIT

In the secondary circuits there are two types of flow restrictor used:

- 20 l/min is for the gradient coil circuit.
- 30 l/min is for each gradient amplifier loop.

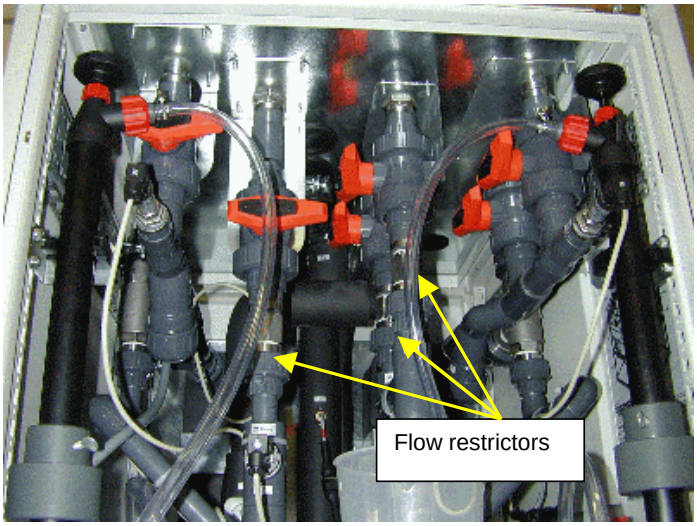
The arrow on the flow restrictor shows the direction of flow.

**Figure 52 – The flow restrictors FRU's**




1. Remove the LCC cabinet front cover.
2. Switch OFF the mains power to the LCC in the mains distribution unit.
3. Close the ball valves and drain the affected circuit.
4. Loose the swivel nut on both sides and remove the flow restrictor.

**Figure 53- The flow restrictors**




5. Loosen the valve above the flow restrictor, such that is can be moved slightly.
6. Install the new flow restrictor.
7. Fasten the valve to the bracket.
8. Fill the circuit.
9. Check for leaks.
10. Switch ON the mains power to the LCC in the mains distribution unit.

11. Install the LCC cabinet front cover.

## 6.13 THE 3-WAY-VALVE ACTUATOR

1. Remove the LCC cabinet front cover.
2. Switch OFF the mains power to the LCC in the mains distribution unit.
3. Turn the valve position knob counter clockwise until the mechanical stop.
4. Unscrew the knurled ring (turning the housing of the actuator helps to release the knurled ring).

**Figure 54 - The actuator**

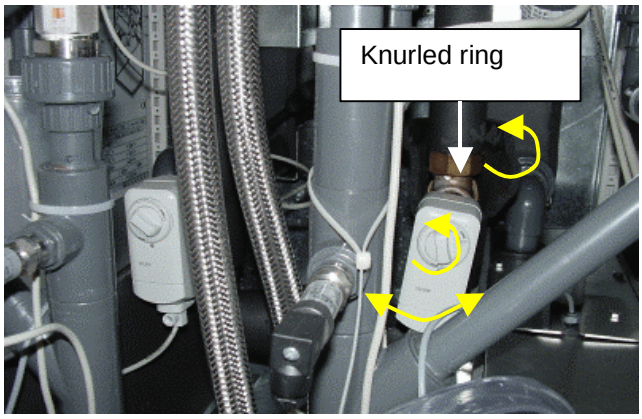
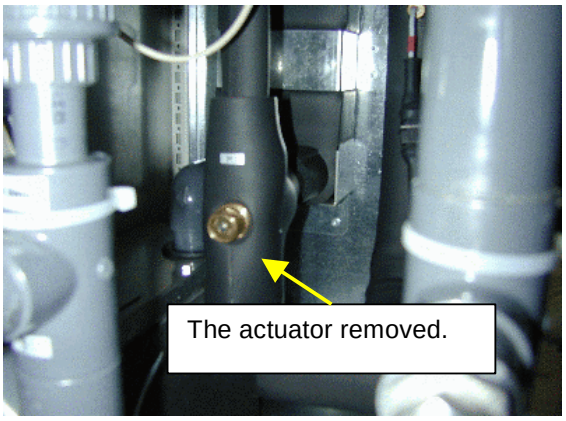
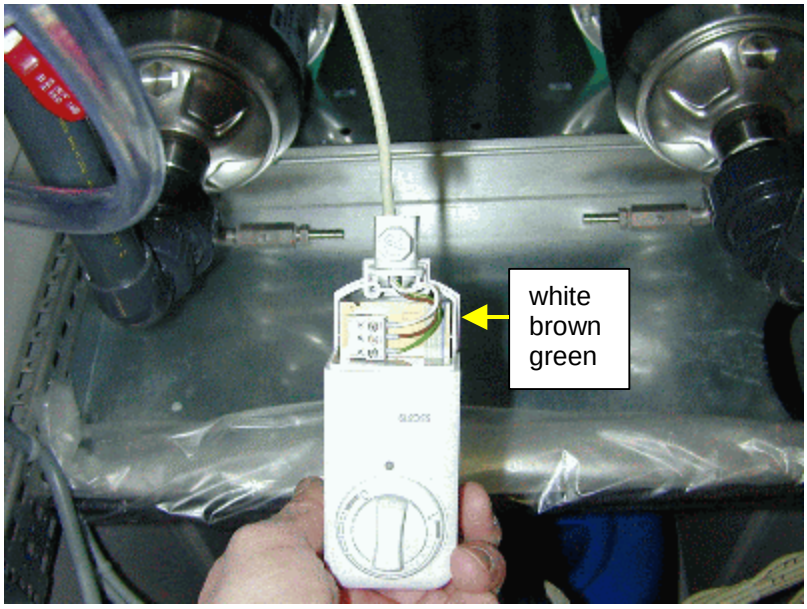



**Figure 55 - The valve visible**




5. Open the housing of the actuator and disconnect the cable. Mind the color connection of the wires. Connect the new actuator to the cable.

**Figure 56 - The wire connection**




6. Install the actuator at the 3-way-valve, by tightening the knurled ring.
7. Switch ON the mains power to the LCC in the mains distribution unit.
8. Install the LCC cabinet front cover.

## 6.14 THE LEVEL SWITCH

1. Remove the LCC cabinet front cover.
2. Switch OFF the mains power to the LCC in the mains distribution unit.
3. Unscrew the screws that hold the tank cover with level switch and take assembly from the tank.
4. Disconnect the level switch from the cable.
5. Unscrew the level switch from the cover.

**Figure 57 – The cover with level switch**

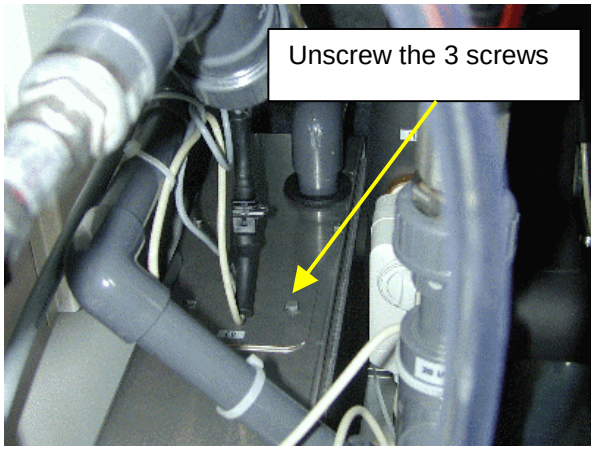
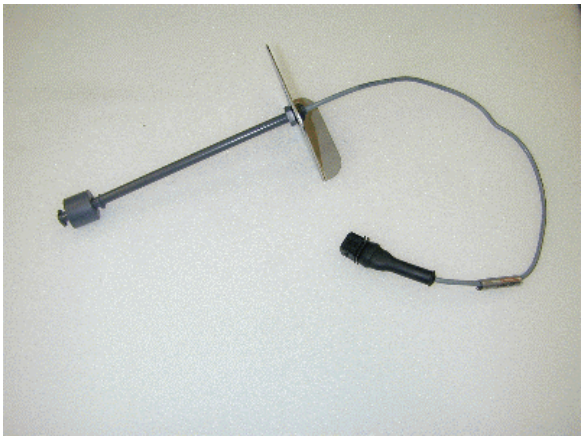



**Figure 58 – The level switch**

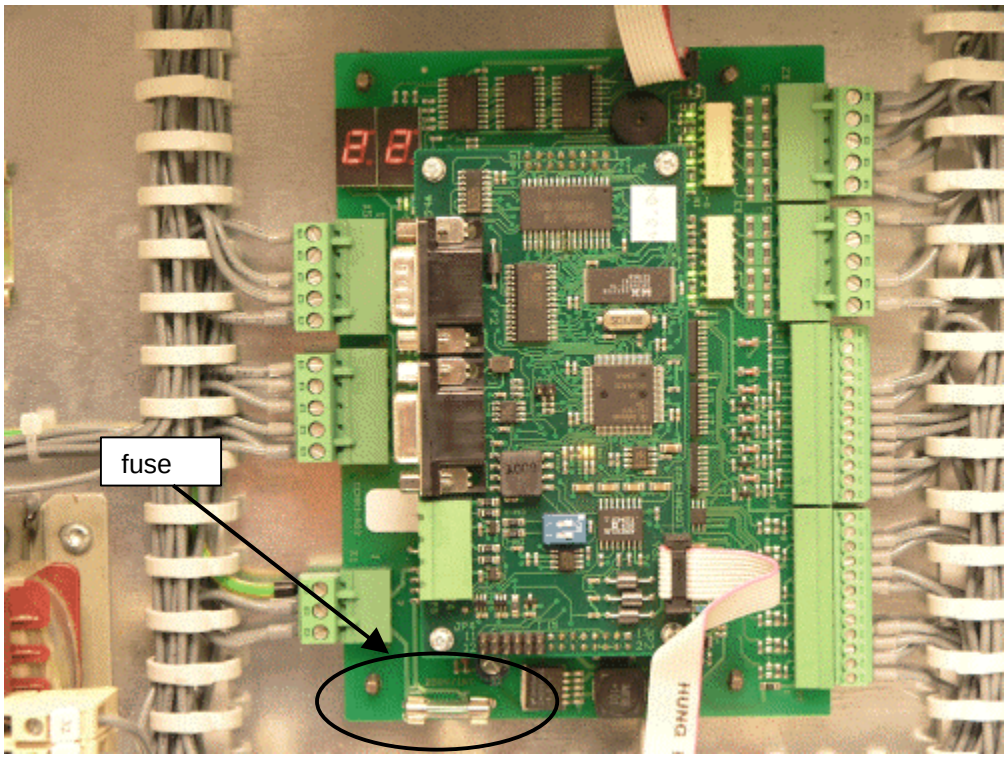


6. Install the new level switch in the cover.
7. Connect the new level switch to the cable.
8. Install the tank cover with new switch.
9. Switch ON the mains power to the LCC in the mains distribution unit.
10. Install the LCC cabinet front cover.

## 6.15 THE FUSE AT THE PCB

1. Remove the LCC cabinet front cover.
2. Open the control box
3. Switch off F5.
4. Replace the fuse. (1 A slow blow)

**Figure 59 - Location of the fuse**




5. Switch ON F5
6. When the LCC is up and running, close the control box.
7. Install the LCC cabinet front cover.

## 6.16 PRIMARY HOSES

1. Shut off the external shut-off valves.
2. Remove the LCC cabinet front cover.
3. Open the control box.
4. Switch off F4 (circuit breaker primary) and F5 (circuit breaker secondary).
5. Drain the primary circuit.
6. Disconnect the hose at the LCC and at the primary side. When the primary circuit is disconnected, water will drain from it.

## 6.17 GRADIENT COIL HOSES

1. Remove the LCC cabinet front cover.
2. Open the control box.
3. Switch off F4 (circuit breaker primary) and F5 (circuit breaker secondary).

4. Close the secondary gradient coil valve to the good hose, the one for the defective hose remains opened.
5. Drain the gradient coil circuit.
6. Disconnect the hose at the LCC and at the gradient coil. When the gradient is disconnected, water will drain from it.

**Note**

**The diameter of the hose is ¾ inch (19 mm) and the length 15 meters.**

7. Connect the new hose to the LCC and the gradient coil.
8. Fill the gradient coil circuit.
9. Open the secondary valves.
10. Switch on F4 (circuit breaker primary) and F5 (circuit breaker secondary).
11. Close the control box.
12. Install the LCC front cover.

## 6.18 GRADIENT AMPLIFIER HOSES

1. Remove the LCC cabinet front cover.
2. Open the control box.
3. Switch off F4 (circuit breaker primary) and F5 (circuit breaker secondary).
4. Close the secondary valves except the one for the defective hose.
5. Drain the gradient amplifier circuit.
6. Disconnect the self sealing quick connect of the affected hose from the gradient amplifier.
7. Disconnect the affected hose from the LCC.

**Note**

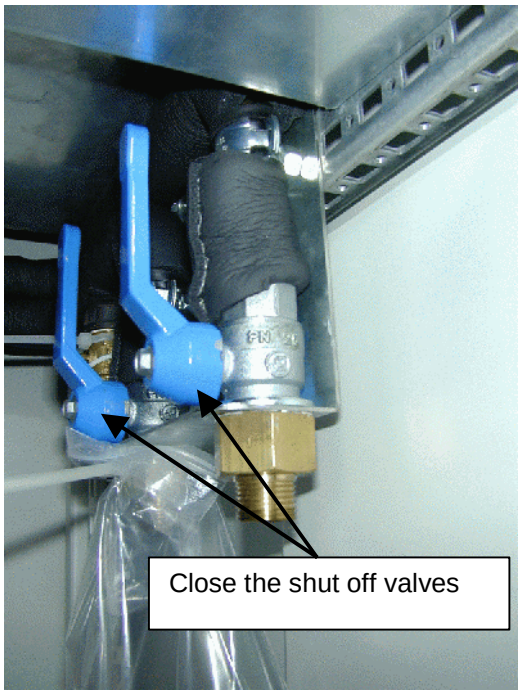
**The diameter of the hose is ¾ inch (19 mm) and the length 5 meters.**

8. Push open the quick connect with a blunt tool and drain the coolant from the hose.
9. Connect the new hose to the LCC and to the gradient amplifier.
10. Fill the gradient coil circuit.
11. Open the secondary valves.
12. Switch on F4 (circuit breaker primary) and F5 (circuit breaker secondary).
13. Close the control box.
14. Install the LCC front cover.

## 6.19 REPLACING THE HOSES TO THE COMPRESSOR

1. Remove the LCC cabinet front cover.
2. Switch off the compressor.
3. Install the ramps and roll the compressor out of the LCC.
4. Close the shut off valves of the primary circuit.

**Figure 60 - The compressor water connection**




5. Disconnect the affected hose from the compressor. Coolant will drain from the hose and compressor.
6. Disconnect the other end of the hose from the valve connection.

**Note**

**The diameter of the hose is ½ inch (12 mm).**

7. Connect the new hose to the compressor and the valve.
8. Roll the compressor into the LCC and remove the ramps.
9. Open the ball valves.
10. Switch on the compressor.
11. Install the LCC front cover.

## 6.20 REPLACING THE FLEXIBLE HELIUM GAS LINE FOR APD COMPRESSOR

The SUPPLY line is marked red and RETURN line is marked green.
The minimum bend radius is 460 mm.

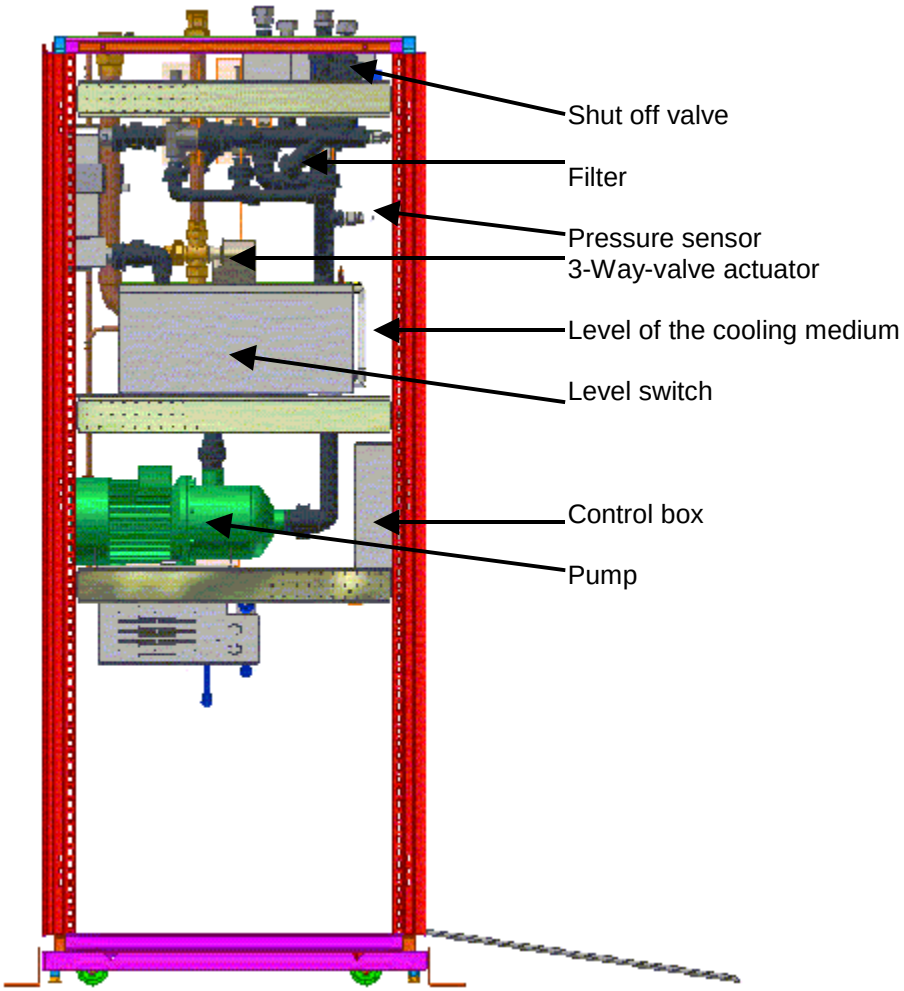
1. Remove the LCC cabinet front cover.
2. Switch off the compressor.
3. Install the ramps and roll the compressor out of the LCC.
4. Release the stain relief inside the LCC of the affected gas line.
5. Disconnect the self sealing gas line connections.

6. Replace the affected gas line.
7. Connect the gas line to the compressor and to the gas line on top of the LCC.

## 6.21 THE SEALS

1. Remove the LCC cabinet front cover.
2. Open the control box
3. Switch OFF F4 (circuit breaker primary) and F5 (circuit breaker secondary).
4. Drain the affected circuit.
5. Unscrew the affected connection and exchange the seal.
6. Reconnect the connection hand tight.
7. Fill the affected circuit.
8. Check for leaks.
9. Switch ON F4 (circuit breaker primary) and F5 (circuit breaker secondary).
10. When the LCC is up and running, close the control box.
11. Install the LCC cabinet front cover.

**Figure 61 - Over view of the LCC components**



## Gaskets

1x Primary circuit screw connection shut off valve

2x Tank
1x Primary circuit water inlet
1x Primary circuit water outlet

2x Level switch

1x Primary circuit helium compressor shut off valve

4x Plate heat exchanger primary circuit
2x Primary circuit helium compressor inlet flow limiter
6x GA I + GA II + GC

7x 3-way-valve

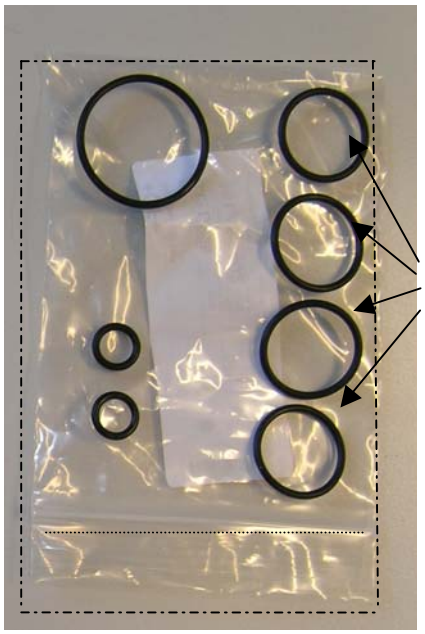
## O-Rings

2x Pump outlet
4x Plate heat exchanger
secondary circuit

2x Overflow valve
2x Filter
2x Flow limiter GA + GC

2x Pump inlet
2x Overflow valve

4x pressure sensor
2x pump draining valve



1x Shut off valve
Secondary circuit

## 6.22 THE LOW FLOW SWITCH

**Figure 62 – The flow switch location**

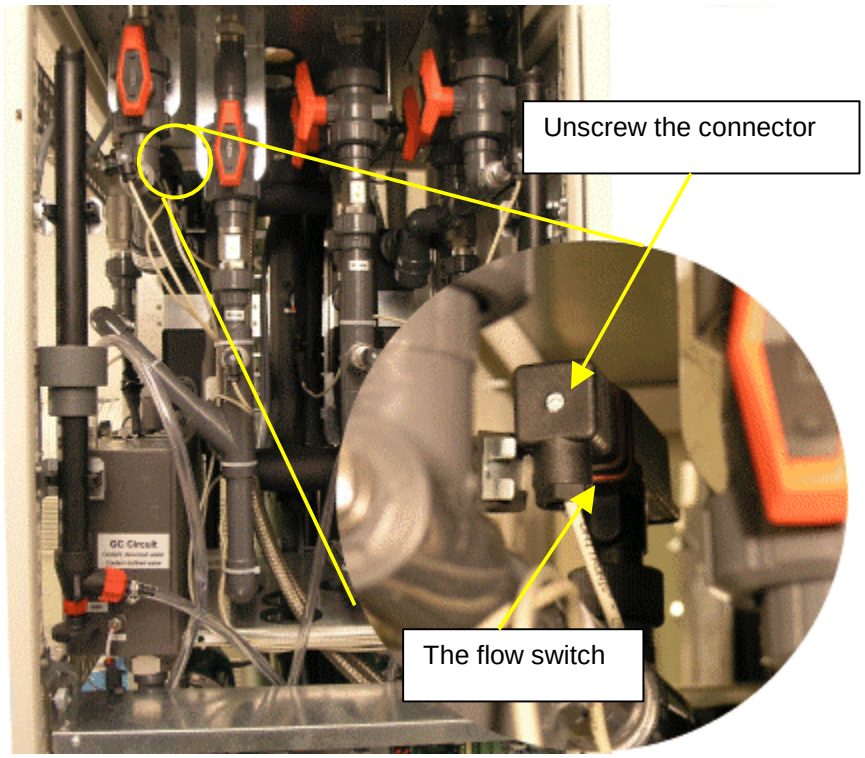
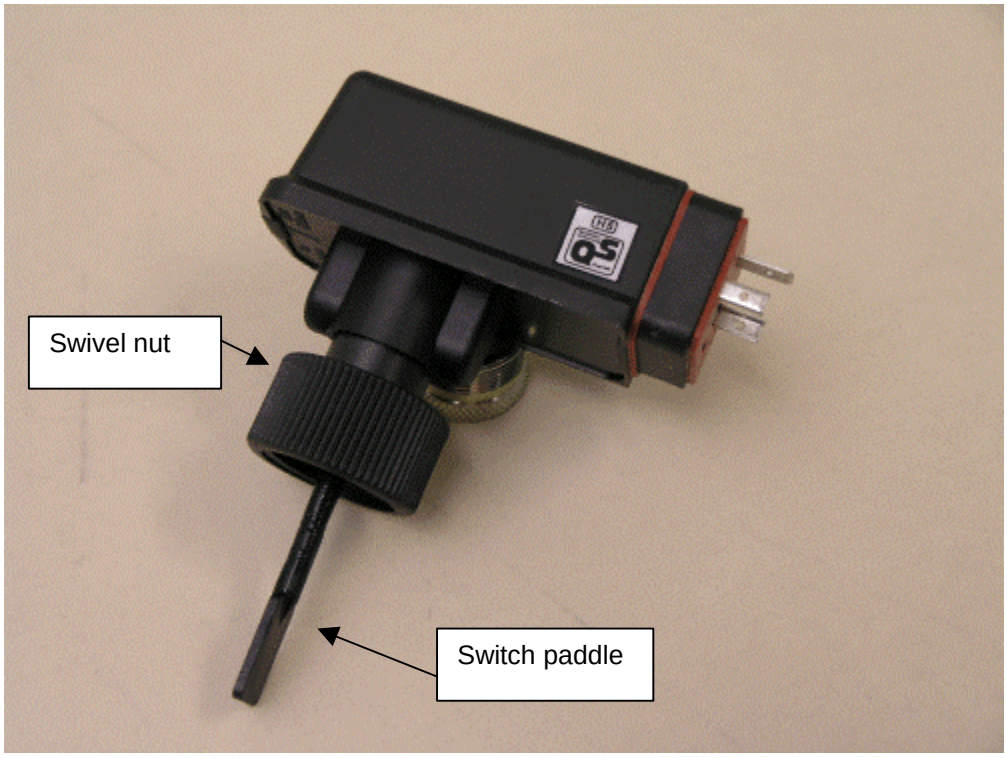


**Figure 63 – The flow switch**




Refer to Figure 62 and Figure 63 for next procedure:

1. Switch off the GC pump by switching off F1 in the electronics box.
2. Close the two GC shut off valves at the top of the LCC.
3. Hold a cup under the flow switch.
4. Unscrew the connector and pull it from the flow switch.
5. Unscrew the swivel nut and remove the defective flow switch.
6. Insert the new flow switch.
7. Ensure that the arrow on the flow switch is in parallel to the axis of the pipe. The arrow also shows the flow direction.
8. Fasten the swivel nut hand tight.
9. Push the connector on the flow switch and fasten the screw.
10. Open the two GC shut off valves at the top of the LCC.
11. Switch on the GC pump by switching on F1 in the electronics box.

## 6.23 THE OVERFLOW VALVE

TBD

# 7 FAULT-FINDING PROCEDURES

***NOTE***

***Cable CC-X1 DGB-X11is disconnected at the CGI / gradient amplifier side:***
*The green OK LED at GCI I/0 board stays ON and gradient amplifier axis amplifiers stay power on. However a scan attempt or starting a test will result in a fault. In the log file next line will be visible: CDAS <DEVICE>: LCC Device has a hardware Error: No communication.*

***Cable CC-X1 DGB-X11is disconnected at the LCC side:***
*Gradient axis amplifiers do not power up and GCI I/O board OK LED is OFF.*

---

**CAUTION**

*Output signals of the temperature sensors and pressure sensors cannot be shorted for test purpose. Shorting these signals will result in a burned PCB in the electronics box within a couple of hours.*

---

| Fault | Cause | Repair suggestion |
|---|---|---|
| No communication with LCC | Cable CC-X1 DGB-X11 | Connect cable CC-X1 DGB-X11 |
| No communication with LCC | Bad contact at CC-X1, metric and USC treaded connection. (gradient axis amplifiers do not start up and GCI I/O board OK LED is OFF) | Connect cable CC-X1 DGB-X11 the other way around. The cable is one to one, but one side has metric screws and the other side has UNC screws. UNC screw must be at LCC side. |
| Level switch trips | Low level in the tank | Add coolant until the max indicator |
| Level switch trips | Turbulent coolant flow in tank | Ensure that the over flow valve is closed.<br>Ensure that the output valves are opened. |
| Level switch trips | Excessive foam build up in tank, could be caused by improper venting of the pump after filling. | Drain and refill the affected circuit. |
| High pressure at filter side | Debris in the filter | Clean filter |
| Low pressure at pump | Pump pressure tool low | Replace pump |
| Primary temp T1 > T2 | Primary input and out put hose wrong connected. | Correct primary water connection. |

If you have any addition or suggestion to help increasing this list, please contact me:
mailto:Frank.Bergmans@philips.com

# 8 SITING ISSUE, LCC INSTALLED UNDERNEATH THE MRI SCANNER

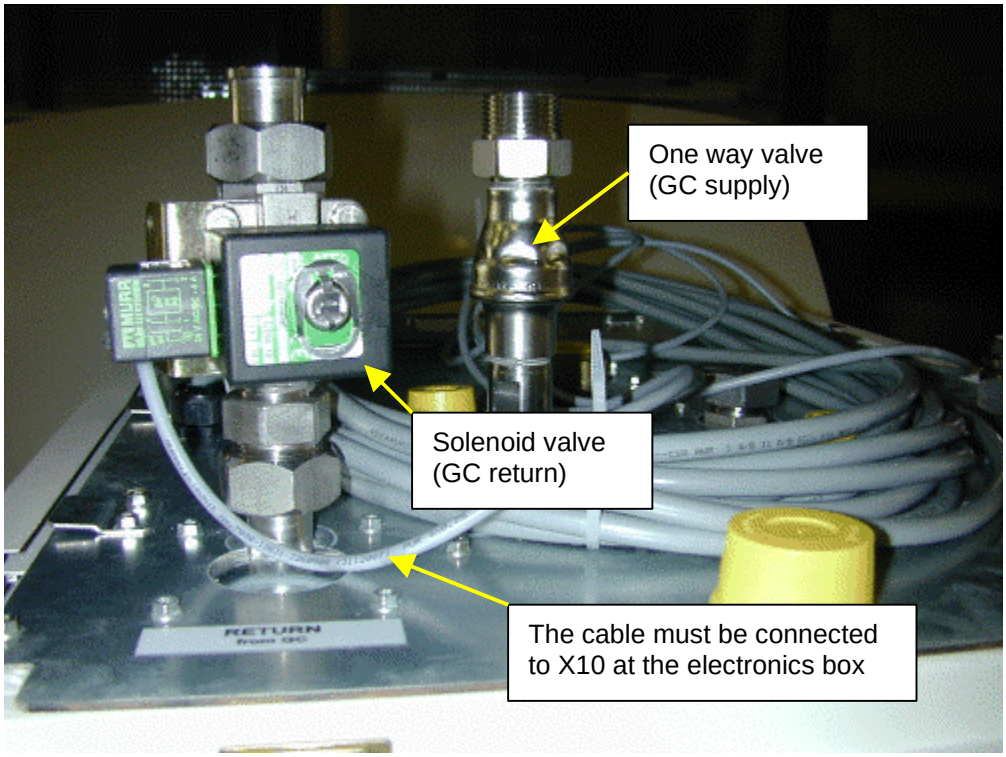
When the LCC is installed underneath the MRI scanner, the optional solenoid valve and one-way valve must be installed in the gradient coil loop, to avoid that the gradient coil circuit will drain through the LCC when the pump is stopped.

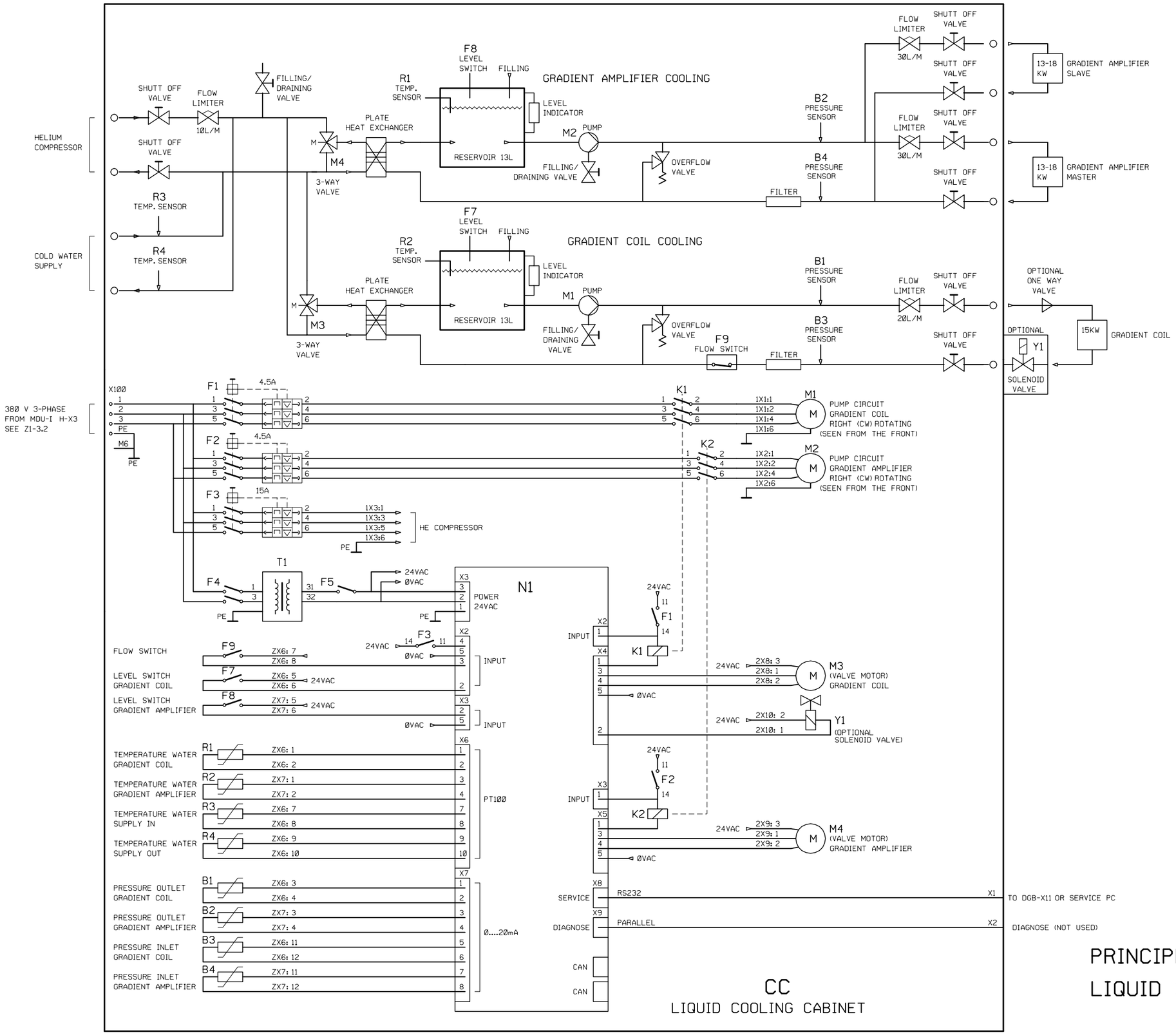
These valves are available as one spare part set.

When the pump is not operating, the coolant in the gradient coil circuit will flow back through the pump into the open tank. Since the total volume will exceed the tank capacity, finally the tank will overflow.
Both valves must be installed on top of the LCC in line with the GC connections.

To prevent this an optional solenoid valve combined with a one way valve is placed in the gradient coil circuit. The solenoid valve is normally open and closes only when the pump is switched off. The one way valve is pushed open by the flow. When closed, the coolant in the gradient coil loop cannot flow back to the LCC. See Figure 64.

**Figure 64 – The optional solenoid valve and one way valve installed**






# PRINCIPLE DIAGRAM
# LIQUID COOLING CABINET