|  |  |
| --- | --- |
| **Document Title** | Swiss Cryostat Procedure |
| **Document Number** | 01 |
| **Issue** | 1.0 |
| **Date** | 2014-11-24 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Prepared By** | **Will Cochrane** | **Signature** |  |
|  | **Date** |  |
| **Approved By** |  | **Signature** |  |
|  | **Date** |  |
| **Released By** |  | **Signature** |  |
|  | **Date** |  |

|  |  |
| --- | --- |
| **Contributors** | |
| **Mark Cliffe** |  |
| **Angus Gallie** |  |
|  |  |

**TABLE OF CONTENTS**

[1 INTRODUCTION 5](#_Toc407011433)

[1.1 Purpose of Document 5](#_Toc407011434)

[2 Cryostat Setup 6](#_Toc407011435)

[2.1 The Cryostat 6](#_Toc407011436)

[2.1.1 Temperature Sensors 6](#_Toc407011437)

[2.2 Sealing the Cryostat 6](#_Toc407011438)

[2.3 GEX Mechanism 10](#_Toc407011439)

[2.4 VACUUM SYSTEMS 11](#_Toc407011440)

[2.4.1 Roughing Pump 11](#_Toc407011441)

[2.4.2 Turbomolecular Pump 11](#_Toc407011442)

[2.4.3 Gate Valve 12](#_Toc407011443)

[2.4.4 Vacuum Gauges 13](#_Toc407011444)

[3 Start-up Procedure 14](#_Toc407011445)

[4 Shut Down Procedure 20](#_Toc407011446)

[5 GEX Mechanism Control Procedure 24](#_Toc407011447)

[6 Encoder Instructions 27](#_Toc407011448)

**List of Figures**

|  |  |
| --- | --- |
| FIGURE | PAGE |

[Figure 2‑1: Temperature Sensor's 6](#_Toc407011449)

[Figure 2‑2: Rad. Shield 2 End Cover 7](#_Toc407011450)

[Figure 2‑3: Metal Brackets for Rad. Shield 8](#_Toc407011451)

[Figure 2‑4: Rad. Shield 2 Sensor Connector 8](#_Toc407011452)

[Figure 2‑5: Rad. Shield 1 Connector 9](#_Toc407011453)

[Figure 2‑6: Shutting the Front Door 10](#_Toc407011454)

[Figure 2‑7: EcoDry M15 Rotary Pump 11](#_Toc407011455)

[Figure 2‑8: TPH 330 Hardware 12](#_Toc407011456)

[Figure 2‑9: Control Panel 12](#_Toc407011457)

[Figure 2‑10: Gate Valve Control 13](#_Toc407011458)

[Figure 3‑1: Steps for setting a vacuum in the chamber 14](#_Toc407011459)

[Figure 3‑2: Valve Indicators 15](#_Toc407011460)

[Figure 3‑3: Indicators 15](#_Toc407011461)

[Figure 3‑4: The big chiller 16](#_Toc407011462)

[Figure 3‑5: Compressors 17](#_Toc407011463)

[Figure 3‑6: Temperature Controllers 18](#_Toc407011464)

[Figure 3‑7: Driving compressor 1 18](#_Toc407011465)

[Figure 3‑8: Temp. Controller 1 18](#_Toc407011466)

[Figure 3‑9: Compressor Drive Buttons 19](#_Toc407011467)

[Figure 4‑1: Compressor Buttons 20](#_Toc407011468)

[Figure 4‑2: Temp. Controllers 20](#_Toc407011469)

[Figure 4‑3: Vacuum Controls 21](#_Toc407011470)

[Figure 4‑4: Big Chiller 21](#_Toc407011471)

[Figure 4‑5: Gas Fill Valves 22](#_Toc407011472)

[Figure 4‑6: Pressure Gauges 22](#_Toc407011473)

[Figure 4‑7: Bleed Valve 23](#_Toc407011474)

[Figure 5‑1: GEX Mechanism Control Hardware 24](#_Toc407011475)

[Figure 5‑2: Initial Mechanism Screen 24](#_Toc407011476)

[Figure 5‑3: Parameters Screen 25](#_Toc407011477)

[Figure 5‑4: Initial Screen 25](#_Toc407011478)

[Figure 5‑5: Motor Drive Screen 26](#_Toc407011479)

[Figure 6‑1: STOP Button 27](#_Toc407011480)

[Figure 6‑2: Encoder Screen 28](#_Toc407011481)

**List of tables**

|  |  |
| --- | --- |
| TABLE | PAGE |

**No table of figures entries found.**

|  |  |
| --- | --- |
|  |  |

# INTRODUCTION

## Purpose of Document

This document sets out the operation procedures for the Swiss cryostat. This is the generic procedures that are used to prepare the cryostat for experiments in a vacuum from temperatures ranging from 4 to 300 K (TBC). It is also the procedure that needs to be followed to re-pressurise the cryostat when an experiment is completed.

# Cryostat Setup

This section has been provided to give an overview of how the cryostat and the attached mechanisms operate. This is to help with any future understanding that might be required.

## The Cryostat

### Temperature Sensors

Figure 2‑1 shows the LabVIEW layout of the cryostat with the temperature sensors marked on it. The diagram is representative of the cryostat and the sensor location corresponds with the actual locations. The sensors being used are Lakeshore … and can operate within a range of … to … K.

|  |
| --- |
| Rear of cryostat  Front of cryostat  Temp. Sensors |

Figure 2‑1: Temperature Sensor's

## Sealing the Cryostat

The following step-by-step instructions are for setting up the cryostat.

1. **Attach the second radiation shield end cover**
2. Slot the radiation shield onto the two spikes of rad shield 2; ensure the flange is flat against the corresponding part.
3. Bolt the metal brackets to the locations shown below. There are 3 brackets to be attached.

|  |
| --- |
|  |
|  |

Figure 2‑2: Rad. Shield 2 End Cover

|  |
| --- |
| Locating Spikes  Metal Bracket |
| Metal Bracket |

Figure 2‑3: Metal Brackets for Rad. Shield

1. Plug sensor 2 into the plug located at the bottom of rad. shield 2.

|  |
| --- |
| Connector  Sensor Plug from Rad. Shield  Rad. Shield 2 |

Figure 2‑4: Rad. Shield 2 Sensor Connector

1. **Attach the first radiation shield end cover**
2. Slot the radiation shield onto the spikes at the end of rad. Shield 1 ensuring that the flange is pressed up against the corresponding part.
3. Bolt the three metal brackets to the locations shown below.
4. Plug sensor 1 into the plug located on the underside of rad. shield 1.

|  |
| --- |
| Rad. Shield 1  Sensor Plug from Rad. Shield |

Figure 2‑5: Rad. Shield 1 Connector

1. **Bolt door shut**
2. Bolt the front door shut using the four bolts around the edge. Using the tool in FIGURE, tighten the bolts gradually one after the other to maintain an even force distribution.

|  |  |
| --- | --- |
| Door Bolt Location  Door Bolt Location  Door Bolt Location  Door Bolt Location | |
|  |  |
| 1. Door Bolts | 1. Door Bolt Socket Tool |

Figure 2‑6: Shutting the Front Door

**NOTE: Opening up the cryostat is the reverse of this procedure.**

## VACUUM SYSTEMS

### Roughing Pump

The cryostat consists of a single EcoDry M15 rotary pump that will bring the cryostat chamber down to a pressure of 10-1 mbar. It achieves this with three compression stages that are formed using three pistons. The gas enters the cylinder through slots on the walls that are uncovered when the piston reaches bottom dead centre (BDC). When the piston rises the gas is compressed and released through a large valve. This is an oil-free rotary pump. It does not use liquid lubrication that can be back fed into the cylinders also known as compression chambers. The pistons are driven through an electric motor that is powered from the mains socket.

|  |
| --- |
|  |

Figure 2‑7: EcoDry M15 Rotary Pump

### Turbomolecular Pump

To get the cryostat’s chamber pressure down to ~10-8 mbar a TPH 330 Pfeiffer Turbomolecular pump is used. This is an air cooled unit that operates at 1 KHz. It is controlled using the panel on the computer rack and the cryostats software.

|  |
| --- |
| Air Cooler  Turbomolecular  Pump |

Figure 2‑8: TPH 330 Hardware

|  |
| --- |
| Turbomolecular Pump Controls |

Figure 2‑9: Control Panel

### Gate Valve

There is a pneumatic powered gate valve located between the vacuum pumps and the cryostat chamber. This is operated by the slider button on the computer rack or within the software.

|  |
| --- |
| Gate Valve |

Figure 2‑10: Gate Valve Control

### Vacuum Gauges

There are two gauges monitoring the cryostat chamber’s pressure. One is a Pfeiffer PKR 251 full range gauge that is designed to measure a range between 5x10-9 and 1000 mbar. This gauge functions by using two separate measurement systems. One is the Pirani system and the other the cold cathode system. The Pirani system is always in operation and is the only system operating for pressures greater than 10-2 mbar. The cold cathode measurement system activates for pressures below 10-2 mbar.

#### Pirani Gauge

Pirani gauges measure the pressure within a vacuum chamber through the thermal conductivity of the gas inside the chamber. There are two metal wire filaments, one inside the vacuum chamber and the other in a sealed housing with a reference gas. The heat loss of the wire inside the vacuum chamber is compared against the wire inside the reference gas. The gas inside the chamber will remove heat from the wire. The more gas that is present the greater the cooling effect on the wire. The gauge will apply a greater current to the wire to maintain its heat. The current required is proportional to the heat being removed. Note that the wires have a Wheatstone bridge arrangement. The gas being measured inside the vacuum chamber has an effect on the accuracy of the gauge. This is reasonably suitable for air, nitrogen and helium but should be re-calibrated for other gases.

#### Cold Cathode Gauge

The cathode is the outer cylinder of the gauge tube and is maintained at ambient temperature. A voltage is applied to a wire in the centre of the gauge (the anode) that induces a field emission of electrons from the cathode. The electrons ionize the gas inside the vacuum chamber that is then collected at the cathode as current. The current is proportional to the pressure inside the vacuum chamber. A magnet is used to increase the path length of electrons to amplify their effect.

## GEX Mechanism

Construction of the GEX mechanism, Encoder being used, Type of Stepper motor, resolution and full rev.

The GEX mechanism consists of a 5-phase stepper motor that is coupled with a worm gear that is in turn meshed with a spur gear.

### GEX Mechanism Control Procedure

The following procedure is used to control the GEX mechanism. A laptop using LabVIEW sends commands to a five phase stepper drive box that in turn sends drive pulses to the GEX mechanisms stepper motor.

1. **Software Setup (This step must be completed even if parameters are not going to be changed)**
2. Make sure that the laptop is connected to the control box and that the control box is switched on

|  |
| --- |
| GEX Control Box (Brenda)  GEX Control Laptop  Cryostat |

Figure 5‑1: GEX Mechanism Control Hardware

1. Open the LabVIEW file on the desktop called “Kmos.exe”.
2. Switch on the toggle switch
3. Select “Set Parameters” (Note that the buttons in this software need to be held down for a couple of seconds to get a response. Do not hold down for too long as it can send multiple commands.)

|  |
| --- |
| c)  d) |

Figure 5‑2: Initial Mechanism Screen

1. Set the required parameters and accept

|  |
| --- |
|  |

Figure 5‑3: Parameters Screen

1. **Stepper motor control**
2. Select “Relative Position” on the initial LabVIEW screen

|  |
| --- |
| a) |

Figure 5‑4: Initial Screen

1. Set the direction of the stepper motor using the “Direction” toggle switch
2. Enter the number of steps to be sent to the stepper motor (1 step = 0.0069°)
3. Turn the power on with the “Power” toggle switch
4. Press “Start” to send the command to the stepper motor

|  |
| --- |
| e)  d)  c)  b) |

Figure 5‑5: Motor Drive Screen

**NOTE: To change the number of steps and/or direction of the stepper motor the “Power” toggle switch must be turned off and the changes made. If this is not done the controller will continue to send the previous command.**

The “Step Count” dialogue box (circled above) shows the numerical summation of steps delivered to the motor. The forward direction accumulates positive numbers and the reverse direction negative numbers.

### Encoder Instructions

The following is a list of instructions for accessing the Hedeinhain (external) and Zettlex (internal) encoder’s readouts on the LabVIEW software. This currently uses the desktop computer at the Swiss cryostat table. Note that the Zettlex encoder can operate down to 133 K if the supply voltage is adjusted to 30 V. This is above the recommended operating voltage. The encoder does not operate below 133 K.

1. Turn on power supply to the encoders (24 volts for > 160 K, 30 volts for < 160 K)
2. Open the file named “EncodersWithRemote“ from the following directory “C:\Harmony - Local\Rotator Tests\Labview Code\Encoder Files”
3. Make sure the “STOP” button is light grey and not dark grey

|  |  |
| --- | --- |
|  |  |

Figure 6‑1: STOP Button

1. Press the run code button in the toolbar (circled below)

|  |
| --- |
| b)  c) |

Figure 6‑2: Encoder Screen

If the Zettlex encoder is turned off when the cryostat is below 160 K it will not turn on until the temperature is greater than 160 K.

# Start-up Procedure

The following procedure is applied to cool down the cryostat to a required temperature. This procedure is followed after the user has setup their experiment and is ready to begin.

1. **Ensure the cryostat is sealed and ready for cool down.**

This includes re-attaching the two radiation shield ends into their respective locations with the sensor plugs connected as described in section 2. The door of the cryostat should be closed with the four locking bolts tightened (see section 2). Inspect the seals, windows, feed through, door etc. making sure that they are completely sealed. Also make sure that the MCN server is running to operate the cryostat from the LabVIEW program (see section 2).

1. **Depressurise the chamber**

Figure 3‑1 shows the LabVIEW controller for the Swiss cryostat.

|  |
| --- |
| c)  a)  b) |

Figure 3‑1: Steps for setting a vacuum in the chamber

1. Click on “SET” in the valve box to open the valve between the chamber and pumps. The indicator light will be RED for closed and GREEN for opened and the text will also indicate the status of the valve.

|  |  |
| --- | --- |
|  |  |

Figure 3‑2: Valve Indicators

1. Turn on the Rotary Vane Pump by clicking on “SET” in the dialogue box. The text and indicator light will alter to show its status.
2. When the Pressure dialogue box reaches 1.0E-1, the Turbo Pump can be activated by clicking on “SET” in the corresponding dialogue box. Note, that the turbo pump will require a few minutes to get up to speed before the “Low Speed/Standby” indicator will change to green. The turbo pump operates at 1 kHz.

|  |  |
| --- | --- |
|  |  |

Figure 3‑3: Indicators

1. **Cooling the chamber**

Once the chamber reaches a pressure below 1.0E-4, the coolers can be switched on.

1. Switch the big chiller on in the green shed/box that sits outside the mechanical lab. This requires the red power switch to be turned to the on position and then the on button pressed. Ensure there is enough ventilation for operation.

|  |  |
| --- | --- |
| Green shed |  |
| Indicates if boiler is on  Warning lights  Temp. Sensor used in b)  #2 – Press to turn on  #1 – Turn to on position | |

Figure 3‑4: The big chiller

1. After the chiller has reached ~12.3, switch the two compressors on located in the main mechanical lab next to the double blue doors.

|  |
| --- |
|  |

Figure 3‑5: Compressors

1. The compressors can now be driven by the software. The dialogue boxes for both compressors should have green indicators for pressure and temperature. If one of the indicators is red check that the hardware is not overheating and the big chiller is not cutting out.
2. Change temperature controller 4 to “PID” mode in the drop down box. Set “Range” to the desired heater power (Choice of off / 10mW / 100mW / 1W / 10W / 100W). Type into the SP box the desired temperature of the chamber. Do the same with temperature controller’s 1 & 2. Note that temperature controller 1 is in Celsius.

|  |
| --- |
| Chosen temperature units  Set temperature  Set heater power  Change to PID  Temp. Controller 1 in Celsius |

Figure 3‑6: Temperature Controllers

1. Click on the “SWITCH DRIVE” button in the compressor 1 dialogue box to begin driving the compressor. The drive indicator will now turn green and the cold head will begin operating.

|  |  |
| --- | --- |
| c) |  |

Figure 3‑7: Driving compressor 1

1. Give compressor 1 a few seconds then press “Run” in the temperature controller 1 loop. Pressing too soon can stop the cold head.

|  |
| --- |
|  |

Figure 3‑8: Temp. Controller 1

1. Give compressor 1 a few minutes before clicking “SWITCH DRIVE” to turn on the second compressor.

|  |
| --- |
| d) |

Figure 3‑9: Compressor Drive Buttons

1. The cryostat will need time to reach the desired temperature. The cooling rate is approximately 20K/hour (Gallie, 2013).

# Shut Down Procedure

Once an experiment is completed the following procedure is applied to warm up and then re-pressurise the cryostat.

1. **Warming up the chamber**
2. Stop driving the compressors by clicking on “SWITCH DRIVE” in both dialogue boxes (circled below). The drive indicators will go from green to red to show that they are off

|  |  |
| --- | --- |
|  |  |

Figure 4‑1: Compressor Buttons

1. Turn off the temperature controllers by selecting “off” in the heater range and “off” under the mode (circled below). Note that when selecting the mode to off it will jump to manual. This is ok.

|  |
| --- |
|  |

Figure 4‑2: Temp. Controllers

1. Close the vacuum valve by selecting “SET”
2. Turn off the Turbo Pump by pressing “SET”. Both indicators will go red.
3. Turn off the rotary pump by pressing “SET”, the indicator will go red.

|  |
| --- |
| d)  e)  c) |

Figure 4‑3: Vacuum Controls

1. Switch off the compressors
2. Switch off the big chiller in the green shed

|  |
| --- |
|  |

Figure 4‑4: Big Chiller

1. Leave cryostat to heat up to ambient temperature. The heating rate is approximately 20K/hour (Gallie, 2013).
2. **Re-pressurising the chamber**

Note that when re-pressurising the chamber the pressure gauge PAA235 is a more accurate indicator above 2 mbar than the on screen and Pfeiffer indicators.

1. Set refill bottle (either He or N2) to approximately less than 0.5 bar
2. From the software, press the “SET” button to open the valve for the chosen refill gas. The indicator will turn from red to green and the text will say “Open” to show that the valve is open.

|  |
| --- |
|  |

Figure 4‑5: Gas Fill Valves

1. Allow pressure to rise to desired pressure (use the red PAA235 indicator circled below)

|  |
| --- |
|  |

Figure 4‑6: Pressure Gauges

1. Close gas refill valve when indicator reaches ~ 960 mbar
2. Close refill bottle
3. Carefully open manual bleed valve to check pressure in chamber

|  |
| --- |
| f) |

Figure 4‑7: Bleed Valve

1. Once manual valve can be opened and no air is being sucked in the cryostat then the chamber is re-pressurised.