Oxford Instruments NanoScience

OptistatDry TLEX

Cryofree Sample Loading into Exchange Gas

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Contents

1 Introduction

This manual is designed to introduce you to the OptistatDry TLEX, one of a range of cryofree cryostats manufactured by Oxford Instruments. This manual contains important information for the safe operation of your system. We recommend that you read this manual carefully before operating the system for the first time.

In addition to this manual for the OptistatDry TLEX, further manuals and documentation will have been supplied with the system. These further manuals and documents detail the other components of the system as well as important safety information, as shown in Table 1-1. Please ensure you have reviewed the information supplied in all the manuals before you attempt to operate your system.

Documentation	Format
Mercury iTC Manual	Electronic copy on USB
Operation Manual of SRDK-101D-HC4A2	Electronic copy on USB
Operation Manual of SRDK-101D-HC4E2	Electronic copy on USB
267825A (HC-4A2 Air Compressor Manual)	Electronic copy on USB
267318A (HC-4E2 Water Compressor Manual)	Electronic copy on USB
Practical Cryogenics	Electronic copy on USB
Safety Matters	Electronic copy on USB
TLEX Test Results	Hard & Electronic USB copy
Unpacking Information	Hard copy
Mercury iTC Safety Sheet	Hard copy
OptistatDry TLEX Safety Sheet	Hard copy
Cold Head Test Results & Technical Instruction	Hard copy

Table 1-1: Documentation supplied with the OptistatDry TLEX

Please keep all the manuals supplied with your system and make sure that you check for updated information and incorporate any amendments. If you sell or give away the product to someone else, please give them the manuals too.

1.1 Copyright

Oxford Instruments will not be responsible for the accuracy of the information contained in this document, which is used at your own risk and should not be relied upon. The information could include technical inaccuracies or typographical errors. Changes are periodically made to the information contained herein; these changes will be incorporated in new editions of the document.

1.2 Statement of intended use

The equipment has been designed to operate within the process parameter limits that are outlined in the user manual. The equipment is intended to be installed, used and operated only for the purpose for which the equipment was designed, and only in accordance with the instructions given in the manual and other accompanying documents. Nothing stated in the manual reduces the responsibility of users to exercise sound judgement and best practice. It is the user's responsibility to ensure the system is operated in a safe manner. Consideration must be made for all aspects of the system's life-cycle including, handling, installation, normal operation, maintenance, dismantling, decontamination and disposal. It is the user's responsibility to complete suitable risk assessments to determine the magnitude of hazards.

The installation, usage and operation of the equipment are subject to laws in the jurisdictions in which the equipment is installed and in use. Users must install, use and operate the equipment only in such ways that do not conflict with said applicable laws and regulations. If the equipment is not installed, used, maintained, refurbished, modified and upgraded as specified by the manufacturer, then the protection it provides could be impaired. Any resultant non-compliance damage, or personal injury would be the fault of the owner or user.

Use of the equipment for purposes other than those intended and expressly stated by Oxford Instruments, as well as incorrect use or operation of the equipment, may relieve Oxford Instruments or its agent of the responsibility for any resultant non-compliance damage or injury. The system must only be used with all external covers fitted.

1.3 Restrictions on use

The equipment is not suitable for use in explosive, flammable or hazardous environments. The equipment does not provide protection against the ingress of water. The equipment must be positioned so that it will not be exposed to water contact.

1.4 Maintenance and adjustment

Only qualified and authorised persons should service or repair this equipment. Under no circumstances should the user attempt to repair this equipment while the electrical power supply is connected.

1.5 Warranty

The Oxford Instruments customer support warranty is available to all our customers during the first 12 months of ownership from date of delivery. This warranty provides repair to faults that are a result of manufacturing defects at Oxford Instruments NanoScience.

1.6 Acknowledgements

All trade names and trademarks that appear in this manual are hereby acknowledged.

1.7 Technical support

If you have any questions, please direct all queries through your nearest support facility (see below) with the following details available. Please contact Oxford Instruments first before attempting to service, repair or return components.

System type: OptistatDry TLEX
Serial number: The Sales Order (SO) number and/or other identifiers of your system.
Contact information: How we can contact you, email/telephone details.
Details of your query: The nature of your problem, part numbers of spares required, etc.

Europe, Middle East, Africa and India (EMEAI)

OINS, Tubney Woods, Abingdon, Oxon, OX13 5QX, UK
Tel: +44(0)1865 393200 (sales)
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Fax: +44(0)1865 393333 (sales and support)
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Fax: +81 3 6732 8939 (sales and support)
Email: nanoscience.jp@oxinst.com (sales, service and support)
Web: www.oxford-instruments.jp

2 Health and safety

Before you attempt to install or operate your system, please make sure that you are aware of all safety precautions listed in this manual together with the warnings and cautions set out in other documents supplied with the system.

All cryogenic systems are potentially hazardous, and you must take precautions to ensure your own safety. The general safety precautions required when working with cryogenic systems are given in Oxford Instruments' Safety Matters document. We recommend that all users should read this document, become thoroughly familiar with the safety information provided and be aware of the potential hazards.

It is the responsibility of customers to ensure that the system is installed and operated in a safe manner. It is the responsibility of customers to conduct suitable risk assessments to determine the nature and magnitude of hazards.

2.1 Disclaimer

Oxford Instruments assumes no liability for use of any document supplied with the system if any unauthorised changes to the content or format have been made.

Oxford Instruments' policy is one of continued improvement. The company reserves the right to alter without notice the specification, design or conditions of supply of any of its products or services. Although every effort has been made to ensure that the information in this document and all accompanying documents is accurate and up to date, errors may occur. Oxford Instruments shall have no liability arising from the use of or reliance by any party on the contents of this these documents (including this document) and, to the fullest extent permitted by law, excludes all liability for loss or damages howsoever caused.

Oxford Instruments cannot accept responsibility for damage to the system caused by failure to observe the correct procedures laid down in this manual and the other manuals supplied with the system. The warranty may be affected if the system is misused, or the recommendations in the manuals are not followed.

2.2 Disposal and recycling instructions

You must contact Oxford Instruments (giving full product details) before any disposal begins. It is also important to check with the appropriate local organisations to obtain advice on local rules and regulations about disposal and recycling.

2.3 Maintenance

Observe the necessary maintenance schedule for the system. Consult Oxford Instruments if you are unsure about the required procedures. Only qualified and authorised persons must service or repair this equipment.

2.4 General hazards

The following general hazards must be considered when planning the site for installation and operating the equipment. Please take notice of the following relevant warnings.

2.4.1 Warning notices

Warning notices draw attention to hazards to health. Failures to obey a warning notice may result in exposure to the hazard and may cause serious injury or death. A typical warning notice is shown below.

	WARNING A warning triangle highlights danger which may cause injury or, in extreme circumstances, death.

2.4.2 Caution notices

Caution notices draw attention to events or procedures that could cause damage to the equipment, may severely affect the quality of your measurements, or may result in damage to your sample or measurement apparatus. Failure to obey a caution notice may result in damage to the equipment. A typical caution notice is shown below.

	CAUTION Caution notices highlight actions that you must take to prevent damage to the equipment. The action is explained in the text.

2.5 Specific hazards

All OptistatDry systems consist of a cryostat which is cooled by a Gifford-McMahon (GM) cooler. Safety information that applies specifically to the OptistatDry is provided in this manual. Where additional components are supplied as part of a system, please read and follow all safety information in the respective manuals and take additional precautions as necessary.

2.5.1 Hazardous voltages

	HAZARDOUS VOLTAGE Contact with hazardous voltage can cause death, severe injury or burns. Ensure that a local electrical earth (ground) connection is available at the installation site.

	PROTECTIVE EARTH The cryostat and any other parts of the system fitted with earthing points must always be connected to protective earth during operation.

Parts of the system carry high voltages that can cause death or serious injury. Ensure that a local electrical earth (ground) connection is available.

The electrical supply to the system must include an isolation box to ensure that mains electrical power to the system can be isolated. The isolation box must allow the supply to be locked OFF but must NOT allow the supply to be locked ON.

2.5.2 Low temperatures

	COLD OBJECTS Contact with cold objects and cryogens can cause serious injury to the skin. Skin may adhere to cold objects. Ensure that any cryogenic or coolant delivery systems are designed to prevent contact with the cold components.

Consider the hazards of low temperatures when planning the installation of the system. Proper safety equipment must be made available to all personnel expected to handle cryogenic liquids, including hand and eye protection.

2.5.3 Closed vessels

> CLOSED VESSELS
> Closed vessels in the system are protected by pressure relief valves that exhaust directly to atmosphere unless otherwise stated.

Do not tamper with any of the pressure relief devices fitted to the system or attempt to modify or remove them. Also ensure that the outlets of the relief devices are not obstructed. The correct operation of these relief valves is critical to the safety of the system. All closed vessels in the system are protected by pressure relief valves, as described in Table 2-1.

Location	Description	Setting
OVC body	Relief plate to atmosphere	0.12 bar differential
Sample space	Relief valve to atmosphere	0.1 bar differential

Table 2-1: Pressure relief valve information

There is an over-pressure relief plate on the rear of the cryostat, as shown in Figure 2-1 (Left). It prevents the internal pressure in the cryostat outer vacuum chamber from rising significantly above atmospheric pressure by lifting to allow gas to vent. Four restoring springs provide the force required to re-seal the relief plate automatically when the pressure drops. Note that the relief plate will not lift during normal operation of the system.

The NW16 variable temperature insert (VTI) sample space pump and flush valve has a built-in pressure relief plate (the red coloured cap), as shown in Figure 2-1 (Right), which allows the sample space to vent should it become over-pressurised. A restoring spring provides the force required to re-seal the cap automatically when the pressure drops.

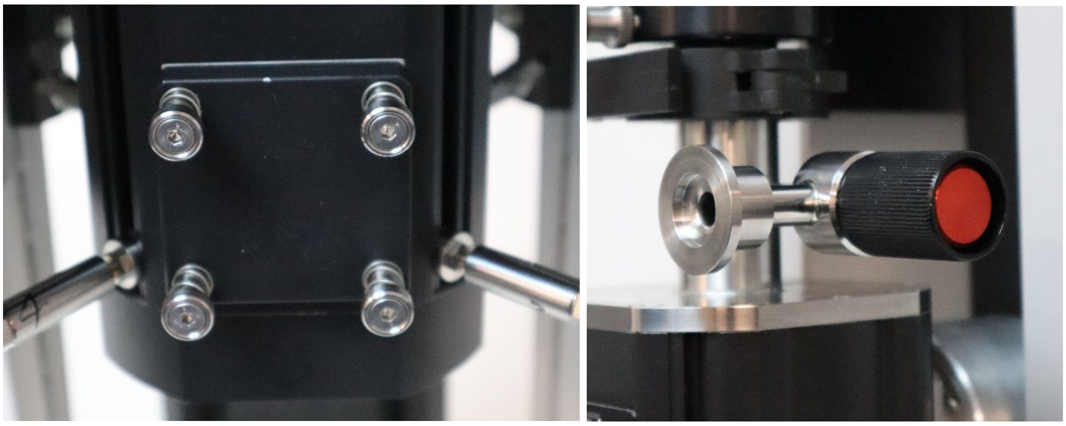

Figure 2-1: Pressure relief plate (Left) and valve (Right) on the system.

Do not modify or tamper with these safety features in any way. Ensure that nothing can restrict the movement of either pressure relief valve.

2.5.4 Pressurised gas

HIGH PRESSURES

The helium compressor and lines are supplied pressurised to > 16.5 bar (240 psi) with ^{4}He gas. Follow manufacturer guidelines should you need to charge the compressor. Do not modify the couplings.

The compressor is manufactured by Sumitomo (SHI) Cryogenics of America, Inc. and the cold head is manufactured by Sumitomo Heavy Industries, Ltd. Safety features for the cold head and compressor are described in the SHI documentation supplied with this system. You should ensure that you understand and comply with all SHI safety warnings and cautions.

Should the gas in the compressor need to be charged or discharged for any reason, refer to the SHI compressor technical manual and follow the manufacturer’s guidelines.

2.5.5 Weight and lifting

HEAVY OBJECT

Incorrectly lifting heavy objects can cause severe injury. Use the appropriate lifting equipment, operated by fully trained personnel, when handling heavy system components.

Appropriate lifting equipment and Personal Protective Equipment (PPE) must be provided for the duration of the system installation and should always be used whilst operating the system.

2.5.6 Fire

FLAMMABLE GAS

Atmospheric oxygen can condense on cryogenically cooled objects. Oxygen can cause flammable substances to ignite in the presence of heat or arcing, risking severe injury.

Oxygen from the air will condense on the cold surfaces, for example the sample probe if it has been removed whilst cold. Oxygen enrichment may cause spontaneous combustion.

2.6 Temperature and voltage limits

The OptistatDry TLEX system is supplied with a Mercury iTC temperature controller. Safety features for the temperature controller are described in the Mercury iTC manual supplied. You should ensure that you understand and comply with all safety warnings and cautions.

The Mercury iTC will have been set up in the factory in order to prevent you from accidentally exceeding the maximum safe operating temperature of the cryostat and to limit the heater voltage to a safe level.

2.7 Safety equipment

The following items are recommended for safe operation of any system:

- Personal protective equipment, including thermally insulated gloves, face protection and protective footwear.

- Hazard warning signs, barriers or controlled entry systems to ensure that personnel approaching the system are aware of the potential hazards. This precaution is especially important if your system includes a superconducting magnet.
- Oxygen monitors should be fitted in the laboratory to warn personnel if the concentration of Oxygen in the air falls below safe levels.

2.8 Risk assessments

It is the responsibility of customers to perform their own risk assessments before installing, operating or maintaining the system. Risk assessments must obey regulations stipulated by the local regulatory authority.

3 System description

The OptistatDry systems comprise a range of compact cryostats with optical access cooled by a closed cycle refrigerator. These systems are capable of cooling samples to liquid helium temperatures without the need for liquid cryogens, providing significant benefits for ease of use and running costs. The OptistatDry range is designed to be versatile and simple to use, whilst providing optical excellence.

The OptistatDry TLEX system provides a temperature-controlled, sample-in-exchange gas measurement environment within a cryogen-free cryostat. The system enables optical and electrical measurements to be carried out on the user's sample.

The cooling source for the cryostat is a two-stage Gifford McMahon (GM) refrigerator supplied by Sumitomo Heavy Industries (SHI). The variable temperature insert (VTI) heat exchanger cools through a direct conductive thermal path to the second stage of the refrigerator, and the sample is cooled by the heat exchanger through exchange gas. The first stage of the refrigerator is used to cool a radiation shield, which minimises the radiation heat load on to the second stage and sample region.

The sample probe has been designed to be easy to remove and replace even when the cryostat is cold.

3.1 The cryostat

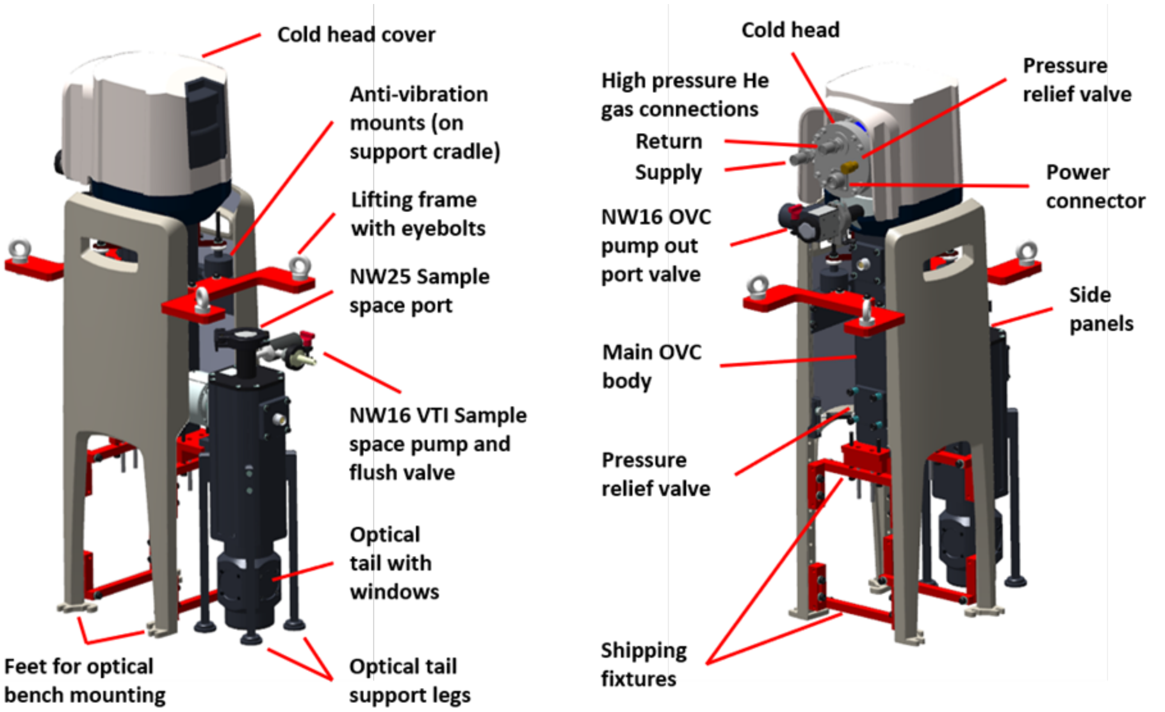

Figure 3-1: OptistatDry TLEX schematic

A schematic of the OptistatDry TLEX cryostat is shown in Figure 3-1. The main features of the cryostat are:

- The VTI heat exchanger, fitted with a temperature sensor and heater wired to a 16-way Fischer on the VTI tail section to assist with temperature control of the sample region.

- The cold head, to which the VTI heat exchanger is thermally attached by a conductive link. The 1st and 2nd stages of the cold head are fitted with temperature sensors for monitoring purposes.
- The outer vacuum chamber (OVC) and radiation shields isolate the sample from the room temperature surroundings. The radiation shield is fitted with an activated charcoal sorption pump which helps maintain the cryostat vacuum when the system is in operation.
- The optical window block, allowing optical access to the sample region.
- The support stand, in which the cryostat is located. This stand can be securely mounted to an optical table. The cryostat support cradle has built-in anti-vibration mounts. Four radial restraints keep the cryostat central, and four legs support the VTI tail section of the OVC.

3.2 The sample probe

The sample probe, shown in Figure 3-2, fits into the VTI sample space and has been designed to be easy to remove and replace, even when the cryostat is cold. The sample probe includes:

- A sample mounting platform, fitted with a temperature sensor and heater, wired to a 16-way Fischer on top of the probe. In conjunction with the MercuryiTC, this enables temperature control of the sample region in the range 4K - 300K.
- Experimental wiring for sample measurements. A 24-way Fischer connector is wired from the top of the probe to Harwin pins just above the sample mounting platform. The pin layout for this connector is shown in Figure 3-3, as viewed from above (as the connecting cable mates).

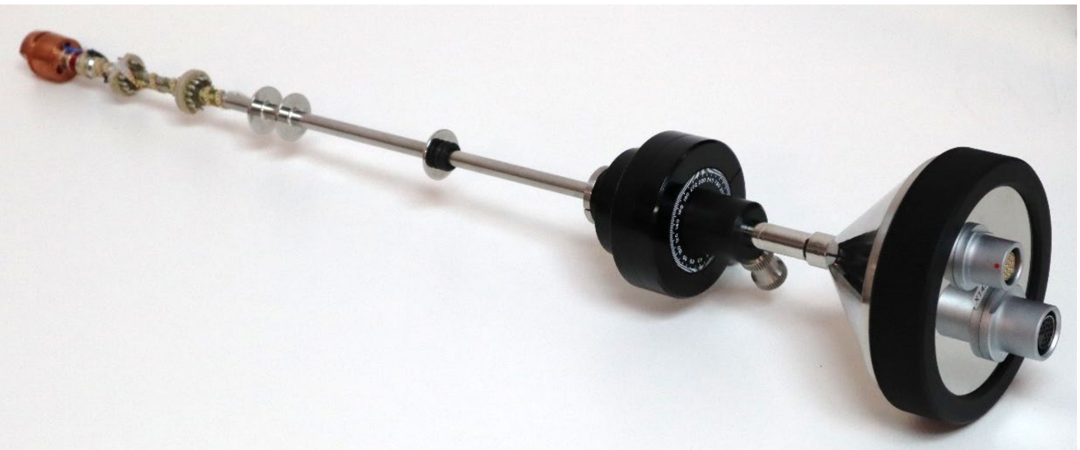

Figure 3-2: The TLEX height-adjust and rotate sample probe

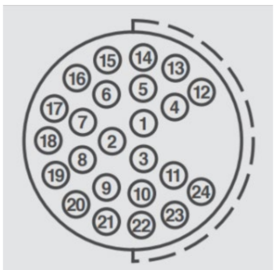

Figure 3-3: Pin configurations for 105-series 24-way type A Fischer (receptacle)

3.3 The cryocooler

The cryocooler is a two-stage Gifford McMahon (GM) refrigerator supplied by Sumitomo Heavy Industries (SHI). The package includes:

- The cold head, which forms part of the cryostat;
- The compressor, which supplies compressed ^{4}He gas to the cold head;
- Two high-pressure gas lines, between the cold head and compressor; and
- The power cable, between the cold head and the compressor.

3.4 The MercuryiTC temperature controller

A Mercury iTC is used as the temperature controller for the system. The Mercury iTC monitors and controls the thermometry and heating for the VTI heat exchanger and sample probe and monitors the thermometry for the 1st and 2nd stages of the GM cooler.

The MercuryiTC is configured with measurement cards in specific locations. This configuration is detailed, along with the interconnecting cables, in Table 3-1.

Slot Number	Card Type	Function	Connection
Main Board	Temperature and Heater	VTI sensor and heater	CWA9249
1	Heater	Probe sample heater	n/a
2 - 5	Not Used	n/a	n/a
6	Temperature	Probe sample sensor	CWA9249
7	Temperature	GM1 sensor	CWA9252
8	Temperature	GM2 sensor	

Table 3-1: MercuryiTC configuration for the OptistatDry TLEX

3.5 Diagnostic wiring

There are two hermetically sealed, 16-way Fischer diagnostic wiring connectors on the cryostat, and one on the sample probe. The pin layout for these connectors are shown in Figure 3-4, as viewed from above (as the connecting cable mates).

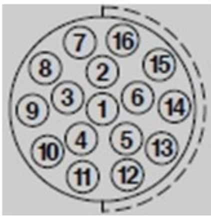

Figure 3-4: Pin configurations for 104-series 16-way type A Fischer (receptacle)

The wiring configurations for each diagnostic connector are set out in the following tables:

Pin No.	Function	Polarity	Type
1	GM1 sensor	V+	Silicon diode
2		V-	
3		I+	
4		I-	
5	GM2 sensor	V-	Cernox
6		V+	
7		I+	
8		I-	
9 - 10	Not used	n/a	n/a

Table 3-2: GM wiring from the 16-way Fischer to the cold head stages

Pin No.	Function	Polarity	Type
1	VTI sensor	V-	Cernox
2		V+	
3		I+	
4		I-	
5 - 8	Not used	n/a	n/a
9	VTI heater	+	Firerod (nominal 40 ohm)
10		-	
11 - 16	Not used	n/a	n/a

Table 3-3: VTI wiring from the 16-way Fischer to the VTI heat exchanger

Pin No.	Function	Polarity	Type
1	Sample sensor	V-	Cernox
2		V+	
3		I+	
4		I-	
5 - 8	Not used	n/a	n/a
9	Sample heater	+	Firerod (nominal 40 ohm)
10		-	
11 - 16	Not used	n/a	n/a

Table 3-4: Probe wiring from the 16-way Fischer to near the sample stage

Note: Depending on when your OptistatDry TLEX system was manufactured, it may have an older wiring configuration (typically 21-way and 15-way micro-D connectors). In such case, it is recommended to refer to the manual supplied with your system at the time of installation.

3.6 Sensor calibrations

Calibrations for the individually calibrated sensors on the system (Cernox sensors) will have been loaded into the MercuryiTC at the factory. The raw calibration data from the sensor's manufacturer will also be supplied separately.

3.7 System components and layout

A schematic showing connections between components of the system is shown in Figure 3-5.

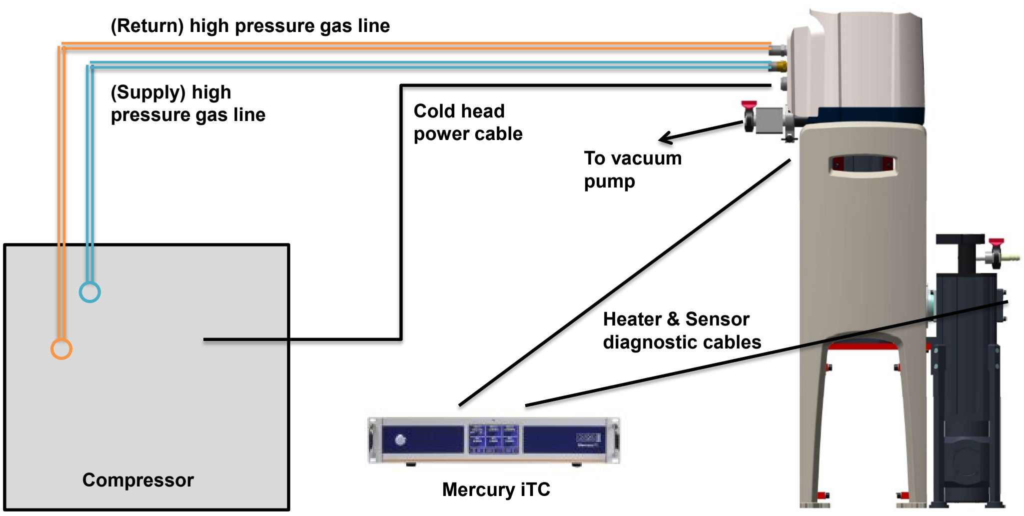

Figure 3-5: Connections between system components

3.8 Weights and dimensions

The dimensions and weights for the main system components are given in Table 3-5.

Component	Length / mm	Width / mm	Height / mm	Weight / kg
TLEX cryostat	400	240	800 - 880	28
Mercury iTC	310	485	90	8
SHI compressor (water)	485	430	505	82
SHI compressor (air)	488	453	715	111

Table 3-5: Weights and dimensions of system components

4 System installation

Assembly of the OptistatDry TLEX is a straightforward procedure requiring no specialist training. A spares kit containing the tools required for assembly is provided; the contents are listed below in Table 4-1, along with the contents of the SHI compressor spares kit in Table 4-2.

Tool	Quantity	Function
5mm ball end hex-key	1	Cryostat height and radial restraint adjustments
2.5mm ball-end hex-key	1	Radial restraint adjustments
10mm open-ended spanner	2	Cryostat height and radial restraint adjustments
7mm ring spanner	1	Adjustment of locator studs
Flat blade screwdriver (0.8 x 4 mm)	1	Removal/fitting of optical windows

Table 4-1: OptistatDry spares kit

Tool	Quantity	Function
17mm Spanner or socket & ratchet	1	Removal of shipping bolt underneath compressor package
5/16 inch open ended spanner	1	Compressor bulkhead water fitting jam-nut (water cooled only)
7/8 inch open ended spanner	1	Compression nut on water fitting (water cooled only)

Table 4-2: Sumitomo compressor spares kit

4.1 Unpacking the system

HEAVY OBJECT

The total weight of the cryostat and the support stand is approximately 28kg. This is too heavy for one person to manage safely. All processes that require lifting or moving the partly or fully assembled system require two people.

The OptistatDry TLEX system is supplied as two main packages, each on wooden pallets. If an optional turbo pump is supplied, this will be an additional package. Please retain all packing materials, should you need to transport or store the system in the future.

The first package includes the SHI compressor, gas lines and assembly tools. Remove external plastic wrapping and proceed as described in the SHI compressor technical manual installation section. At this stage, the main tasks are siting of the compressor and the removal of the shipping bolt beneath the compressor. Electrical connections, water connections (if applicable) and compressor testing are covered later.

The second package consists of the cryostat, windows, sample holder(s) and any optional items ordered, e.g. MercuryiTC, cables and spares kit. Open this box by turning the two black plastic closure fittings and lifting back the lid. These fittings may be quite stiff - you can use pliers to turn them. Remove the internal packing foam layers and take out all the system components.

The cryostat and frame should be placed upright on a firm flat surface. Note that the weight of the cryostat and frame assembly is 28kg, therefore two people are required to lift and move the assembly safely. When unpacking the system, check each item against the packing list to make sure that all the components are present. Examine the system to make sure that it has not been damaged since it left the factory. If you find any missing items or any signs of damage, please contact Oxford Instruments immediately.

Figure 4-1: The TLEX cryostat in its packaging

Note that the cryostat is shipped under vacuum in order to keep the charcoal sorption pump as clean and dry as possible. The OVC will have to be let up to atmospheric pressure in order to adjust the height of the cryostat or to change the optical windows (both described later). It is a good idea to keep the default windows in position whilst the system is installed., these can be removed and swapped for other window options after the system has been operated for the first time to check its performance.

CAUTION - Transit Fixtures
The OptistatDry TLEX system is fitted with transit fixtures that must not be removed until the cryostat is as close as practical to its final operating position.

The system is fitted with transit fixtures that must not be removed until the cryostat is as close as practical to its final operating position. The red support beams positioned between the legs of the support stand are shipping fixtures. These are also used to assist in the adjustment and positioning of the optical tail, so it is important they are not removed until the cryostat is seated in its final position (or as close as possible).

4.2 The support stand

The cryostat’s support stand consists of two side panels and a support cradle. It may be used to support the cryostat securely above an optical table. The support stand has four legs, with slotted feet for compatibility with both imperial (1“) and metric (25mm) optical tables.

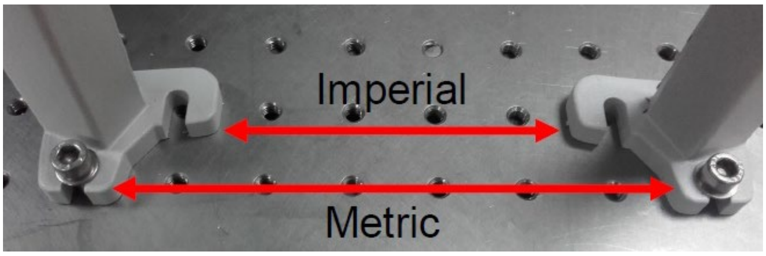

Figure 4-2: Spacing of the support stand feet

The support cradle can be moved up or down with respect to the side panels, so the height of the cryostat windows above the optical table can be varied to suit the experimental set-up. The default position of the support cradle (as shipped) within the stand is the lowest possible position setting, with the base of the optical tail just above ground level when positioned on a flat surface. If necessary, the height of the optical windows can be changed to suit the experimental setup.

4.3 Before adjusting the height

The following sections describe how to adjust the height of the cryostat in the support stand in order to precisely set the distance between the centre of the transverse windows and the top face of the optical bench. The optical window height can be adjusted to sit anywhere between the default position and +80mm (approx.). Remember to keep the transit fixtures in place until the system is in its final position and secured to the optical table.

CAUTION - System Under Vacuum
The Optistat TLEX will be under vacuum when it is received. Before adjusting the height, vent the OVC via the NW16 OVC pump out port valve using dry nitrogen gas.

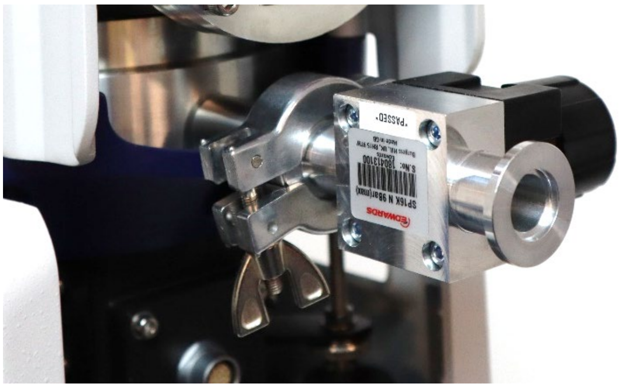
Figure 4-3: NW16 OVC valve and pump-out port

Before making any height adjustments, always remove the probe and radial restraints as detailed in Sections 4.4 and 4.5. If the experimental setup requires the window height to be adjusted by more than 25mm, the cryostat position should first be adjusted following the instructions in Section 4.6. Should the window height need to be adjusted by up to 25mm, follow the instructions in Section 4.7.

4.4 Removing the sample probe

Before starting with any height adjustment, it is recommended that you remove the sample probe from the system. Vent the sample space with helium gas at atmospheric pressure through the VTI sample space pump and flush valve. With reference to the pictures in Figure 4-4, undo and remove the NW25 clamp holding the probe in place and carefully withdraw the probe. Fit an NW25 blank to the port to prevent moisture and other contaminants from getting into the sample space, and re-secure the clamp. Store the probe in a safe location whilst removed from the system.

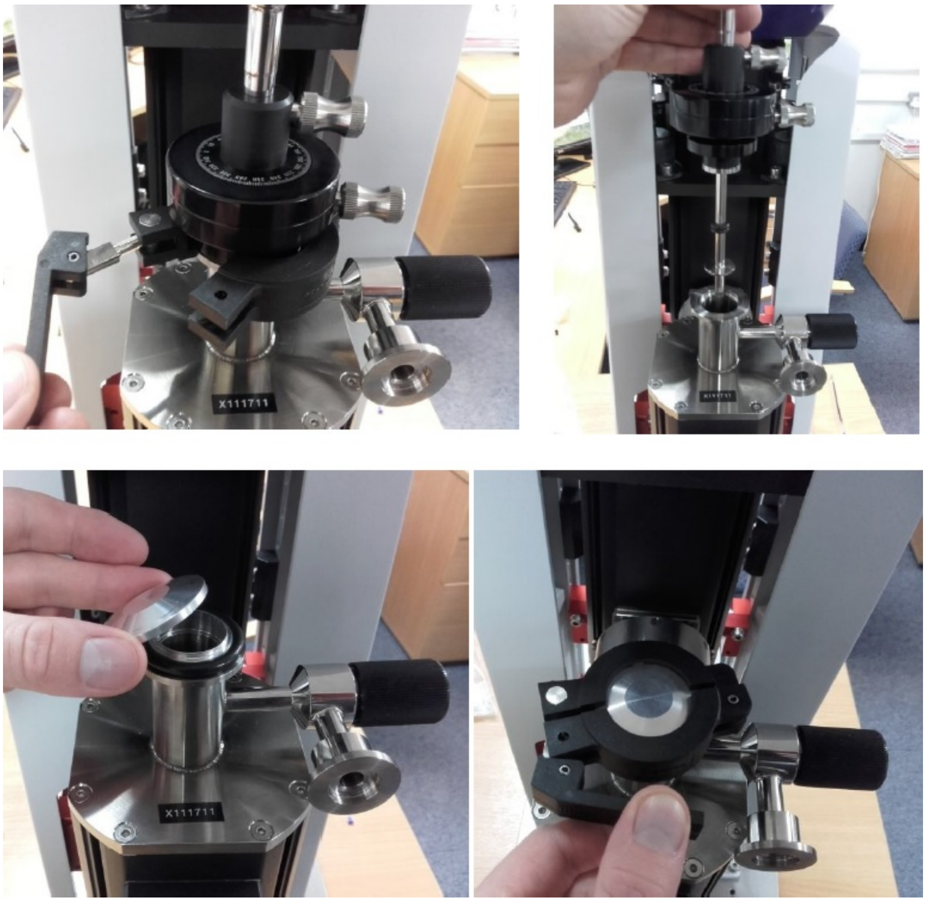

Figure 4-4: Removing the sample probe

4.5 Removing the radial restraints

In order to allow the height of the cryostat to be adjusted, the horizontal radial restraints, which keep the cryostat central in the support frame, must first be removed. The radial restraints are fitted (under slight compression) between the locator studs on the exterior of the main OVC body and the four side panel legs, as shown schematically in Figure 4-5.

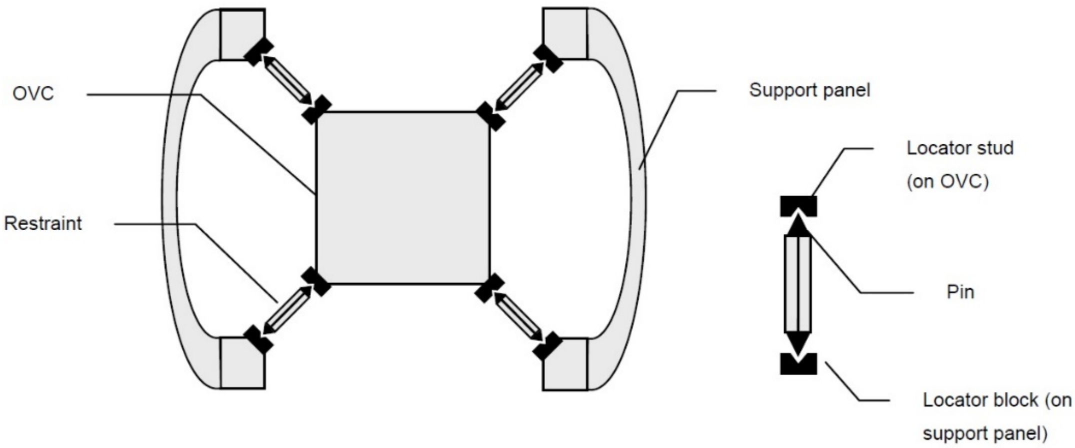

Figure 4-5: Cryostat radial restraint schematic

A photograph of one of the radial restraints and its main features is shown in Figure 4-6.

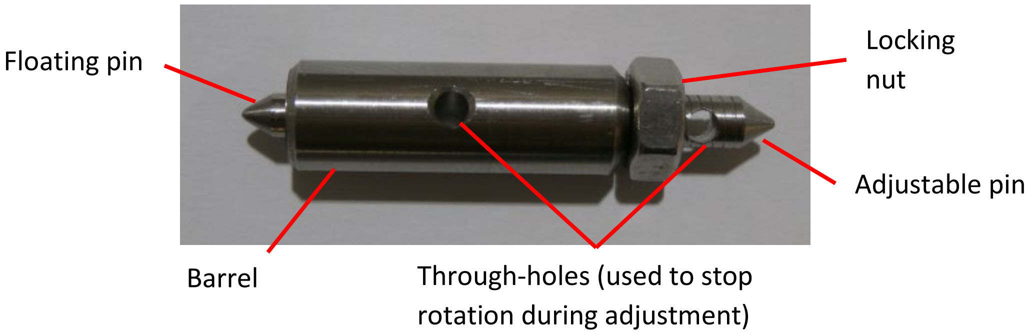

Figure 4-6: Photograph of radial restraint

When the system is unpacked, all four radial restraints will be pre-set to the correct length. To avoid altering and then having to reset the restraint lengths the locator blocks can instead be loosened and moved to allow the restraints to come free. This is done by loosening the two bolts that attach each locator block to the side panels, as shown in Figure 4-7. Be sure to make a note of which restraint is removed from which corner, as their individual lengths may be slightly different. This will be important later.

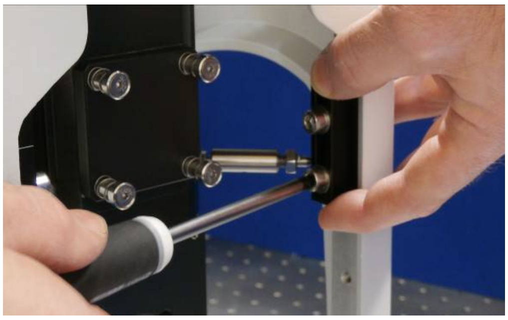

Figure 4-7: Loosening a locator block

4.6 Coarse height adjustment (> 25 mm)

The height of the cryostat is coarsely adjustable in 25 mm stages using the bolt hole pairs on each side panel as shown in Figure 4-8. In this process it is the support cradle which is moved in order to adjust the system's height. Once the red-coloured shipping fixtures are removed (described later), the cryostat will be suspended from the support cradle via rubber anti-vibration mounts. The rubber anti-vibration mounts can be seen in Figure 4-9.

> **!** CAUTION – Support Stand
> Note that the stand must be securely bolted to the optical table before attempting this procedure.

Figure 4-8: Side panel bolt spacing

Start by loosening the M6 nuts on top of each of the rubber mounts, as shown in Figure 4-9 (Right), until the nuts are more than 25mm clear of the black “L” brackets. Then loosen the four bolts (2 front and 2 back) adjacent to the grub screws in the red shipping plate until the end of the bolts are flush with the top of the red shipping plate as shown in Figure 4-10 (Right).

Figure 4-9: Raising M6 nuts on the rubber mounts

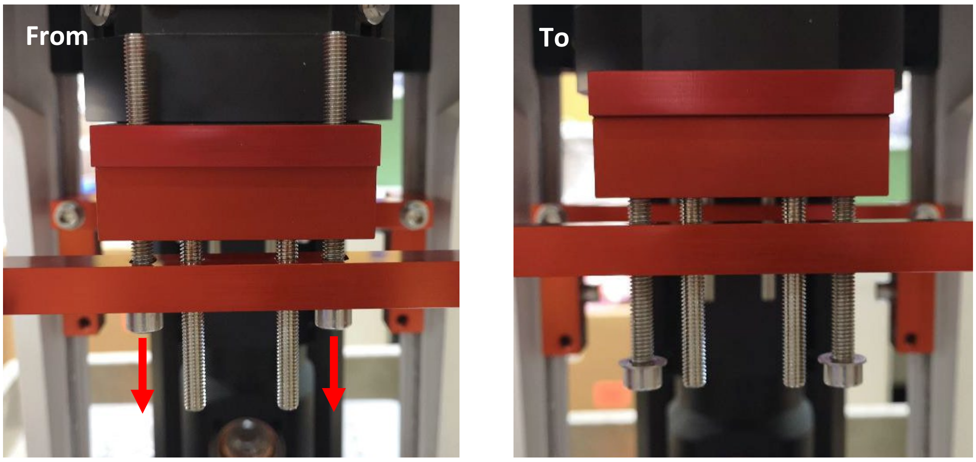

Figure 4-10: Loosening the shipping plate bolts

Carefully tighten each of the grub screws (2 front and 2 back), adjusting them evenly to keep the cryostat level. This will slowly raise the red plate away from the red crossbars, as shown in Figure 4-11 (Left). Once the gap between the red plate and crossbars is 25mm in height stop tightening the grub screws. Then raise the thumb-nuts on the rubber mounts to up to the cryostats black "L" brackets, as shown in Figure 4-11 (Right), to help steady the top of the cryostat.

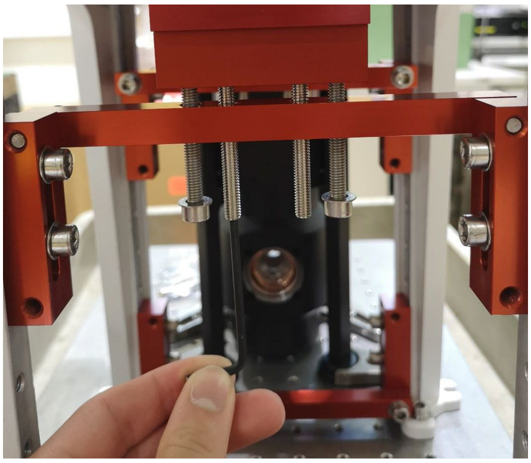

Figure 4-11: Tightening the shipping plate grub screws (Left) and raising the thumb nuts (Right)

To add extra support to the cryostat, the four legs on the side of the optical section can also be lowered, however, do not clamp them to the table at this stage. To lower the legs, loosen the two countersunk screws on each leg and adjust the leg so the foot is sitting on the table surface as shown in Figure 4-12. Tighten the screws again once the legs are positioned. The support cradle is now ready to be raised by a single bolthole.


Figure 4-12: Adjusting leg height of optical cryostat section

The cryostat is currently supported by the red shipping fixtures at the bottom and the thumb-nuts at the top. It is therefore safe to adjust the bolts holding the support cradle. Remove the lower four bolts (one at each corner) and loosen the upper four bolts at each corner, as shown in Figure 4-13. Lower the four thumb-nuts on the rubber mounts until they are just touching the top of the mounts. Then lift the support cradle until it is possible to insert the previously removed bolts into the next pair of bolt holes up on each side panel, this will raise the support cradle evenly by 25mm. Tighten all eight bolts holding the support cradle and raise the thumb-nuts so that they support the cryostat body's black "L" brackets again.

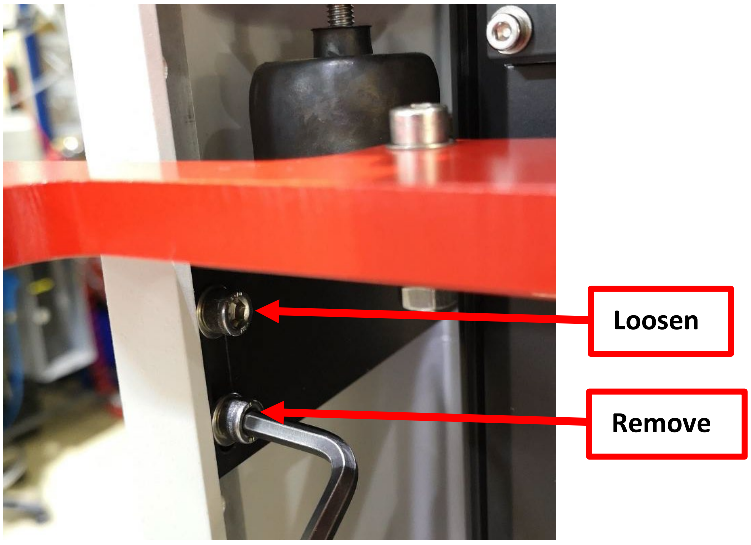

Figure 4-13: Support cradle bolt adjustment

Next, you will need to raise the height of the upper set of red crossbars. Remove the lower bolts and loosen the upper bolts that secure the top pair of crossbars to the side panels. The cryostat is now suspended firmly by the thumb-nuts on the rubber mounts and so the grub screws to the red plate can be loosened. Un-do the grub screws until the tops sit flush with the face of each crossbar, as shown in Figure 4-14 (Left). Then tighten the bolts either side of the grub screws to pull the crossbars up to the red plate (the crossbars can also just be lifted), as shown in Figure 4-14 (Right). Replace the removed bolts through the crossbar slots into the next pair of bolt holes up on each side panel. Finally tighten the eight bolts that secure the crossbars to the side panels.

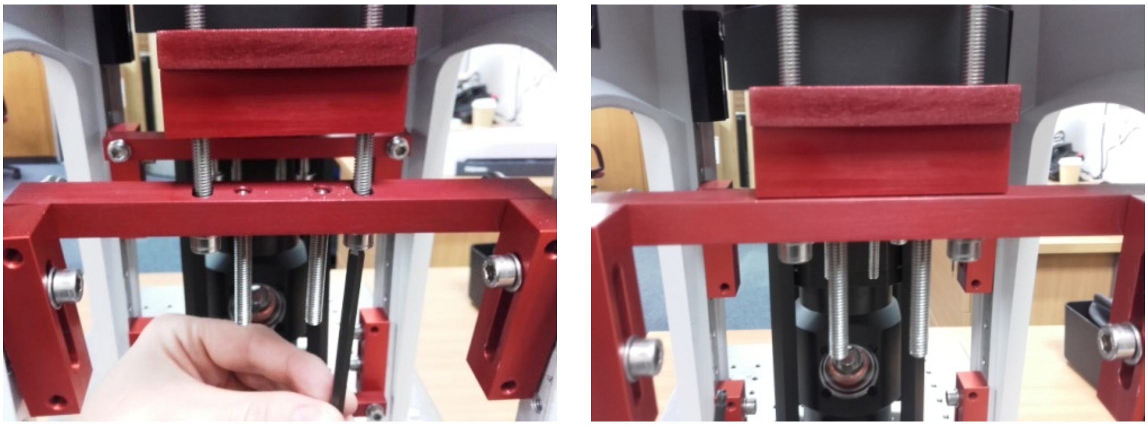
Figure 4-14: Upper crossbar height adjustment

The cryostat will now be back to the same state as at the beginning of this section, except the height of the cryostat, and hence optical windows, has been raised by ~25mm. For further coarse adjustment, return to the top of this section and repeat the necessary steps. In order to make smaller adjustments to the height of the optical windows, carry out the fine height adjustment process as described below.

4.7 Fine height adjustment (< 25 mm)

The process for fine adjustment of the window height begins with the same steps as for the coarse adjustment. First loosen the M6 nuts on the rubber mounts to raise them away from the black "L" brackets, as shown in Figure 4-15 (Left). Next loosen the crossbar bolts next to the grub screws that hold the red fixing plate, and use the grub screws to adjust the height of the cryostat, as shown in Figure 4-15 (Right). It is important that the grub screws are adjusted evenly to ensure the cryostat remains level in the frame. Continue to adjust the grub screws until the windows are at the desired height, then use the thumb-nuts on the rubber mounts to help support (but not fully take) the weight of the cryostat.

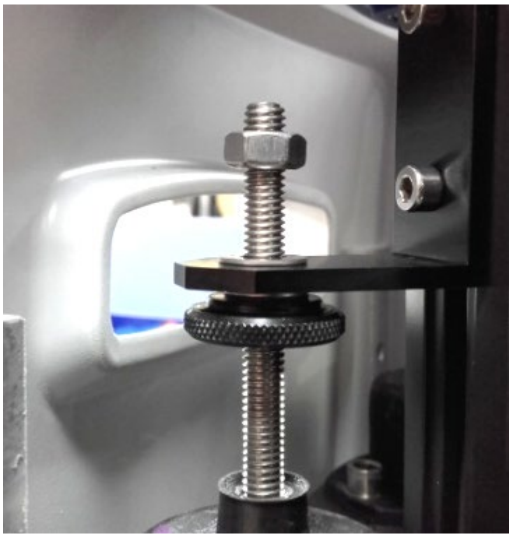
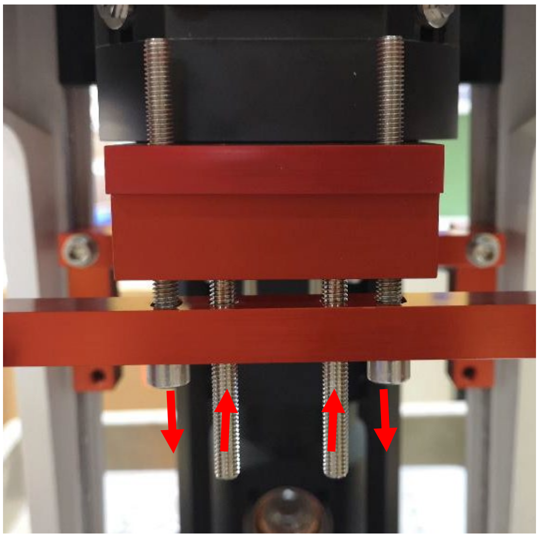

Figure 4-15: Fine height adjustment process

Before the removal of the red shipping fixtures, the cryostat must be firmly bolted in place. This is because the red plate is holding the optical tail at the correct height and position relative to the main body of the cryostat.

First, make sure that the support stand is firmly secured to the optical table using the appropriate slots in the feet of the support stand as per Figure 4-2. Next, adjust and position each of the optical tail legs to be level with the table surface, as shown earlier in Figure 4-12. Now the feet can be clamped to the optical table using the clamping forks and bolts provided in order to hold the optical tail securely in place, as shown in Figure 4-16.

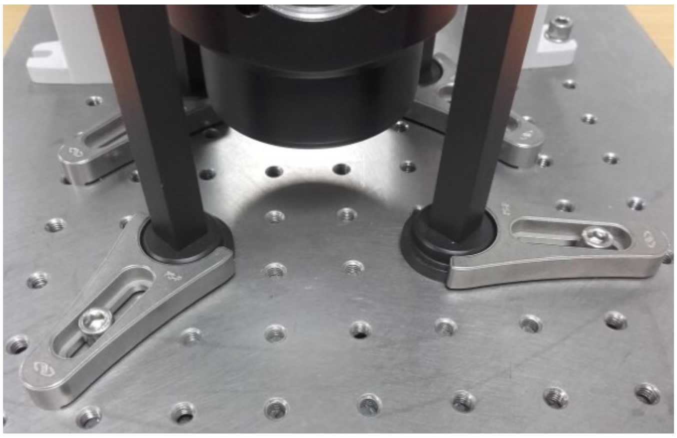

Figure 4-16: Optical tail legs secured in place with clamping forks

Loosen, but do not fully remove, the four small screws on the underside of the red plate, as shown in Figure 4-17 (Left). This will allow the height of the cryostat to be carefully adjusted with the thumb-nuts, allowing the rubber mounts on the support cradle to take the full weight of the cryostat. Adjust the thumb-nuts further to raise the cryostat a small (~1 mm) but even distance away from the red plate, as shown in Figure 4-17 (Right).

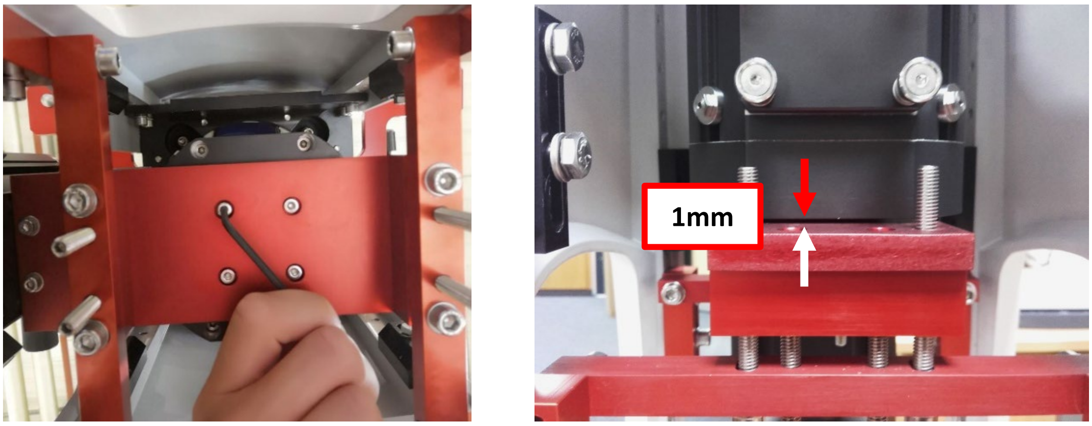

Figure 4-17: Demounting the shipping plate from the cryostat body

Finally, it is important to check for electrical isolation across the bellows between the cryostat body and optical tail, as shown in Figure 4-18. A resistance reading (touch) here indicates that the bellows are misaligned at either end. This means that either the cryostat body or optical tail is not sat square relative to the support stand. If a resistance reading is observed at this point use the thumb-nuts and optical tail support legs to adjust the position of the cryostat and optical tail until the resistance reading shows an open circuit.

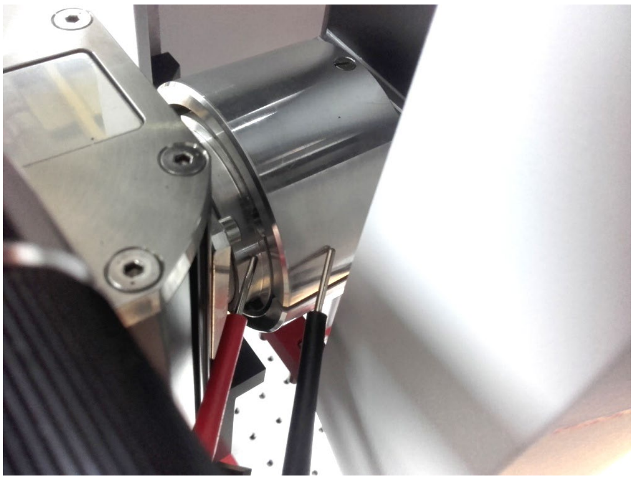

Figure 4-18: Electrical isolation check between the cryostat body and optical tail

With the legs now holding the optical tail securely in position and the weight of the main body of the cryostat suspended from the support cradle, the next stage is to re-fit the radial restraints which assist in keeping the cryostat square within the frame when the OVC is evacuated.

4.8 Fitting the radial restraints

It is vital that the cryostat sits centrally to the support stand. The radial restraints which were removed earlier provide lateral support and help attenuate cryostat vibration relative to the optical table. They are fitted (under slight compression) between the locator studs on the exterior of the main OVC body and the four side panel legs, as shown previously in Figure 4-5.

Pins at each end of each restraint match recesses in locator blocks mounted on each side panel leg and in the locator studs on the corners of the cryostat as shown in Figure 4-19. The four locating blocks should be positioned such that one of the small impressions in the block is at the same height as the locator studs on the cryostat body so that each restraint will sit horizontally.

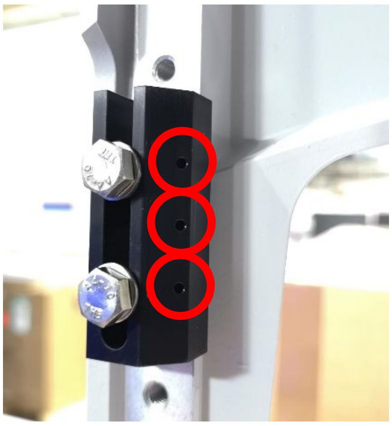

Figure 4-19: OVC locator stud (Left) and side panel locating blocks (Right)

Insert the radial restraints by moving the locating block above or below the locator stud, positioning the restraint between the two, and sliding the block into place before tightening the bolts to secure the locator block to the side panel. It is important that each restraint sits horizontally, and not at an angle. Since the length of each restraint should not have changed replacing each one back in the corner from which it was removed should hold the cryostat central to the frame. The restraints at the front of the cryostat (near the optical tail) are slightly more difficult to access, so these should be located first.

Since the previous resistance check between the cryostat body and optical tail should already indicate that the cryostat is well-centred, the radial restraints should only need gentle tightening into position without the need for applying any significant force to the cryostat body. Once the restraints are in place, repeat the resistance check, as previously shown in Figure 4-18. If a touch has appeared, very carefully adjust the restraints lengths to move the cryostat body back into an open circuit position.

Should you require to change the length of the restraints for any reason, this is done by loosening the hexagonal locking nut on the restraint using a 10mm open-ended spanner and changing the overall length by screwing the adjustable pin in or out by hand. Each restraint has two small through-holes, which serve as points through which a small Allen key can be used to assist with loosening and tightening as shown in Figure 4-20. Once the correct length is set, tighten the locking nut to hold the restraint at the correct length.

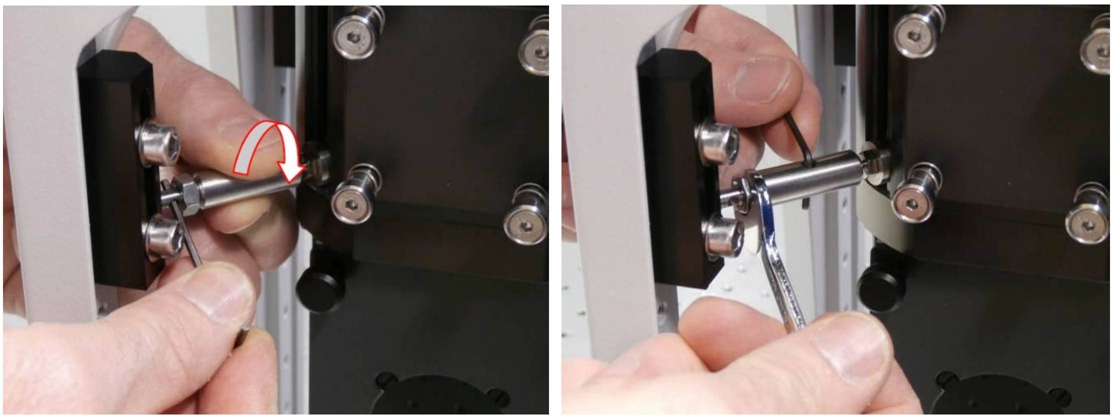

Figure 4-20: Adjusting the length of radial restraints

4.9 Removing the shipping fixtures

Even if the height of the cryostat has not been adjusted, it is still necessary to firmly secure the support stand side panels to the optical table, as shown in Figure 4-2, and bolt down the feet of the optical tail section, as shown in Figure 4-16, before proceeding. Additionally, a resistance check, as shown in Figure 4-18, should be carried out to check the cryostat body and optical are aligned correctly.

The red shipping fixtures can now be removed. Be sure to store them in a safe place as they will be required in future should the system height need adjusting or if the system needs to be transported.

To remove the shipping plate, begin by removing the four small bolts on the underside of the red plate to detach the shipping plate from the cryostat body. Then remove the four bolts that secure the red plate to the crossbars. Finally, remove the two bolts that secure the plate to the optical tail, as highlighted in Figure 4-21 (Left). The plate can then be removed via the rear of the support stand.

To remove the red lifting plates with eyebolts, remove the four bolts, two from each, that secure the plates to the support cradle. The bolts to be removed from each plate are highlighted in Figure 4-21 (Right).

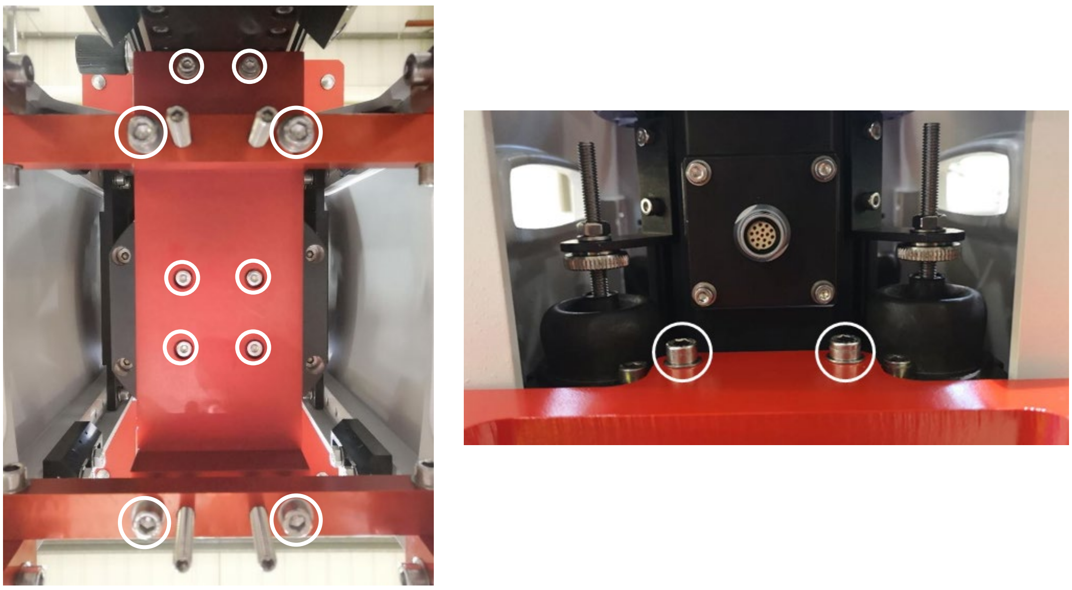

Figure 4-21: Bolts to be removed to free the shipping plate (Left) and lifting plates (Right)

Again, check the resistance across the bellow to ensure nothing has moved, as previously shown in Figure 4-18. Finally remove all four sets of red crossbars from the legs of the frame and perform a last resistance check once all the shipping fixtures have been removed. The system should now resemble the system shown in Figure 4-22.

Figure 4-22: OptistatDry TLEX system after the removal of shipping fixtures

4.10 Setting up the compressor

Ensure the compressor always remains level. When installed, you must allow at least 600 mm on all sides of the compressor for maintenance purposes. To install the compressor, you must read and follow the following procedures as described in the SHI compressor technical manual:

- Remove the shipping bolt.
- Mains power supply connection.
- Field wire the compressor. How to hard wire the compressor to your power supply.
- Compressor checkout. The compressor should be operated before being connected to the other system components. This section also describes connection to the coolant supply, for water-cooled compressors. With water-cooled compressors, it is advisable to install a water detection monitor in case the compressor leaks during operation to prevent slip hazards.

⚠	HAZARDOUS VOLTAGE Permit only qualified electrical technicians to open electrical enclosures, perform electrical checks or perform tests with the power supply connected and wiring exposed. Failure to observe this warning can result in serious injury or death.

!	CAUTION – Compressor Setup If the compressor boost transformer tap settings do not match the mains supply voltage this may result in damage to the compressor.

4.11 Setting up the high-pressure helium lines

You must read and follow the procedure described in the SHI compressor technical manual. The compressor and cold head ports are labelled **Supply** and **Return**. You must connect correctly, **Supply** to **Supply** and **Return** to **Return**. The two lines are otherwise identical, as can be seen in Figure 4-23.

Figure 4-23: GM cooler high-pressure lines

A typical support and restraint setup for the high-pressure lines is shown in Figure 4-24. For optimum vibration performance, the following guidelines should be followed when routing the helium gas lines from the compressor to the cold head.

- The lines must be supported horizontally where they attach to the cold head so that they exert no force on the cryostat.
- The cryostat must be supported evenly on all four anti-vibration mounts so that the cryostat body is vertical. Check that the clearance between the cold head cover and side panels is the same on both sides to confirm that this is the case.
- The supply line should be restrained as close as is practically possible to the cold head. Ideally, the restraint should take the form of a rubber lined clamp that conforms to the profile of the line, without crushing or damaging it.
- The return line should be supported but not restrained. The return line is subject to slight movements caused by gas pressure pulses and hence should be provided with a guide manufactured from PTFE or similar that will allow it to move without causing wear to the protective outer braid.
- Both lines should remain flexible, not taut. The minimum bend radius is 180mm.
- Standard high-pressure helium gas lines are 3m long. Longer lines (up to 20m) are available by special request but may affect the cryogenic performance of the system.

Make the connections to the compressor first, following the guidance notes in the SHI Helium compressor technical manual. Connect the cold head motor power cable to the correct receptacle on the compressor front panel. Support the other ends of the lines as described previously before making the connections to the cold head. With all the helium gas line connections made, check that the static pressure indicated on the gauge of the compressor is within the range specified for your combination of cold head, gas line length and compressor. The nominal charge pressure is 16.6bar / 241psi.

Figure 4-24: Connections between the GM compressor and cold head

4.12 Connecting the temperature controller

The supplied MercuryiTC will have been configured in the factory for use with your system. The cables from the MercuryiTC to the cryostat should be connected as per Table 4-3.

Cable	From (Mercury)	To (Cryostat)	Function
CWA9252	DB7 (Slot 7)	OVC body (24-way)	GM1 sensor
	DB8 (Slot 8)		GM2 sensor
CWA9249 (a)	MB1 (Sensor Heater)	VTI tail (16-way)	VTI sensor & heater
CWA9249 (b)	DB6 (Slot 6)	Sample probe (16-way)	Sample sensor & heater

Table 4-3: Connections from the Mercury iTC to the Cryostat

5 System operation

5.1 Loading the sample probe

If the probe was removed earlier in order to adjust the height of the system, to perform a sample change, or for any other reason, it should be re-inserted at this stage.

!	CAUTION – Loading the sample probe Before loading the sample probe inspect the KF25 fitting on both the cryostat and sample probe for any damage or debris that could cause an air leak.

!	CAUTION – Loading the sample probe Before loading the sample probe inspect the O-ring to ensure it is not damaged or contaminated with any debris that could cause an air leak. Clean the O-ring if required with isopropanol and re-apply a light coating of vacuum grease.

When pumping and flushing the sample space, it is recommended that you use high-quality (five-nines) helium gas and a dry pump in order to help prevent contamination of the sample space. Flush the sample space to one atmosphere before loading the probe (following the reverse of the procedure as set out in Section 4.4).

The probe can now be loaded into the sample space. It is recommended that the seal between the probe and the sample space is leak checked, using a mass spectrometer-type leak detector, before flushing the sample space with helium. Finally, pump and flush the sample space one more time, leaving one atmosphere of helium gas in the sample space. Fit an NW16 blank to the sample space pump and flush port when you have finished so that the port will still be sealed even if the valve fails to close fully.

5.2 Checking the thermometry

Switch on the Mercury iTC by operating the switch on the rear panel, then press the Power button on the left of the front panel, which will illuminate blue. The Mercury iTC initialises and the home screen will be displayed appears on the touch screen, as shown in Figure 5-1. Check that the indicated temperatures are all consistent with your laboratory environmental temperature.

Figure 5-1: MercuryiTC home screen at room temperature

5.3 Regenerating the sorption pump

During use, the cryostat vacuum is maintained using an internal sorption pump (sorb), with activated charcoal as the adsorption material. The sorption pump is an integral part of the radiation shield inside the main OVC body. The performance of the sorb can be adversely affected by any build-up of moisture or other contaminants over time.

It is recommended that you regenerate the sorb before using the system for the first time, or if the system has not been used for an extended period, or if the OVC has been open to atmosphere for any period. It is recommended to wear gloves (latex or similar) when handling the sorb assembly.

To remove the sorb, first vent the cryostat with dry nitrogen gas via the NW16 OVC valve and pump-out port (Figure 4-3). If the height of the system has been adjusted prior to use, the OVC should already be vented.

With the OVC vented, remove the lower sealing plate and O-ring from the main OVC body. This is held on by 8 screws from the underside. Removing this plate gives you access to the sorb assembly, which is attached to the bottom of the radiation shield by four screws. Remove these screws and carefully remove the sorb.

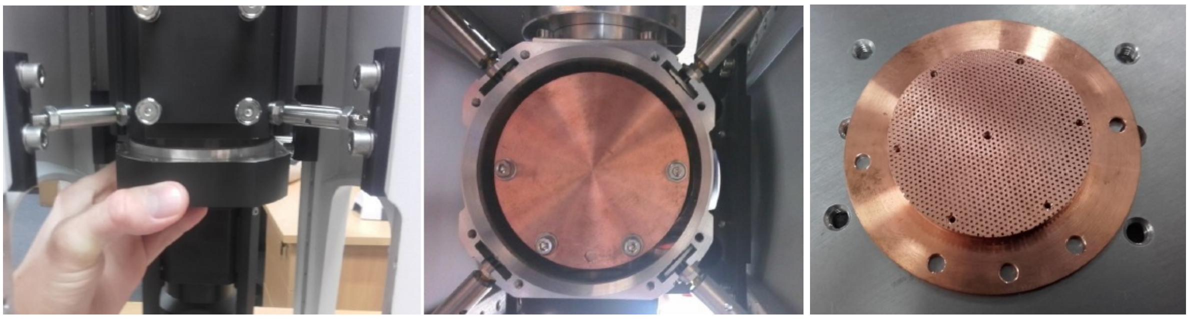

Figure 5-2: Removing the cryostat's sorb

The sorb is on the upper side of the copper plate that you just removed from the cryostat. The activated charcoal is contained underneath a copper mesh. It is not necessary to remove the charcoal from this assembly.

> WARNING – Regenerating the sorb
> While heating the sorb take all precautions necessary to prevent injury/damage to personnel and equipment. Wear suitable PPE such as thermally insulating gloves to reduce the risk of burns.

To regenerate the sorb, heat the assembly to around 100°C using either a heat gun or hot plate. Hold the sorb at this temperature for at least 10 minutes. If possible, the assembly should be placed in a vacuum chamber during or just after heating to assist in the removal of contaminants.

As soon as it is cool enough to handle safely, re-fit the sorb assembly to the cryostat, replace the sealing plate (making sure that the O-ring is clean) and immediately pump out the OVC. Always try to minimize the time the OVC and sorption pump are left exposed to atmosphere. It is advisable to refit the sorb and pump out the OVC as soon as possible, even if you are not intending to cool the system immediately.

5.4 Evacuating the cryostat

Connect a suitable pumping system to the cryostat pumping port using a suitable length of 25mm diameter flexible stainless-steel pumping line. Avoid straining the cryostat cradle, anti-vibration mounts and cryostat restraints when connecting the external pump to the cryostat. The cryostat should be pumped for a minimum of 2 hours using an oil-free pump capable of achieving a base pressure of < $1x10^{-6}$ mbar.

Ensure that the temperature controller is in manual mode and that no heat is being applied to the VTI heat exchanger or sample probe, then close the OVC valve and disconnect the pump. Then fit an NW16 blank to the OVC valve port so that it will still be sealed even if the valve fails to close fully.

During operation, the refrigerator maintains the sorption pump temperature below 60K even when the sample region is controlled at 300K. Consequently, the pumping efficiency is maintained at all times and there is no need to have the OVC continuously connected to an external pumping system once the system is cold.

5.5 Starting up the compressor

CAUTION – Vacuum Space
Do not operate the compressor while pumping out the cryostat. If you do, there is a risk of contaminating the cryostat vacuum space. In normal use, the cryostat OVC valve is closed when the compressor is running.

Examine the static (equilibrium) gas pressure reading on the compressor and compare this with the data in the SHI compressor technical manual. If any correction is needed, proceed as described in the SHI manual. Also confirm that the 50/60 Hz toggle switch on the compressor front panel is set correctly. Start up the compressor as instructed in the SHI manual, by first closing the compressor circuit breaker and then pressing the power switch. The indicator in the switch will light and the compressor will start.

5.6 Running the system to base temperature

Monitor the sample position temperature sensor and confirm that it reaches base temperature as stated in the system test data sheet. This should take less than 6 hours from when the compressor is switched on. At base temperature, the thermometry display should be similar to that in Figure 5-3.

Figure 5-3: MercuryiTC home screen at base temperature

5.7 Temperature controlling

You can control the temperature of the system either using the heater and sensor on the VTI heat exchanger, or the heater and sensor on the sample probe. For most experiments it is recommended that you control using the probe heater and sensor as this will give the best sample position temperature control.

The control temperature for the VTI or sample probe can be set to any value between base temperature and 300K. Do not set a control temperature higher than 300K. For a given set point, the MercuryiTC will automatically control the heater power to maintain the set temperature.

CAUTION – Temperature Control Do not set a control temperature in excess of 300 K.

On the Mercury home screen, tap "Control" to display the control loop screen, as shown in Figure 5-4. Select the sensor (either VTI or probe) that you wish to control from the drop-down menu at the top left of the screen. The heater control should be changed from manual (set applied power) to automatic (set temperature point) as seen below.

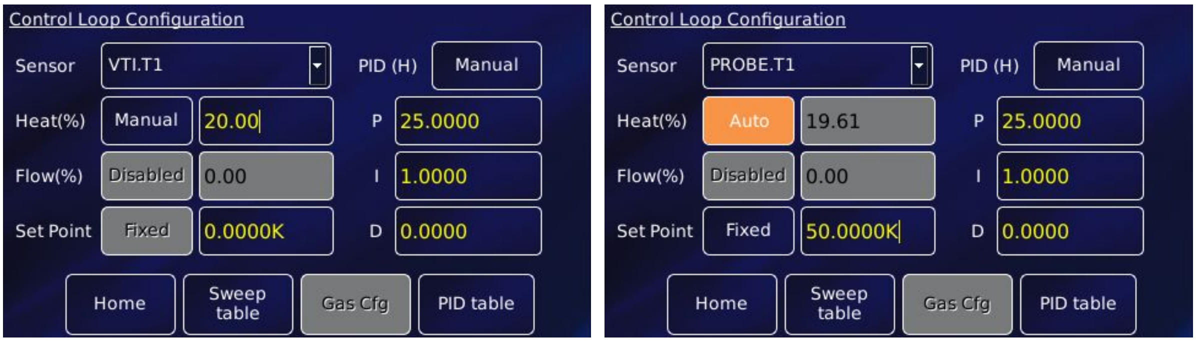

Figure 5-4: MercuryiTC control loop screens

The Mercury iTC is a three-term controller - the temperature control is optimised by setting the best values for:

- Proportional band (P)
- Integral action time (I)
- Derivative action time (D)

By default, the P, I, D values for the OptistatDry TLEX controller are set to 25, 1, 0. These numbers are suitable to give good stability across the operational temperature range. Control theory and a procedure for optimising the PID values are given in the Mercury iTC manual.

5.8 Sample changing

The sample probe is designed to be removed and loaded into the VTI sample space even if the VTI heat exchanger is cold. If you wish to reduce the thermal shock on the sample, control the temperature of the probe or the VTI heat exchanger at 290 K before removing the probe.

WARNING – Sample Probe Removal

If the sample probe cannot be removed easily from the sample space it is possible that the probe has become frozen into the system due to an air leak. In this scenario the cryostat needs be warmed up with great care as the path to the pressure relief valve may be blocked. Immediately turn off the compressor and evacuate the surrounding area until the system returns room temperature. For full details refer to Oxford Instruments Safety Matters 1.2.4, sections 3.13 to 3.16.

To remove the probe, flush the sample space with clean, dry helium gas, maintaining a positive pressure (just above 1 atmosphere) on the VTI pump-and-flush valve. Remove the probe following the procedure set out in Section 4.4, then evacuate the sample space to < $1x10^{-1}$ mbar.

COLD OBJECT – Unloading the sample probe

If the sample probe is not warmed before removal from the VTI sample space it's temperature could be as low as 4 K. Contact with cold objects and cryogens can cause serious injury to the skin as skin may adhere to cold surfaces. Ensure thermally insulated gloves are used during probe removal.

CAUTION – Loading the sample probe

Before loading the sample probe inspect the KF25 fitting on both the cryostat and sample probe for any damage or debris that could cause an air leak.

CAUTION – Loading the sample probe

Before loading the sample probe inspect the O-ring to ensure it is not damaged or contaminated with any debris that could cause an air leak. Clean the O-ring if required with isopropanol and re-apply a light coating of vacuum grease.

Make sure the probe is clean and dry before re-loading it. Before reloading the probe, once again flush the sample space with helium gas just above atmospheric pressure before carefully removing the NW25 blank. Once the probe is loaded and the NW25 clamp re-fitted, pump out the sample space, then flush with helium gas to one atmosphere before closing the VTI pump-and-flush valve. Fit an NW16 blank to the sample space pump and flush port when you have finished so that the port will still be sealed even if the valve fails to close fully.

5.9 Warming up the system

To warm the system to room temperature first switch off the compressor, then set the VTI heat exchanger to temperature control at 300 K. Once all the temperature sensors on the system read above 100 K, it is possible to accelerate the warm-up process by introducing a few mbar of dry nitrogen gas into the OVC. **Do not use air.** When all the temperature sensors read above 285 K, stop the VTI heater control and check that the heater output is zero.

5.10 Fitting optical windows

The OptistatDry TLEX is supplied with Spectrosil WF quartz windows fitted to the 4 radial ports, and blanks fitted to the axial port. A full set of blanks are supplied in the system spares kit.

Before changing any windows, ensure that the system is fully warm by checking that all temperature sensors read above 285K. Windows can be removed and replaced while the cryostat is mounted on the optical table, if there is adequate access. Always wear protective gloves when handling any of the windows. For cleaning, use a dry aerosol can to remove dust or fibres, and lint-free tissue with a suitable solvent (e.g. isopropanol) to remove grease or moisture.

Refer to the images in Figure 5-5 showing how the OVC and radiation shield windows are mounted. A vacuum tool or plastic tweezers can be helpful for handling windows. **Do not use sharp tools.**

Use dry nitrogen gas to vent the system via the NW16 OVC valve. The OVC windows (or blanks) are held in place by one O-ring and 4 x M3 nylon screws. Holding the window in place, remove the four screws before carefully removing the window. For the radiation shield, remove the spring clip holding the window (or blank) in place before carefully removing the window.

Carefully remove the OVC O-ring. If any signs of wear are found, the O-ring must be replaced. Clean the O-ring before coating the surface with a thin layer of silicone vacuum grease, then carefully place the O-ring back in its groove.

Fit the new windows and blanks as required. The radiation window ports can be left empty, if desired. Ensure the radiation shield windows are held securely by the spring clips. OVC windows should be placed directly onto the O-rings before replacing the four screws. Tighten the screws uniformly until the heads just contact the window surface. The screws are only required to stop the window falling out - the vacuum force exerted in operation will seal the window uniformly.

CAUTION – Window Mounts
Do not over-tighten the OVC window screws. Over-tightening could lead to window fracture or poor vacuum sealing.

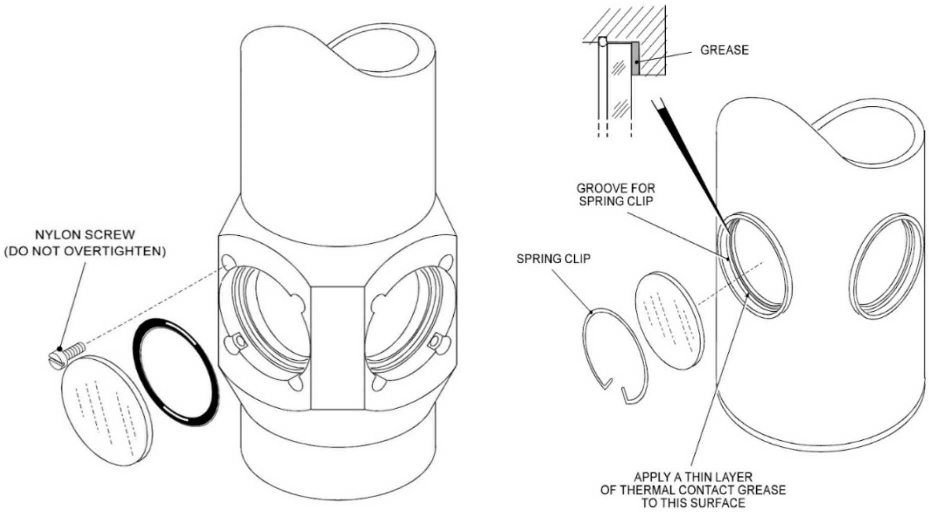

Figure 5-5: Changing OVC and radiation shield windows

6 Service and maintenance

The OptistatDry TLEX will deliver repeatable and reliable performance if maintained properly during its usage. This section contains basic and essential maintenance information.

6.1 Maintenance schedule

Maintenance	Frequency
Anti-vibration mounts	2 years
Radial restraints	2 years
GM cold head	10,000 hours
Compressor adsorber	30,000 hours

Table 6-1: Recommended maintenance intervals for serviceable components of the TLEX.

6.2 Anti-vibration mounts and radial restraints

In order to achieve repeatable and reliable sample position stability performance, we recommend replacing the antivibration mounts and radial restraints, used to secure the system into its stand, on a two-year cycle.

6.3 GM cold head and compressor maintenance

During normal operation the GM cold head's internal components will wear through friction and the oil mist adsorber will become saturated. Maintenance on the GM cold head is recommended at 10,000 run hours for optimum performance. Adsorber replacement must occur every 30,000 hours, as it is critical in ensuring the helium gas circuit remains contaminant-free. The adsorber replacement and helium gas charging procedures are described in the SHI compressor technical manual.

Oxford Instruments offers on-site installation of service exchange cold heads and compressor adsorbers. Please contact us for more information.

6.4 Troubleshooting

Should you encounter a problem with your system, it is first important to establish the source. This could be the cryocooler system, the MercuryiTC, or within the cryostat itself.

Diagnosis of cold head and compressor faults should be made using the *Troubleshooting* section of the SHI SRDK-101D-HC4A2 (or HC4E2) Cryocooler operation manual.

Diagnosis of MercuryiTC temperature controller faults should be made using the MercuryiTC manual *Troubleshooting* chapter.

Refer to the following troubleshooting recommendations for problems arising from the cryostat itself, or a combination of the above.

If you are unable to resolve the problem, please direct all enquiries through your nearest support facility. Please provide a full set of test data for diagnosis, along with details of any additions or modifications that you may have made to the system.

Issue	Possible cause	Recommendation
Poor temperature control	Incorrect temperature controller PID settings	Refer to the system's test results and the MercuryiTC manual.
Heater or sensor wiring fault	Wiring short or break	Check wiring resistances and compare with values in the factory test results.
Poor cryostat vacuum	Vacuum leak	Examine O-rings for contamination or damage. Check windows and electrical connectors are correctly sealed and undamaged. Check pressure relief valves are sealing correctly. Use a leak detector to identify the leak.
	Water contamination	Warm up thoroughly to ensure all internal surfaces are free of condensed water and regenerate the OVC sorption pump.
Sample probe stuck	Vacuum Leak	Switch off the compressor, evacuate the surrounding area and allow system to slowly warm up. For full details refer to Oxford Instruments Safety Matters 1.2.4, sections 3.13 to 3.16.
High base temperature	Thermometer fault	Check sensor resistance at base temperature and compare with the supplied sensor calibration data (remember to account for the resistance of the wiring)
	Cryocooler performance	Check the static room temperature helium pressure readings on the compressor. Check the compressor's run-time counter against the recommended service intervals.
Condensation on OVC	Poor cryostat vacuum	Check poor cryostat vacuum actions.
Condensation on windows	Air humidity	Use a dry nitrogen source to shield the windows.
Compressor will not start	Electrical supply	Refer to SHI manual and check fuses.
Compressor stops unexpectedly	High helium discharge temperature.	Refer to SHI manual.

Table 6-2: Common issues and most likely causes.