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System User Manual

Cryostation 200 PT

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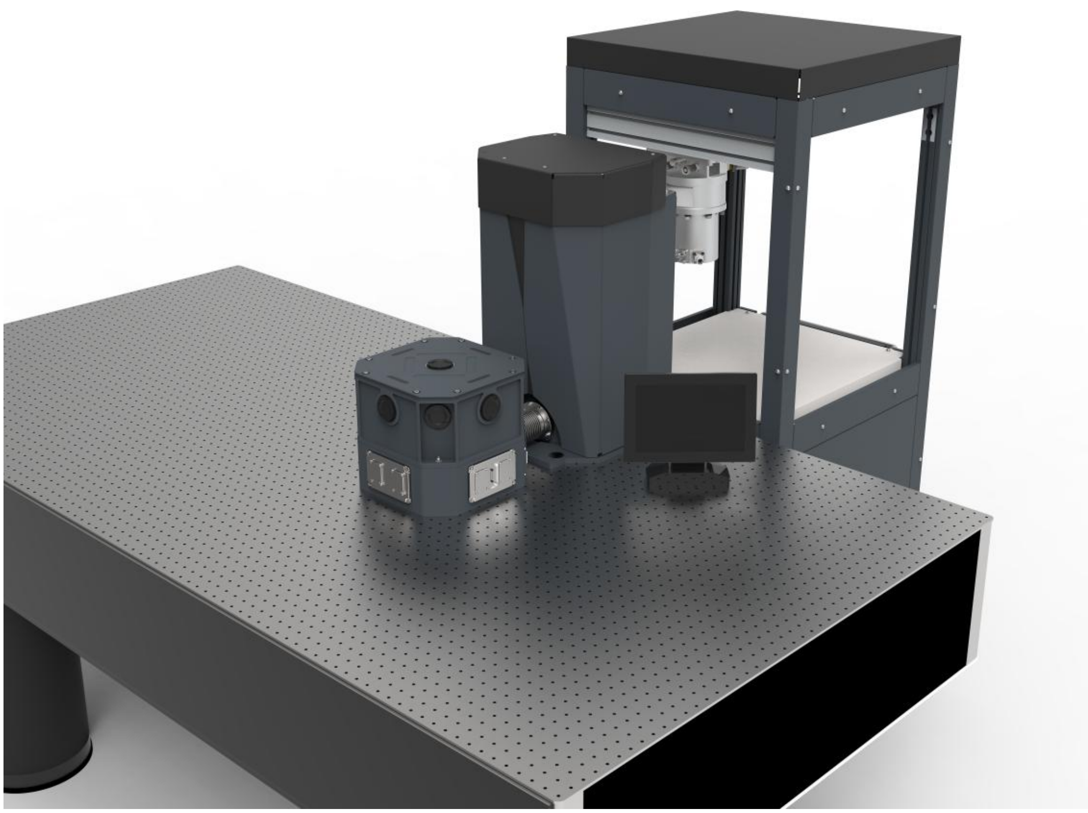
MONTANA INSTRUMENTS®



Specifications and product information listed in this document are accurate at the time of publishing for a standard system. Options, custom designs, and other modifications may cause slight differences. Future design changes to the system, including software updates, may change information.

Table of Contents

Section 1 - Preface

⚠ WARNING

Read all instructions before using this product

All users must read and understand this manual and all other safety instructions before using the equipment. Retain these instructions for future reference.

This manual is intended for users of Montana Instruments products and systems described herein. Users include anyone who may physically interact with the system or peripheral equipment, including installation, setup, or configuration. This includes anyone who may operate system components via control panels, the supplied user interface, or remote interfaces.

This manual may be used by facilities personnel to determine infrastructure requirements in the room or building where the equipment will be installed.

This manual is meant to be referenced by authorized service personnel for important safety and hazard information and other product restrictions.

1.1 Conventions Used in this Manual

The following style conventions are used in this document:

- Vertical bar (|)
  - Indicates alternative selections. The bar may be used in place of “and” or “or”.
- Alphanumeric List (1., 2., 3…| a., b., c…)
  - Indicates instructions or actions which should be completed in a specific ordered sequence.
- Bullet List (• | ◦ | -)
  - Indicates instructions, commands, or additional information about an action.
  - May alternatively be used for unordered lists of materials or additional reference notes.
- `Courier Font`
  - Indicates a label or indicator on a physical product or part.
  - Indicates a system output, such as a display reading.

- May also be used for URLs, file paths, file names, scripting language, prompts, or syntax.

1.1.1 Abbreviations

The following abbreviations may be used:

- ACM: Ancillary Control Module
- CAN: Controller Area Network
- DMM: Digital Multimeter
- HDMI: High-Definition Multimedia Interface
- MI: Montana Instruments
- PCB: Printed Circuit Board
- TCM: Temperature Control Module
- UI: User Interface
- UPS: Uninterruptible Power Supply
- USB: Universal Serial Bus
- VNC: Virtual Network Computing

1.1.2 International System of Units (SI) Symbols

- C: Celsius
- cm: Centimeter
- K: Kelvin
- kg: Kilogram
- m: Meter
- mK: Millikelvin
- MPa: Megapascal
- mTorr: Millitorr
- mW: Milliwatt
- s: Second

1.1.3 System of Imperial Units Symbols

- ft, ‘ : Foot

- in, " :   Inch

1.1.4 Explanation of Safety Warnings

Safety and hazard information includes terms, symbols, warnings, and instructions used in this manual or on the equipment to alert users of precautions in the care, use, and handling of the system. The following hazard levels and information are considered:

DANGER
Serious personal injury
Imminent hazards which, if not avoided, will result in serious injury or death.

WARNING
Serious personal injury
Potential hazards which, if not avoided, could result in serious injury or death.

CAUTION
Possible personal injury
Potential hazards which, if not avoided, could result in minor or moderate injury.

NOTICE
Command or Product Safety Notice
Potential hazards which, if not avoided, could result in product damage.

» NOTE
Points of particular interest for more efficient or convenient equipment operation; additional information or explanation.

1.1.5 Graphical Symbols

The following symbols may be used in diagrams, supporting text, and on physical parts:

	Hazard Alert: General Warning		Hazard Alert: High Voltage
	Hazard Alert: Laser Radiation	HDMI	HDMI port
	CAN bus module		USB port
	Hazard Alert: Hot Surface		Hazard Alert: Magnetic Field
	Waste Electrical and Electronic Equipment (WEEE)	CE	Conformité Européenne (CE)

	Multimeter Required		Hand Push Button

1.2 General Hazard Information

The following descriptions are of general hazards and unsafe practices that may result in product damage, severe injury, or death.

- The products, parts, and components in this manual are to be serviced by authorized Montana Instruments service representatives only. Failure to do so will void the warranty and may damage the product and/or create a safety hazard.
- Only use components provided for the intended purpose described herein.
- If the equipment or any component is used or modified in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

The following hazards may be typical for this product:

⚠ **WARNING**
Risk of injury when lifting or moving system components System components, including standalone equipment and installed assemblies, may be heavy. • Use caution when lifting or moving equipment or assemblies. Ensure proper lifting principles are used to avoid injury. • Equipment or assemblies >20 kg should always be lifted by two or more people or with a suitable lifting device.

WARNING

High voltage: danger of electric shock

Electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or death.

- Before turning on any power supply, the ground prong of the power cord plug must be properly connected to the ground connector of the wall outlet. The wall outlet must have a third prong or must be properly connected to an adapter that complies with these safety requirements.
- Only use replacement power cords or power plugs with the same polarity and power rating as that of the original ones. Do NOT use inadequately rated cables.

If the equipment or the wall outlet is damaged, the protective grounding could be disconnected.

- Do NOT use damaged equipment until its safety has been verified by authorized personnel.
- Do NOT disconnect or tamper with the operation of the protective earth terminal inside or outside the apparatus.

NOTICE

Only clean exterior surfaces with acceptable fluids

- Only use deionized water, glass cleaner, or isopropyl alcohol to clean the exterior surfaces of any enclosure. Do NOT use any volatile chemicals other than isopropyl alcohol.
- Apply fluid to a clean, lint-free cloth and wipe the surface with a cloth. Do NOT apply fluid directly to any surfaces or enclosures.

1.3 Technical Support Information

Any technical questions or issues with the system that cannot be resolved with the information in this manual should be referred to an authorized Montana Instruments service representative.

1.3.1 Warranty & Repairs

If the system or parts need to be returned to the Montana Instruments factory or an authorized service center for repair or service, contact an authorized service representative for a return merchandise authorization (RMA) number and instructions on returning the unit.

For a copy of the Limited Warranty Agreement, visit:
https://www.montanainstruments.com/support/warranty-information

1.3.2 Accessories & Replacement Parts

Only use cables, hoses, accessories, and parts provided or approved by the manufacturer. Follow all instructions for proper installation or replacement.

- To order spare or replacement parts, please contact your local service representative.
- To order new accessories or options, or for more information on other Montana Instruments products and technologies, please contact your local sales representative.

1.3.3 Contact Details

For a complete list of sales and service centers visit: www.montanainstruments.com/Contact

North American Authorized Service

- M-F 8:30am-5pm MST | Call: +1.406.551.2796
- Email: support@montanainstruments.com

North American Sales

- M-F 8:30am-5pm MST | Call: +1.406.551.2796
- Email: sales@montanainstruments.com

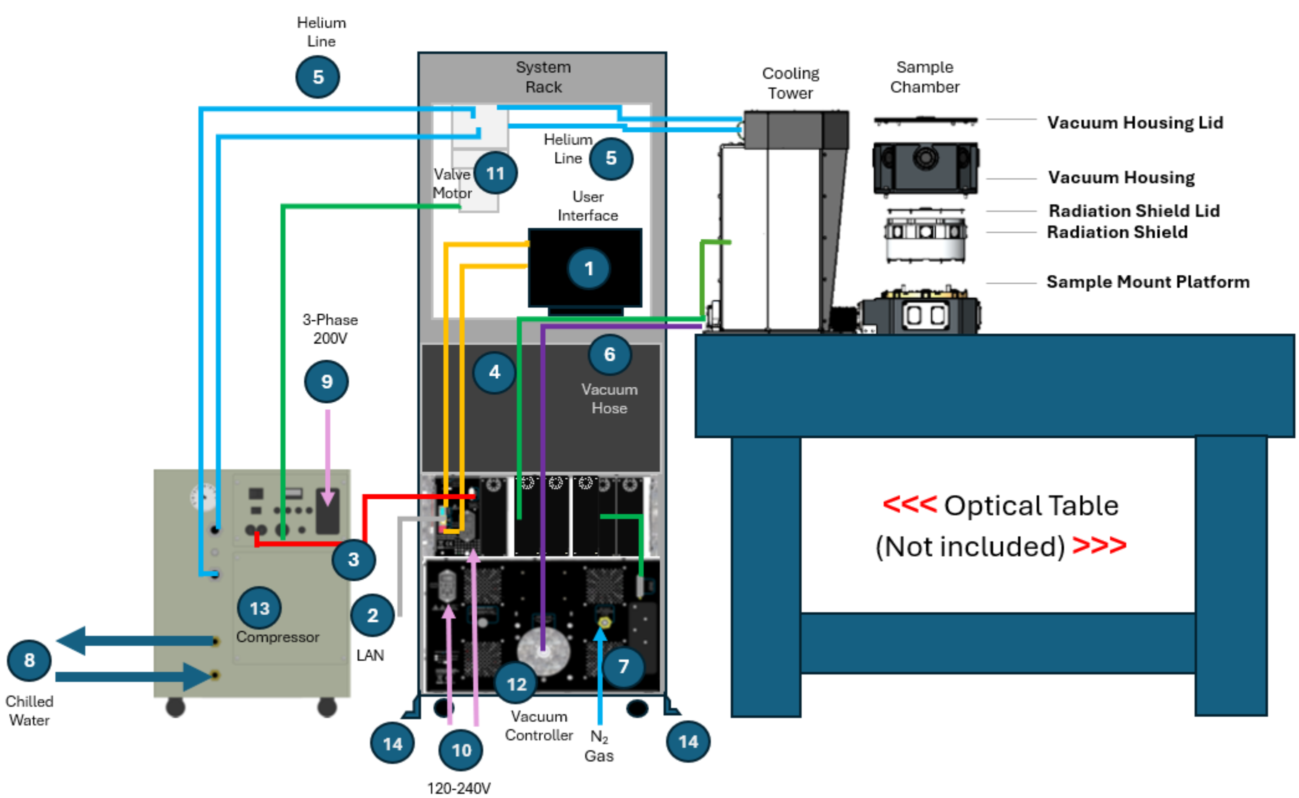
International Sales & Authorized Service

- Visit www.montanainstruments.com/Contact for contact information for your local representative.

Section 2 - System Overview

2.1 System Interconnect Diagram

1. User Interface
2. LAN
3. Compressor Communication
4. System Control
5. Helium Line
6. Vacuum Hose
7. Nitrogen (N2 Gas)
8. Chilled Water
9. 3 Phase 200V
10. 120-240V
11. Valve Motor
12. Vacuum Controller
13. Compressor
14. Earthquake support bracket



2.2 Intended Use

The system is a closed-cycle optical Cryostation used to control the temperature and vacuum parameters of an integrated sample environment.

The Cryostation is designed to connect to the system rack that includes the pulse tube valve motor, vacuum control unit, and system controller and the system rack connects to the helium compressor provided by Montana Instruments.

2.3 Cryostation

2.3.1 Components

Cryostation

The Cryostation consists of the cooling tower assembly and the sample chamber, connected by a baseplate and a semi-rigid bellows assembly. The entire Cryostation assembly is rigidly mounted at either 45° or 90° to the hole pattern on an optical table via screw locations in the baseplate (optical table not included). The Cryostation can be mounted on either imperial or metric optical tables.

Cooling Tower Assembly

The main cooling is provided by a two-stage pulse tube (PT) cryocooler suspended inside the cooling tower assembly (the vertical aluminum cylinder inside the sheet-metal rear case). A vibration damping support structure serves to isolate the cryocooler mechanical vibrations from the optical table and sample platform. The cryocooler is part of a closed-loop flow of helium which is pressurized by the separate helium compressor.

The cryocooler has two principal stages, each with thermometers to monitor temperature and heaters for warmup. Stage 1 is thermally coupled with the radiation shield inside the sample chamber. Stage 2 is thermally coupled with the sample mount platform.

Sample Chamber

The sample chamber consists of the lower vacuum housing with interfacing side panels, the sample mount platform and sample mount assembly, a surrounding radiation shield with inner “cold” windows, and the upper vacuum housing assembly with outer “warm” windows.

Thermal fluctuations are damped using both active and passive techniques. The sample platform mitigates the effects of thermal contraction during cooldown by using a thermal contraction-canceling design of the sample support structure.

Helium Compressor

Compressor unpacking and installation instructions are contained in the Installation Procedure. Refer to the Operating Instructions provided by the original manufacturer for further technical details, advanced operating instructions, and important safety information regarding the compressor. Pressure sensors allow for system monitoring and can aid in the detection of leaks.

2.3.2 Technical Specifications

Environmental Specifications

Humidity	5 – 80% non-condensing
Altitude	<2000 m

Power Specifications

Model	Compressor: F-70LP/F-70HP
Mains Power Connector on Unit	A field wiring terminal box with an opening for a 1-inch nominal or M32 conduit connector is provided.
Line Voltage	200VAC±10% 3 Phase (F-70LP) 460-480VAC±10% 3 Phase, 60 Hz (F-70HP) 380-415VAC±10% 3 Phase, 50 Hz (F-70HP)
Frequency	50/60Hz
Maximum Power Consumption (typical)	6.7-7.2 kW (startup <8.5 kW) at 50 Hz 8.0-8.5 kW (startup <9.8 kW) at 60 Hz
Ambient Temperature *(Cooling Capacity may degrade if ambient temperature is above 28 ºC [82°F])*	4-40 ºC (39-104 °F)
Water Requirements *(See* Lab Requirements document *for specifications related to water quality)*	
Cooling Water Flow Rate	6.8-9 L/min. (1.8-2.4 gal./min.)
Cooling water inlet temperature:	5-25 °C (41-77 °F)
Cooling water outlet temperature:	45 °C (113 °F) maximum

Cooling water supply pressure	8 bar (116 psig) maximum
Pressure drop at 9 L/min	<1bar (<14.5 psig)

Physical Dimensions

Component	L x W x H	Mass
Cryostation	29.6 x 13.6 x 24.2 in [56.3 x 34.7 x 61.5 cm]	300 lbs [136 kg]
Compressor	17.8 x 17.4 x 22.6 in [45.3 x 44.2 x 57.5 cm]	220 lbs [100 kg]
System Rack	28.5 x 25.7 x 68.9 in [72.3 x 65.3 x 175.0 cm]	325 lbs [147 kg]

2.3.3 Safety Information

The following hazards may be typical for this product:

⚠ WARNING

Risk of serious injury due to hazards associated with cryocooling

All personnel working with the system must be aware of the potential hazards associated with cryocooling.

- Personnel working with the system should be trained in emergency measures that may be required in the event of an accident.

Risk of suffocation due to potential asphyxiates.

Nitrogen (N_2) and Helium (He) are potential asphyxiates if released into an enclosed area with poor ventilation. A decrease in air oxygen content can be caused by leaks.

- Ensure that proper tubing is used, and good connections are made at each connection point to prevent the release of these gases.

Risk of explosion due to high pressure if the system is not allowed to vent properly.

- Never bolt or otherwise fasten the lid of the sample chamber closed. The lid acts as a safety pressure release in the event of high-pressure accumulation in the Cryostation.

Risk of cold contact burns.

Parts of this system are very cold and may cause severe burns to the skin.

- Allow components to warm up to room temperature before touching. If contact occurs, consult a physician immediately.

NOTICE

Take care when moving the Cryostation

- Do NOT tilt the Cryostation more than 45 degrees. Inverting the Cryostation will cause damage.
- The Cryostation and sample chamber are a single unit. The attached sample chamber must be supported at all times. Do NOT lift the Cryostation by the sample chamber.
- Do NOT lift the Cryostation by the cryocooler tube or the top of the main body enclosure.
- The Cryostation ships with red locking plugs and shipping support to prevent damage to sensitive components. Do NOT remove these until the unit has been attached to the table.

Take care when moving the compressor

- Do NOT tilt the compressor. Doing so may damage the unit.
- The compressor is on casters for moving. Ensure casters are locked before operating.

Take care when moving system rack

- Do NOT tilt the rack off the floor stabilizers or wheels. Doing so may cause the rack to tip and can cause serious injury and/or damage to the unit.
- Ensure stabilizers and earthquake supports are locked when the system is in use.

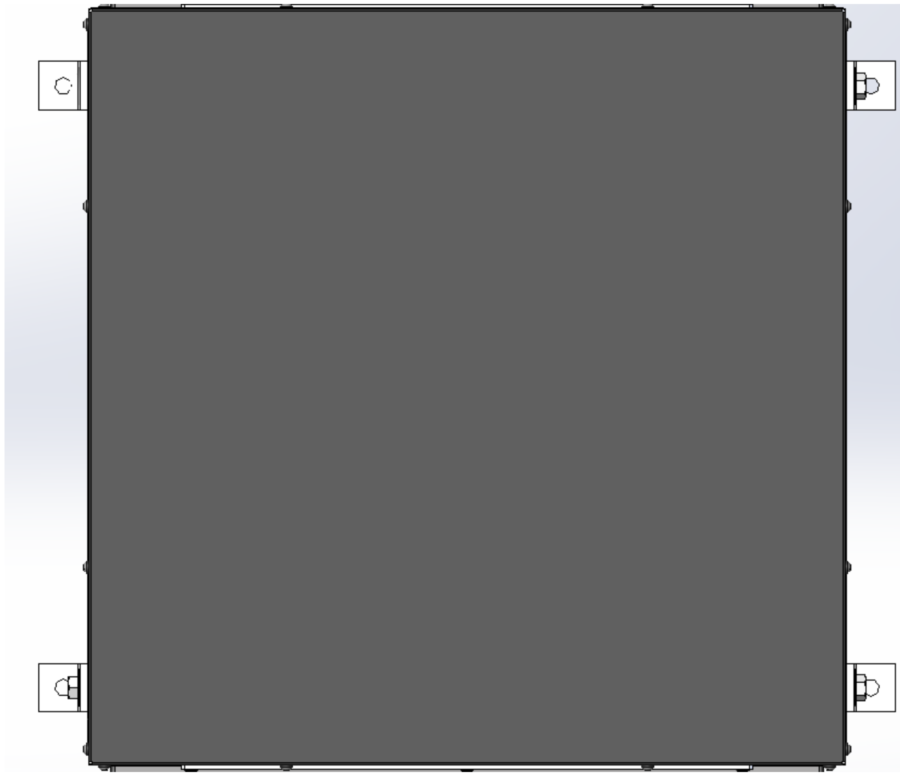
Risk of product damage due to improper use

- **Never disconnect the vacuum hose while the temperature of any stage of the Cryostation is below 285 K.**
- **Never open the case or vent valves when the temperature of any stage is below 285 K.**
- **Only use dry, high-purity nitrogen gas with the Cryostation. Do NOT substitute other gases for system venting.**
- **Avoid using any material in the sample chamber that may outgas or otherwise contaminate the optical windows and Cryostation surfaces.**
- **When manually operating heaters, monitor the Stage 1 and Stage 2 temperatures to ensure these temperatures do NOT rise above 350 K. Temperatures above 350 K may damage critical components within the system.**

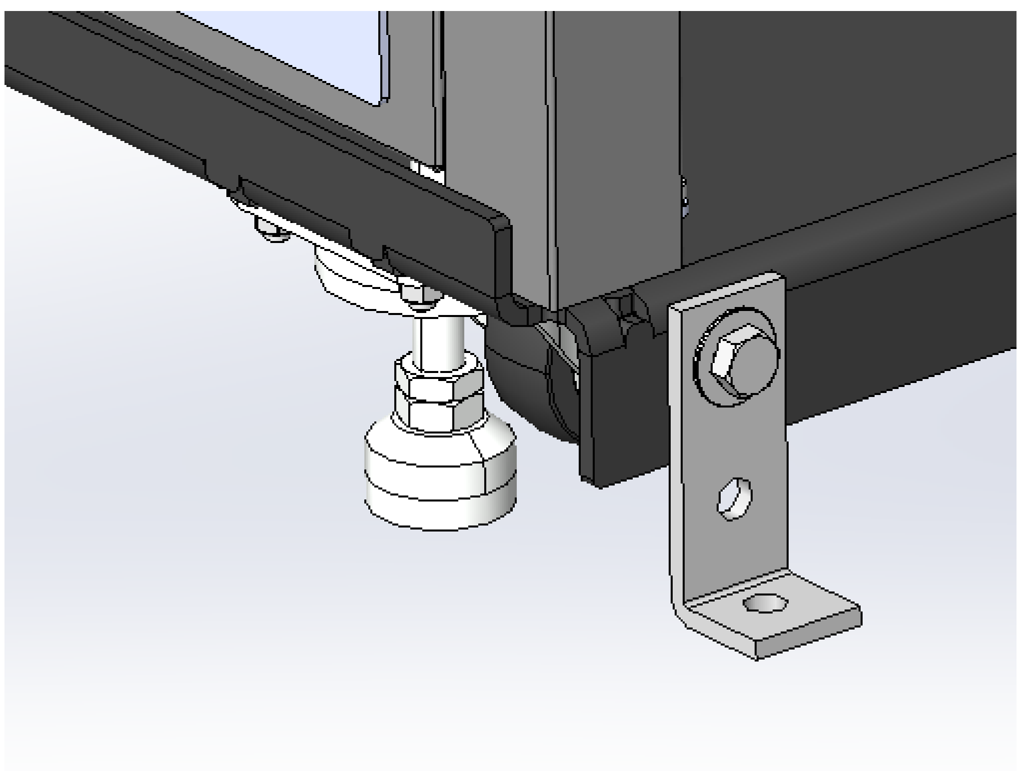
2.4 System Rack

2.4.1 Components

The system rack cart contains the system control unit and vacuum control unit, valve motor, and routing for electrical connections to the Cryostation and helium lines from the compressor to the valve motor. The rack can be moved on caster wheels. Rack Main Power switch is on the front of the unit. The outlets on the rack are C13. When stationary, the rack has adjustable feet to level the rack to achieve optimal vibrational performance. The rack also comes equipped with earthquake supports that are anchored to the floor with 9/16" bolts (hardware provided), which provide extra stability when installed. 4 holes will need to be drilled into the lab or facility floor to anchor the bolts. The following image shows how the adjustable feet and the earthquake support brackets are installed on the system rack.



Top view of system rack with earthquake supports shown



Earthquake support bracket and adjustable rack foot shown (only one corner shown)

⚠ WARNING

Risk of injury due to tipping

The rack cart can cause serious injury if it is tipped over. Ensure all adjustable feet and supports are properly engaged and locked when the system is in use to prevent tipping. Install earthquake supports per local requirements. Take care when moving the rack that all 4 caster wheels are installed properly and are unobstructed when rolling.

2.4.2 Valve Motor

The remote valve motor that is mounted in the system rack controls the pulse tube cryocooler. The connecting helium lines should be oriented as straight as possible to minimize vibrations. The valve motor orientation will be configured at the factory. Consult a Montana Instruments Support Engineer and installation instructions prior to moving the valve motor within the system rack.

NOTICE

Valve motor helium lines are limited in length

- The helium lines from the valve motor to the pulse tube are much shorter than standard helium lines to the compressor. Therefore, the system rack must be kept within 1 foot (30.5 cm) from the edge of the optical table nearest the rear of the cryostation.

2.4.3 System Control Unit

The system control unit consists of an outer enclosure, a single-board computer, peripheral cards, a touchscreen user interface display, and several communication ports. The enclosure is compatible with a standard 19-inch-wide equipment rack (4U) and can be mounted with other rack-mount devices. It can alternatively be placed independently on a table or shelf.

Models
ECA24

System Control Unit with User Interface Touchscreen

Front of Enclosure

Intended Use

The system control unit is a device used for instrumentation control of Montana Instruments products. It provides both the electronics hardware and software interface for communicating with other devices and controlling various instrument parameters.

Components

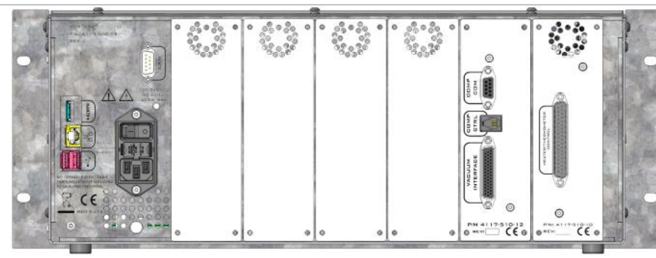
The system control unit consists of an outer enclosure, a single-board computer, peripheral cards, a touchscreen user interface display, and several communication ports. The enclosure is compatible with a standard 19-inch-wide equipment rack (4U) and can be mounted with other rack-mount devices. It can alternatively be placed independently on a table or shelf.

User Interface Touchscreen

A 10-inch touchscreen display provides the main user interface control for the system. The software can alternatively be monitored and controlled via a VNC interface or remote scripting.

Enclosure Communication Ports

ECA24 (no peripheral cards) rear enclosure



ECA24 (two peripheral cards) rear enclosure

<u>HDMI</u>

The HDMI port on the rear face of the enclosure is used to interface with the touchscreen display.

<u>USB</u>

Two USB ports are available on the rear face of the enclosure. One of the USB ports is used to interface with the touchscreen display.

Four USB ports are available on the front face of the enclosure. These can be used for connecting with external storage drives.

<u>Ethernet</u>

An ethernet port is available on the rear face of the enclosure for connecting with a local network or computer. A local network connection is required for controlling the instrument via the remote graphical display or scripting features, and a network internet connection is required for remote technical support.

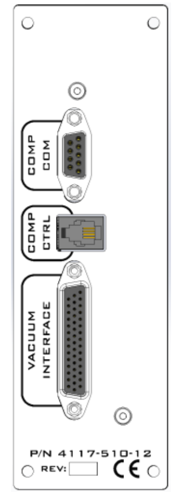
<u>DSUB9 (CAN)</u>

The DSUB9 port on the rear face of the enclosure is used to interface with the helium compressor. This connection allows the system control unit to run the CAN bus in the compressor and display compressor readouts in the UI.

Peripheral Cards

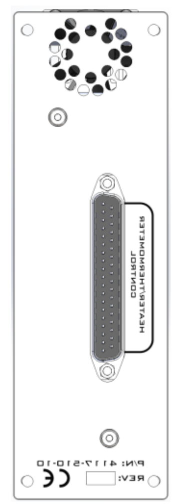
The ECA24 contains slots for up to six, rear-facing peripheral control cards. There are several types of peripheral cards for controlling various equipment. The two standard cards are described below.

Vacuum Control Module (VCM)



A VCM peripheral card in the attached system control unit is used to control the valves and pump in the vacuum control unit and Helium Compressor. The DSUB HD44 port (`VACUUM INTERFACE`) on the VCM is used to interface with the vacuum control unit. The RJ45 and DB9 (`COMP CTRL`) connects to the helium compressor and provides control of the helium compressor.

Temperature Control Module (TCM)



Two TCM peripheral cards in the system control unit are the communication interface used to control the thermometry and heaters located on the cryocooler stages, platform, and user channels and display those readouts in the UI.

The DSUB37 port (`HEATER/THERMOMETER CONTROL`) on the TCM cards connects to the DSUB37 port on the back panel of the Cryostation.

Technical Specifications

Environmental Specifications

Temperature of Environment	5 – 25 °C
Humidity	5 – 80% non-condensing
Elevation	<2000 m

Power Specifications

Model	ECA24
Mains Power Connector on Unit	IEC 60320 C14
Line Voltage	100 – 240 VAC
Frequency	50 – 60 Hz
Maximum Power Consumption	665 W

Physical Dimensions

Component	L x W x H	Mass
ECA24	43 cm x 38 cm x 17 cm	13.6 kg

Safety Information

The following hazards may be typical for this product:

⚠ WARNING

Risk of injury due to sharp edges

The enclosure contains sheet metal parts that may have sharp edges.

⚠ WARNING

High voltage: danger of electric shock

Electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or death.

- No user serviceable parts inside, contact customer service for assistance.

NOTICE

Peripheral cards must not exceed 600 W to avoid product damage

- The system control unit can supply a maximum power of 600 W across all installed peripheral cards. Ensure the cumulative power of all installed peripheral cards (maximum power rating of all cards added together) does not exceed 600 W.

Transportation and installation

- When not mounted in a rack unit, the enclosure should not be stacked on any other equipment, nor should other equipment be placed on it.
- Allow 8 cm minimum clearance from any ventilated face (sides, front) and 20 cm clearance in the rear for cables and hoses.
- Do NOT move the unit during operation. Disconnect all cables before moving. Lift the enclosure by using both handles on the front face.

2.4.4 Vacuum Control

Models
VCM24
VCM24 Turbo Option

Vacuum Control Unit

Intended Use

The vacuum control unit is used for vacuum control of Montana Instruments Cryostations. It is designed to connect to the system control unit and Cryostation provided by Montana Instruments. It is recommended to locate the vacuum control unit near both connected apparatuses.

Components

The standard VCM24 Vacuum Control Module consists of an outer enclosure, an Edwards mXDS3s Mini-Scroll (roughing) pump, KF16 vacuum connection, one case valve, one vent valve, and several communication ports. The enclosure (6U) is compatible with a standard 19-inch-wide rack and can be mounted with other rack-mount devices. It can alternatively be placed independently on a table or shelf.

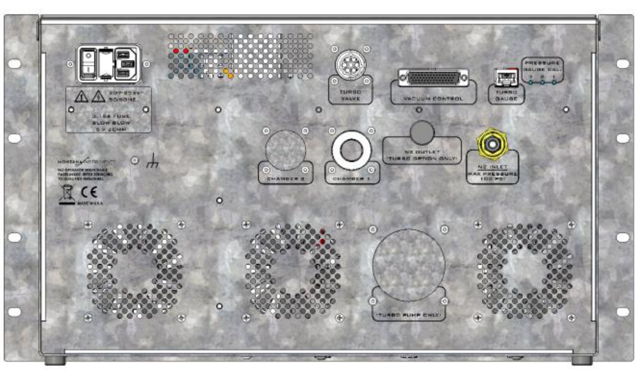
The roughing pump is used to achieve a low vacuum. A high vacuum is achieved with cryopumping. During cooldown, the sample platform temperature lags the Stage 1 temperature in the Cryostation by ~100 K this allows for remaining molecules to be trapped by the charcoal adsorbers, and cold surfaces conductively connected to Stage 1 rather than the sample. This minimizes sample contamination.

The VCM24 Turbo Option Vacuum Control Module consists of an outer enclosure, an Edwards mXDS3s Mini-Scroll (roughing) pump, Edwards nEXT85D Turbo Pump, KF40 turbo pump vacuum connection, one turbo case valve, one vent valve, and several communication ports. The enclosure (6U) is compatible with a standard 19-inch-wide rack and can be mounted with other rack-mount devices. The unit should be mounted in a rack or on a large, flat, stable surface to prevent accidental movement.

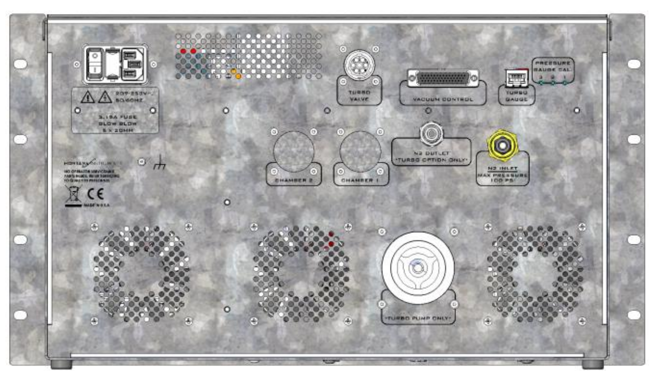
The roughing pump is used to achieve a low vacuum before the turbo pump is engaged. The turbo pump will provide a vacuum higher level of vacuum than the roughing pump. A high vacuum is achieved with cryopumping. During cooldown, the sample platform temperature lags the Stage 1 temperature in the Cryostation by ~100 K this allows for remaining molecules to be trapped by the charcoal adsorbers, and cold surfaces conductively connected to Stage 1 rather than the sample. This minimizes sample contamination.

If the cryostation is placed on the table at a 45- or 90-degree angle from the cart, a 90-degree vacuum flange needs to be installed (provided in install kit). This flange is not required if the cryostation is in line with the cart.

Enclosure Communication Ports



VCM24 rear enclosure



VCM24 (Turbo) rear enclosure

DSUB HD44 (VACUUM CONTROL)

The DSUB HD44 port on the rear face of the enclosure is used to interface with the VCM in the system control unit. This connection allows the system control unit to control the pumps and valves in the vacuum control unit and display the status of the roughing pump, vent valve, case valve, and system pressure readouts in the UI.

RJ45 Connector (VCM24-Turbo only)

The RJ45 connector on the rear face of the enclosure (VCM24-Turbo turbopump version only) is used for communicating with the turbopump vacuum gauge.

Circular 7-Pin Connector

The circular 7-pin connector is used to control the external electro pneumatic valve (VCM24-Turbo turbopump version only)

N2 Outlet

This connection is used to pneumatically operate the external electro pneumatic valve (VCM24-Turbo turbopump version only. 50-100 psi MAX. Port on the back of the vacuum control module is ¼ inch tube (user supplied).

Technical Specifications

Environmental Specifications

Temperature of Environment	5 – 25 °C
Humidity	5 – 80% non-condensing
Elevation	<2000 m

Power Specifications

Model	VCM24/VCM24-Turbo	
Model	115 VAC	230VAC
Mains Power Connector on Unit	IEC 60320 C14	
Line Voltage	115 VAC± 10%	230 VAC± 10%
Frequency	50 – 60 Hz	
Maximum Power Consumption	420W	

Physical Dimensions

Component	L x W x H	Mass

VCM24	43 cm x 38 cm x 26.5 cm	23 kg (50 lbs.)
VCM24-Turbo	43 cm x 38 cm x 26.5 cm	29 kg (62 lbs.)

Safety Information

The following hazards may be typical for this product:

⚠ WARNING

Refer to associated product manuals for complete safety information

- The VCM24-Turbo model contains a Edward nEXT85 Turbo Pump. Refer to the Operating Instructions provided by Edward's for important safety information regarding this component.

⚠ WARNING

Risk of injury if not properly secured (for optional turbo)

- Unit may significantly move if the turbo has a sudden stop during operation. VCM24 Turbo is recommend being installed in a rack or on a large, flat, stable surface.

⚠ WARNING

Risk of injury due to sharp edges

The interior of the enclosure contains sheet metal parts that may have sharp edges.

- When working inside the enclosure (authorized service personnel only), exercise caution to avoid injury.

⚠ WARNING

High voltage: danger of electric shock

Electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or death.

- Completely power down the system and unplug the power cable before accessing the enclosure or when otherwise servicing the unit (authorized service personnel only),.
- If power must be applied to diagnose issues or otherwise, a grounding strap must be applied to the arm-interfacing internal components.

NOTICE

Risk of product damage due to improper use

- Do NOT kink vacuum tubing or install vacuum tubing in an area where it may be pinched.
- Ensure all vacuum clamps and fittings are secured tightly before operation.
- Do NOT disturb vacuum tubing while the turbopump (if applicable) is operational.

Risk of turbopump damage due to improper use (VCM24 Turbo model only)

- Venting the system at rotor speeds higher than 250 Hz may cause damage to the turbopump.
- Do NOT vent the system when the turbopump is rotating faster than 250 Hz. Observe the rotational speed on the UI to ensure safe rotating speeds before manual venting.
- If the system control unit unexpectedly shuts down before turning off the turbopump, turn off the main power to the vacuum control unit and wait at least 15 minutes before venting the system.
- Do NOT mount or store the VCM vertically as this will harm the integrated turbo pump.

Transportation and installation

- When not in a rack unit, the enclosure should not be stacked on any other equipment, nor should other equipment be placed on it.
- Allow 8 cm minimum clearance from any ventilated face (sides, front) and 20 cm clearance in the rear for cables and hoses. For the VCM24, allow 30 cm rear clearance.
- Do NOT move the unit during operation. Disconnect all cables before moving. Lift the enclosure by using both handles on the front face.

Section 3 - Sample Chamber Configuration

3.1 Accessing the Sample Space

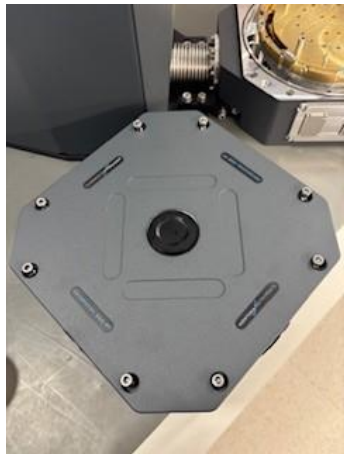
Before starting the Cryostation, check the sample space. Depending on the configuration, there may be foam inserts to remove before cooling the system down for the first time. If applicable, check instructions specific to your configuration.

NOTICE
Keep sample chamber and surfaces clean • Always wear clean gloves when working in the sample chamber to avoid contaminating surfaces. • Take care not to touch the optical windows on the lid, vacuum housing, or the internal radiation shield. Window covers are provided to keep the windows clean. • Keep O-ring seals clean and free from debris. Do NOT place the housing with an o-ring or sealing surface positioned downwards unless there are protruding bosses to keep it from touching the surface. • When working inside the sample chamber, use extreme caution not to drop screws into the chamber assembly.

Start with the system at room temperature and the chamber vented to atmosphere.

1. Loosen the 4X M6 bolts that secure the vacuum housing to the lower sample chamber. Carefully lift the vacuum housing from the sample chamber and place it on the table with the protruding bosses down. The housing may sit on the bosses without compromising the clean surface inside the housing.
2. The vacuum housing lid can be left bolted down or unbolted and removed separately from the vacuum housing. Unbolt the 8X M6 bolt in the lid to remove for access, either leaving the vacuum housing in place or remove the housing and lid together.

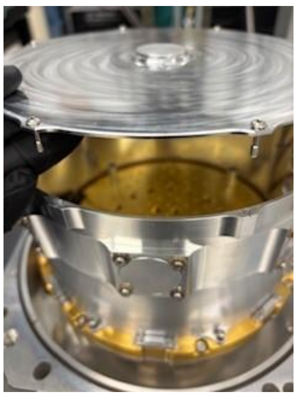
Step 1: Unbolting the vacuum housing from the lower sample chamber



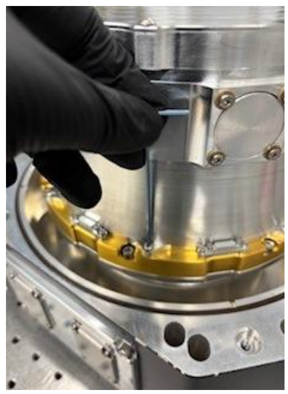
Step 1 and 2: Lifitng the vacuum housing off of the sample chamber, with the housing lid bolts loosened

3. If desired, the radiation shield lid can be removed separate from the rest of the shield. Unscrew the lid and lift it from the radiation shield to remove it.

4. Unfasten the 8X M3 button head screws on each side of the radiation shield (or separately (lid only) see step 3); lift up and over any sample mount structures to remove.



Step 3: Lifting off radiation shield lid



Step 4: Removing radiation shield screws

NOTICE
Take care when reassembling the sample chamber • Before replacing the vacuum housing & lid, carefully check O-rings and sealing surfaces for any loose fibers or debris (contamination could affect vacuum performance). • Take care not to overtighten screws when replacing the radiation shield. Use of a torque screwdriver set to 5 in-lb. is recommended.

3.2 Sample Mounting

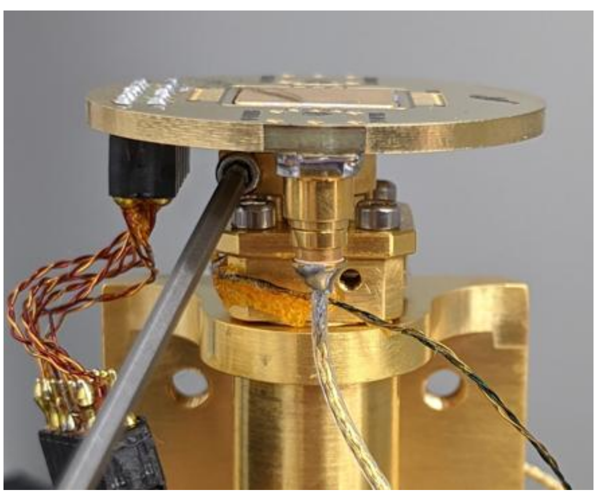
Most systems ship with a user-specified sample mount, depending on the option(s) purchased.

1. Remove the previous sample from the face of the mount if needed. Clean off residual grease with a Kimwipe, lens tissue, or lint-free cloth (use a small amount of isopropanol or acetone if needed)
2. Apply a thin layer of new N-grease to the sample mount surface. Use a flat tool (not metal or cotton) to spread the grease out evenly, taking care not to scratch the surface.

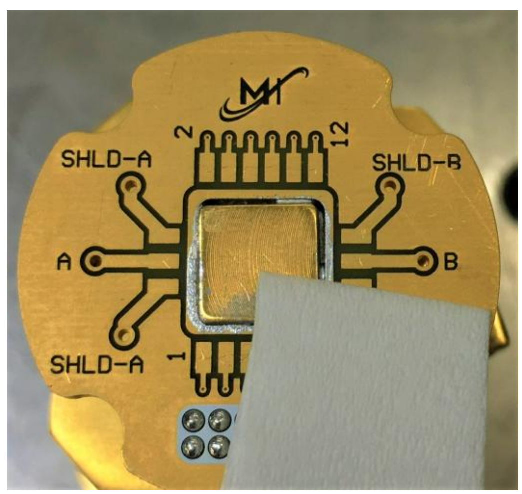
NOTICE
Do not use N-grease for temperatures above 300 K Apiezon® N-grease softens at 305 K. If the user plans to operate above 300 K, it is recommended to use an alternative sample mounting material to ensure a vertically mounted sample does not slide off the sample mount.

» NOTE
Depending on the sample, VGE, silver paint/paste, or copper SEM tape can be used in place of N-grease.

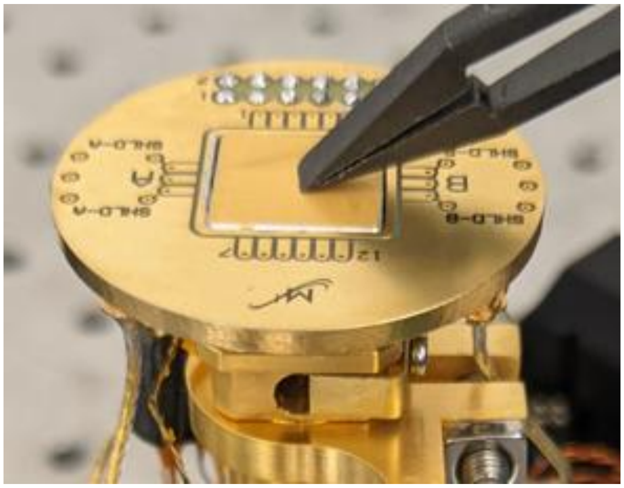
3. Using tweezers, set your sample on top of the grease layer and press down gently to ensure a good thermal connection.



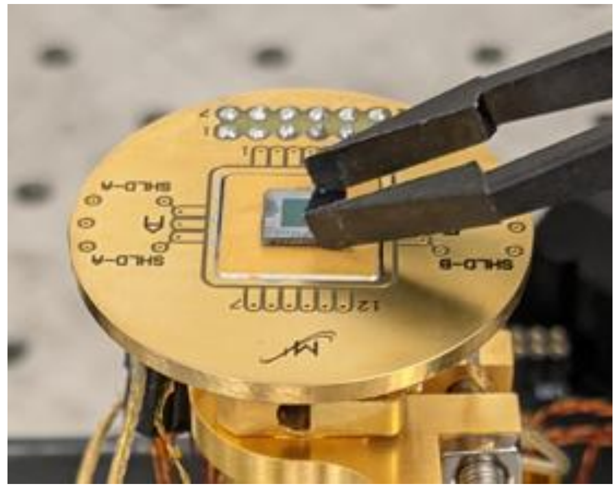
Attach sample mount to exchange boss



Step 1: Clean the surface of the mounting platform



Step 2: Grease mounting surface



Step 3: Attaching new sample

» NOTE
To check if the sample is secure, hold the sample mount horizontally so the sample faces down and forcibly tap the mount with a finger.

3.3 Mounting a Thermometer

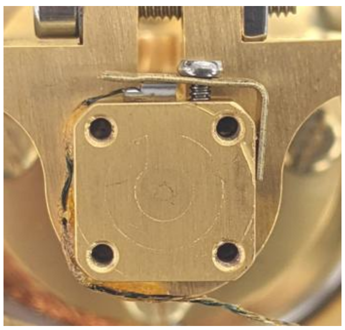
Many users choose to remove the sample thermometer and mount it elsewhere in the system or install a user thermometer. Users can use an H-clamp and M2 screw to mount within the sample space. Users can also use VGE, although this is not the preferred method as VGE is a high outgassing material. To do this:

NOTICE
Cernox® thermometer wires are extremely fragile. Handle wires with care to avoid breaking.

1. If used, remove any VGE (the adhesive lagging the thermometer wire) with isopropyl alcohol or acetone. Clean off any residual VGE.
2. Clean off the area where the thermometer will be mounted with isopropyl alcohol or acetone.
3. Attach the thermometer, ensuring the bottom is in even, flat contact with the mounting surface.

a. **With Clamp:** Apply a thin layer of N-grease to the bottom of the thermometer. Clamp it down securely, ensuring no part of the thermometer "springs up" from the surface.

b. **Without Clamp:** Apply a small amount of VGE (thinned with acetone or isopropyl alcohol) to the bottom of the thermometer, wait 10 seconds, then place on the mounting surface. Use a small weight to apply pressure and hold the sensor in place while it cures (24 hours under ambient conditions or 30 minutes under 60 °C heat).

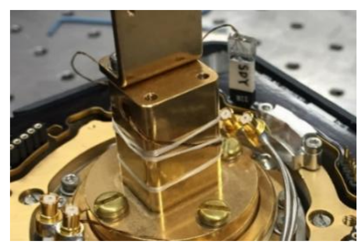


Thermometer clamped to the mounting surface

Thermometer installed in a plug

Wire lagged with VGE (clamp style)

Wire lagged with VGE (plug style)



Wire tied in place with floss (plug style)

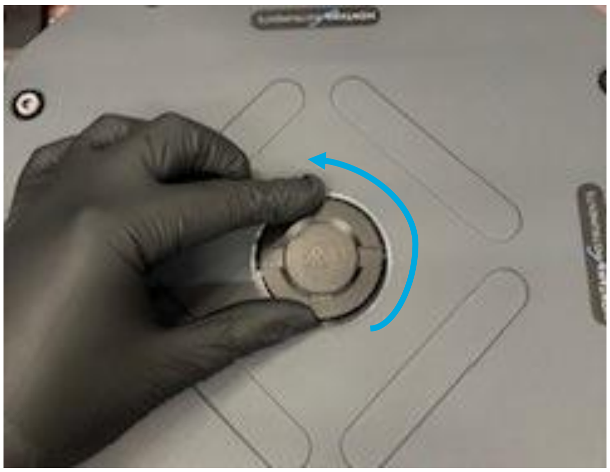
4. Tie the thermometer wire in place using unwaxed floss, nylon string, or Kapton® tape (optional).

» NOTE
• Be sure the thermometer and wire are completely dry before pulling vacuum or cooling down the system. The wire should not touch the radiation shield or sample mount. • The sample temperature may read up to 0.2 K higher than the platform.

3.4 Windows

3.4.1 Window Covers

The standard sample chamber has 8 optical access locations (7 side and 1 top). The system ships with window covers in place. The window covers are removed by turning counter-clockwise until the notches are aligned with the openings in the window retaining ring. To replace the covers, re-align the notches and turn clockwise until the cover locks in place.



» NOTE
Use care when removing the window covers if the system is running, as this may loosen the retaining ring holding the window in place.

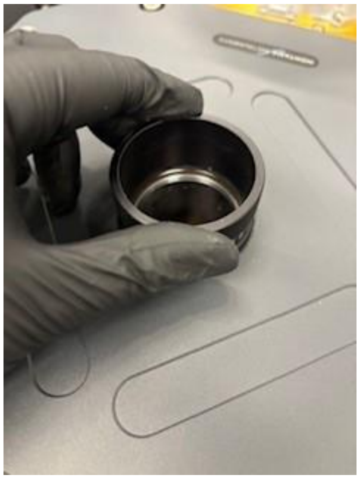
3.4.2 Window Replacement

Vacuum Windows

For replacing outer (warm) vacuum windows, a special window tool is provided in the accessory kit:

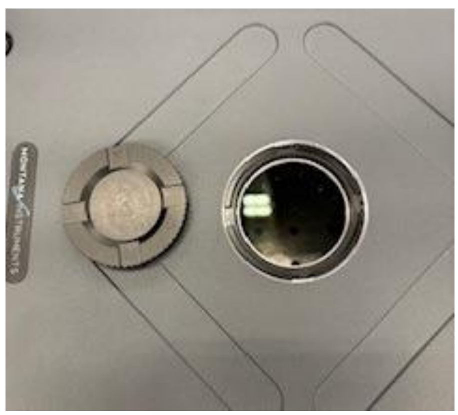
1. Align the tabs on the window tool with the corresponding notches in the Delrin retaining ring holding the window in place.
2. Use the window tool to loosen the retaining ring by turning counter-clockwise.
3. Remove the retaining ring to access the window.
4. Before reinstalling the window, check the O-ring to ensure it is clean and free of debris and has a very thin layer of L-grease (just enough so the surface is shiny).
5. Carefully center the window over the O-ring during reinstallation. Ensure that the O-ring is fully covered by the window. Avoid repositioning the window, as this may spread L-

grease onto the clear aperture. Use the window tool to screw in the retaining ring.



Steps 1-2: Using window tool to unscrew the retaining ring

Step 3: Removing the retaining ring



Step 5: Window centered on O-ring

NOTICE
Take care when handling and removing windows • Handle the radiation shield and windows carefully to prevent scratches or fingerprints. • Before using the window tool, remove the housing from the system. • Do not use too much force on the window tool as this could cause it to slip and damage the window.

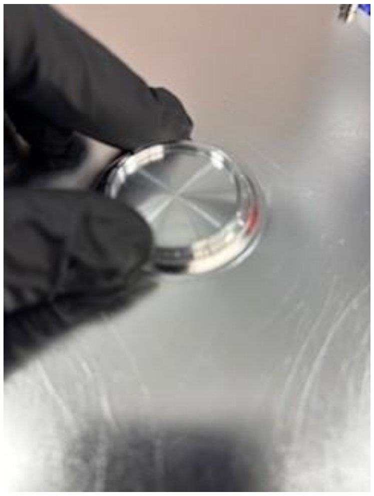
Radiation Shield Windows

The inner (cold) windows on the radiation shield are held in place with a tension ring or four M3 screws.

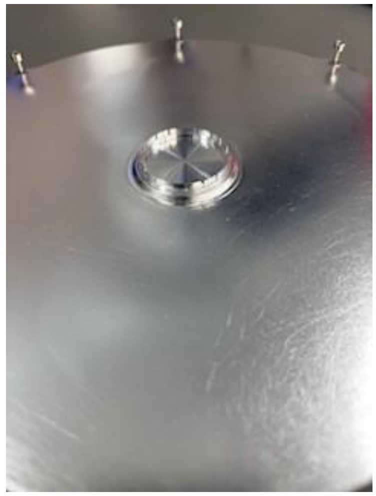
Depending on the model, the radiation window holders are removed by unscrewing the threaded tension ring or removing the four M3 screws surrounding the window.

For tension ring (top radiation shield window):

1. Remove the window from the tension ring by pressing it out of the spring fingers. Some force may be required.
2. Before reinstalling the window, add a very thin layer of N-grease to the edge of the spring fingers. This layer should be thin enough so none of the grease spreads onto the optic when re-assembled.
3. Reinstall the window by press-fitting the tension ring onto the window. Ensure the spring fingers hold the window tightly and evenly.
4. For threaded tension rings, add a small amount of N-grease to the threads before screwing back in place.



Step 1: Unscrewing threaded tension ring



Pressing window out of tension ring

Window removed from tension ring

For screwed windows (side windows):

1. Unscrew four M3 screws surrounding window.
2. Before reinstalling window, ensure window is clean and centered correctly.

Step 1: Unscrew four M3 screws surrounding window or window blank

» NOTE
• The threaded holders can be adjusted to allow the sample to be positioned closer to external optics. Always ensure that no portion of the radiation shield touches the outer housing and that the radiation and vacuum windows do not touch. • If a radiation window is removed, the added heat load can be as much as 50 – 100 mW per window. Depending upon the emissivity and thermal conductivity of the sample, local heating of the sample from this excessive radiation can cause the sample to be significantly warmer than the cold platform it is mounted to.

3.5 Sample Chamber Wiring

3.5.1 Types of Wiring

Various applications require different types of wiring. Always select the optimal wire for the application with the appropriate diameter (between 32-40 gauge). Longer wires are ideal -- the length of wiring between stages should be at least 2 in (5 cm).

- **32 AWG Phosphor Bronze wire**: *low thermal conductivity and good for moderate power transmission*
  - Recommended use: Building additional wiring harnesses
  - Raises temperature ~5 mK per wire
- **Copper wire:** *high thermal conductivity and good for high power transmission*
  - Recommended use: Wiring harness for high power transmission when high base temperatures are acceptable
  - Raises temperature ~300 mK per wire

» NOTE
See our Cryostation Wiring Guide for details, theory, and illustrations.

3.5.2 Thermal Lagging Techniques

To minimize the effects of heat loads through wiring on the base temperature, all incoming wiring (including coax cables) must be properly thermally lagged to Stage 1 of the cryocooler via the 1st stage platform ring (the item below the radiation shield).

The Cryostation 200 PT model provides "pre-lagged" connections for some user inputs and wiring. These wires, which plug directly into the 4 K circuit board inside the sample space, do not need additional thermal lagging.

Wiring must route under the thermal clamp locations when pre-lagged connections are not available:

1. Unscrew the two M2 screws on the top of the thermal clamp. Remove the top cover.
2. Insulate the wires with a small piece of Kapton® tape to help prevent electrical shorts.
3. Place the wires on the felt pad. Wires should not cross or touch one another under the clamp.
4. Replace the top cover of the clamp and replace the two screws. Do NOT overtighten.
5. Check to ensure wires do not touch the inside of the radiation shield.

» NOTE
Ensure there are a few inches of wire before and after the thermal clamp. A 10-inch (25 cm) wire should be thermally lagged such that a 5.0 in. (12.5 cm) length is outside of the thermal clamp and the remaining 5.0 in. (12.5 cm) section is inside of the 4K sample space.

3.5.3 User Wiring Interfaces

The Cryostation provides integrated connectors for user DC feedthroughs, user thermometers, and heaters.

NOTICE
Do NOT remove sample chamber circuit boards • The standard 4 K circuit board (contains USER, SAMPLE THERM, etc.) should not be removed as it can lead to the disconnecting of the platform thermometer and heater. If this board needs to be removed for any reason, please contact an authorized service representative for detailed instructions. • The Operational cable and associated wiring must remain connected for the system to be operational. Do NOT modify these connections.

User DC Connections

User DC connections allow users to route wiring to header pins on the sample chamber circuit board. These available connections can be used to interface with external connections and devices. The system comes with a D-SUB 25POS, FEMALE cable assembly for interfacing user inputs to the external devices.

User Temperature Channels

User thermometer and heater connections allow users to add additional thermometers and heaters at header pin locations on the sample chamber circuit board. The system control unit provides open temperature channels (User 1 & 2) for manually controlling additional thermometers and heaters via the UI. The maximum heater wattage available for each channel is 5 Watts.

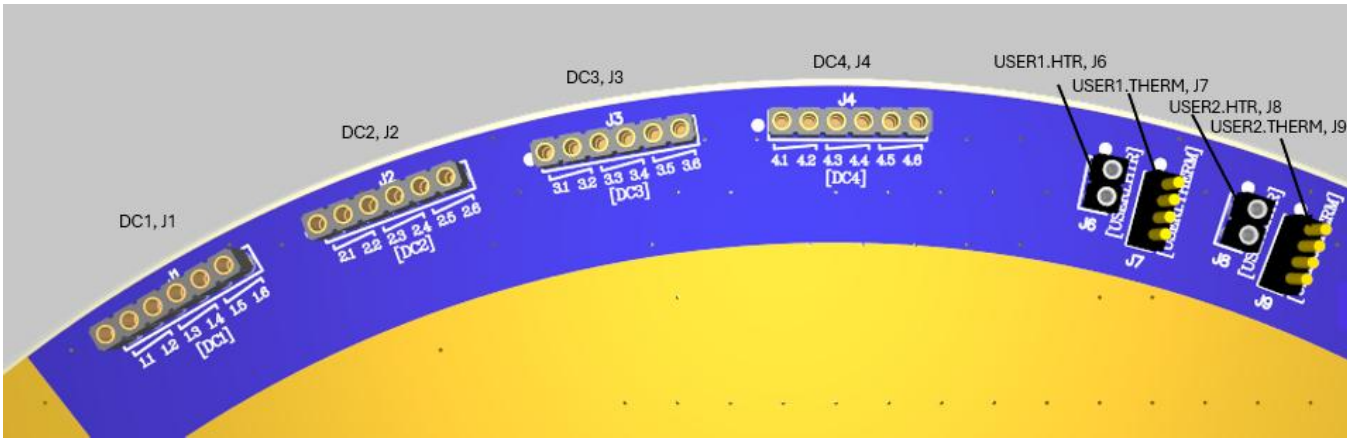
» NOTE
The sample thermometer provided is symmetric, so it can be connected to Pin 1 in either orientation.

3.5.4 Wiring Schematics

The wiring schematic is outlined on the following pages.

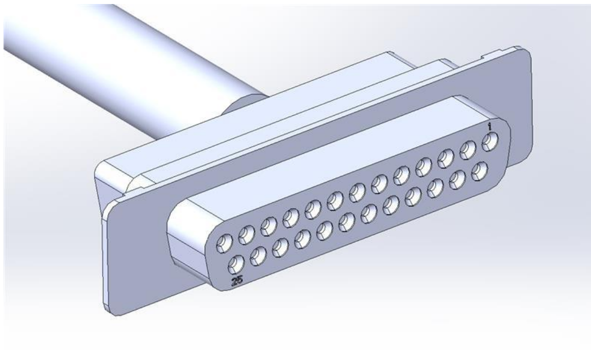
Cryostation 200 PT

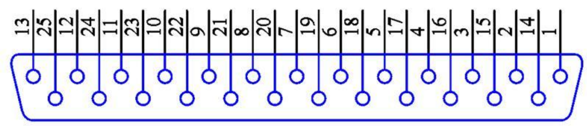
Cryostation 200 PT user wiring to the 4 K circuit board shown below is "pre-lagged" and does not need to be routed under the thermal clamps. Other inputs will require proper thermal lagging. Connectors on the internal 4K PCB for user DC lines are Mill-Max 831-43-006-10-001000 6 contact board connectors. The mates to these connectors are Mill-Max 830 Series/ 10-005000 1x6 Pin solder cups.



Internal Sample Chamber PCB @ 4K

External DC Connector ‘USER’ Cable





Pin Out Diagram of External DC Cable

User Temperature Channels					
User Interface		Internal connections			
Temperature Channel		PCB	Connection Location	Signal Name	Pin
USER 1	Thermometer	USER1.THERM	J7	V(+)	1
				V(-)	2
				I(+)	3
				I(-)	4
	Heater	USER1.HTR	J6	HTR(+)	1
				HTR(-)	2
USER 2	Thermometer	USER2.THERM	J9	V(+)	1
				V(-)	2
				I(+)	3
				I(-)	4
	Heater	USER2.HTR	J8	HTR(+)	1
				HTR(-)	2

User DC Connections						
Internal Connections					External Connections	
PCB	Connection Location	Signal Name	Signal Pairs	Pin	Bulkhead (38999/III PIN)	Cable 4700-7002 D-SUB-25 SKT
DC1	J1	DC1.1	Z	1.1	1	1
		DC1.2		1.2	2	14
		DC1.3	Z	1.3	3	2
		DC1.4		1.4	4	15
		DC1.5	Z	1.5	5	3
		DC1.6		1.6	6	16
DC2	J2	DC2.1	Z	2.1	7	4
		DC2.2		2.2	8	17
		DC2.3	Z	2.3	9	5
		DC2.3		2.4	10	18

		DC2.4	Z	2.5	11	6
		DC2.5		2.6	12	19
DC3	J3	DC3.1	Z	3.1	13	7
		DC3.2		3.2	14	20
		DC3.3	Z	3.3	15	8
		DC3.4		3.4	16	21
		DC3.5	Z	3.5	17	9
		DC3.6		3.6	18	22
DC4	J4	DC4.1	Z	4.1	19	10
		DC4.2		4.2	20	23
		DC4.3	Z	4.3	21	11
		DC4.4		4.4	22	24
		DC4.5	Z	4.5	23	12
		DC4.6		4.6	24	25
		NC			25	13
		NC			26	
		NC			27	
		NC			28	
		NC			29	
		NC			30	
		NC			31	
		NC			32	
		NC			33	
		NC			34	
		NC			35	
		NC			36	
		NC			37	

3.6 System Care

Recommend system care procedures should be followed by any users of the system. For further information on any of these procedures, contact an authorized service representative for assistance.

3.6.1 When Working in the Sample Chamber

- Keep surfaces clean. Avoid touching any surfaces inside the sample space with your fingers as oils or other foreign contaminates can easily be transferred to the surfaces, the sample, or optics. **Always wear clean gloves.**
- Use proper grease and adhesives in the sample chamber. The accessory kit includes Apiezon® L-grease and N-grease.
- Avoid using too much grease – a thin layer (just enough so the surface is shiny) is best for metal-to-metal surfaces, samples, and O-rings. Excessive grease can increase outgassing and contamination of other surfaces in the sample chamber.
- Inspect, wipe, and grease O-rings. Make sure that the O-rings are clean with a thin layer of L-grease. The exposed surface should be wiped with a dry Kimwipe or lens tissue and re-greased every 10-15 uses.
- Check to ensure wires are preserved: make sure wires do not overlap under thermal clamps and that the clamps are not overtightened; make sure wires do not contact the radiation shield or the sample mount (aside from the wire bond pads).

3.6.2 When Not Using the Cryostation

- Keep the lid on the sample chamber to keep it free from dust.
- Supply a small amount of nitrogen to keep the system clean and dry.
    - Use the `VENT` command with "Vent Continuously" enabled to keep nitrogen flowing through the chamber at atmospheric conditions.
- Keep the sample chamber under vacuum. Use the `PULL VACUUM` command button to pull and keep the chamber under a medium vacuum state.

3.6.3 Standard Checks Before Every Cooldown

- Ensure the radiation shield is bolted down and secured. Make sure all radiation shield windows are in place.
- If previously removed or loosened, ensure the vacuum housing and vacuum housing lid are secured and bolted down.
- Ensure the sample is mounted properly.
- Ensure wiring from sample thermometers or other internal components does not touch the inside of the radiation shield.
- Check that the software starts up and reads all thermometers. The temperature channel values should be fluctuating a small amount, indicating the thermometer readings are active.

- Check helium pressure to ensure values are within appropriate values per the table below:

Configuration	Equalization Pressure
F-70LP	1.65-1.70 MPa 1.66 MPa (240 psig) nominal

3.6.4 Periodic Checks Every 6-12 Months

- Inspect adhesive joints (sample mounting and/or wire bonding joints) and repair if needed. Depending on the adhesive used, it can flake off or weaken after several thermal cycles.
    1. For VGE, clean off with acetone or isopropyl alcohol then add a thin layer of VGE in the same location.

» NOTE
O-rings rarely need to be replaced unless they are nicked or damaged. If damaged, use Teflon-tipped tweezers or your fingers to remove the O-ring. Do NOT use metal-tipped tweezers or other sharp objects as this could damage the aluminum housing and create leaks.

3.7 Long-Term Maintenance

3.7.1 30,000 Hour Maintenance

The maintenance procedures below must be completed by a certified technician. This can be done onsite without removing the equipment or disturbing the optical setup. Contact an authorized service representative to schedule maintenance.

Cryocooler Valve Motor

The pulse tube cryocooler valve motor normally needs replaced every 30,000 hours of operation.

Other indicators of needing maintenance include:

- The system has trouble cooling, or the achievable base temperature drastically degrades.
- The system has other faults and failures when attempting to operate.

Compressor Filter and Adsorber

The F-70LP compressor adsorber needs replaced after 30,000 operating hours.

3.7.2 Edwards mXD3s Mini Scroll Maintenance Schedule

The maintenance schedule is provided for the Edwards mXD3s mini-scroll pump inside the Vacuum Control Unit; please refer to the Edwards manual for instructions on maintenance.

Operation	**Frequency (Months)**
Inspect and clean the inlet strainer	12
Inspect and clean the external fan cover if required	12
Check the pump performance	12
Replace the tip-seals	When needed*
Replace the pump bearings	60
Replace capacitor	120
Electrical safety test	60
Exhaust silencer filter	When needed*

*But not more than 30 months

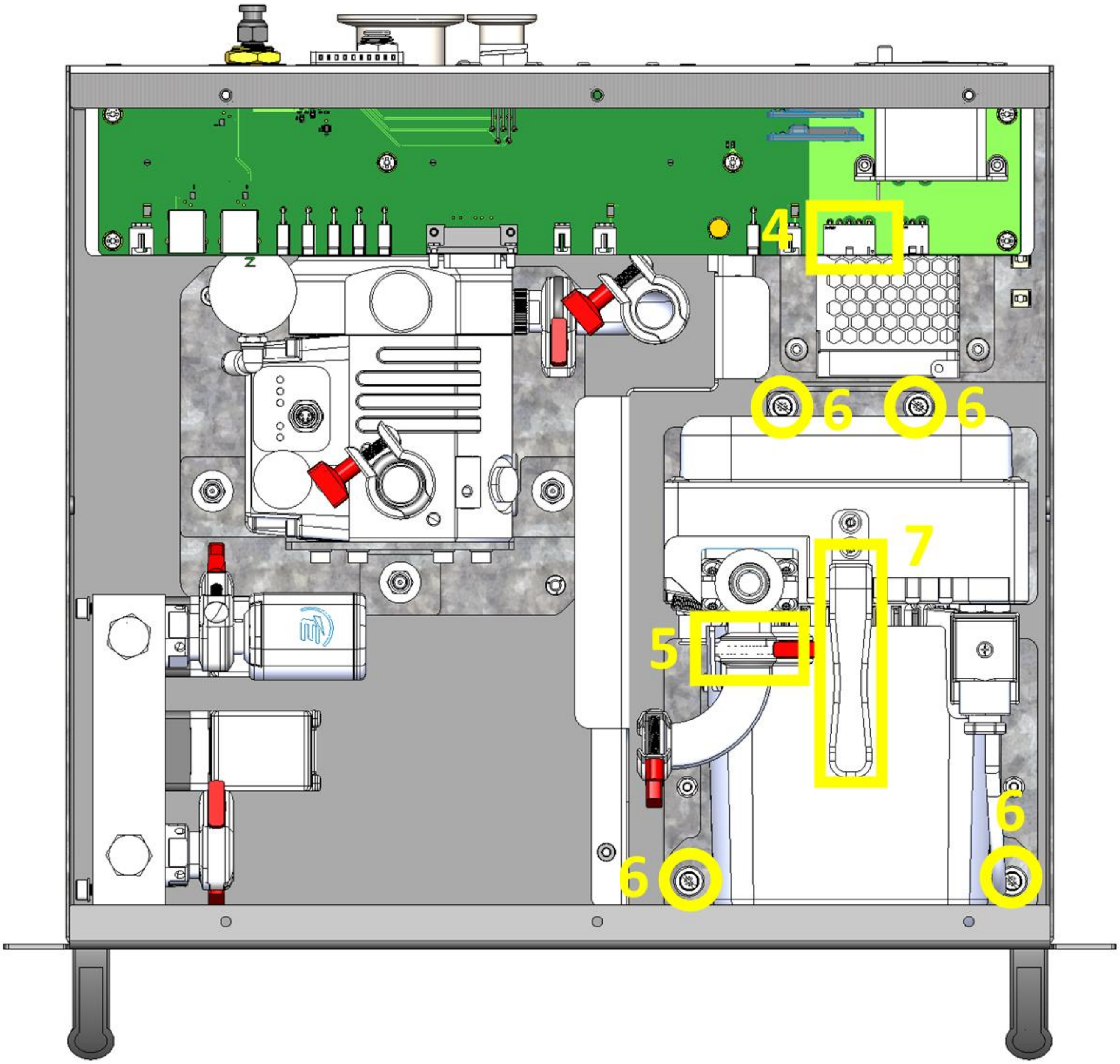
Steps to remove the Edwards mXD3s mini-scroll pump from the Montana Instrument Vacuum Control Unit

1. Unplug the Montana Instrument Vacuum Control Unit from the AC Power.
2. Disconnect the vacuum line, DSUB HD44 connector (VCM interface cable), and N2 purge if connected. For the Turbo version you will also need to disconnect the Turbo Valve cable, Turbo Guage cable, and N2 outlet connection.

⚠ DANGER
Serious personal injury Imminent hazards which, if not avoided, will result in serious injury or death. AC line voltage is present inside of the Vacuum Control Unit; ensure the unit has been removed from AC Power prior to performing any maintenance on the system.

3. Remove the top cover of the Vacuum Control Unit by removing 6 screws on the top cover.
4. Disconnect the internal AC power to the Edwards mXD3s Mini Scroll Pump.

5. Disconnect the vacuum connection.
6. Remove the 4 screws with a long Philips head screwdriver.



7. Carefully lift the mXD3s by handle to remove from Vacuum Control Unit to perform maintenance per the Edwards mXD3s manual.

3.8 Sample Chamber Hardware Torque Specifications

Hardware in Montana Instruments Cryostation is torqued to specifications that ensure optimal and safe system operation. Over time, however, hardware can become loose, so it may be necessary for users to tighten the hardware themselves. The following tables show the torque specifications for screws used in the Cryostation system, with values in in*lbs and N*m. The torque specifications are based on the material of the screw, the size of the screw, and the temperature environment the screw is present in. By following the instructions below, users can ensure their cryostats continue to operate at peak performance. For further questions or help, please contact our Customer Service team.

		Torque (in*lbs)[1]							
Application	**Screw Material**	**M1.6**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**
Room Temp	Brass	0.5	1.1	3.9	9.0	18.1	30.8	51.6	74.8
	Stainless Steel	0.7	1.5	5.4	12.6	25.5	43.4	72.6	105.2
Cold, clamping aluminum	Brass	0.6	1.3	4.7	10.9	21.9	37.3	62.5	90.6
	Stainless Steel[2,3]	1.0	2.1	7.5	17.5	35.2	60.0	100.4	145.6
Cold, clamping copper	Brass	0.3	0.7	2.5	5.8	11.7	20.0	33.4	48.5
	Stainless Steel[2]	1.0	1.9	7.1	16.4	33.2	56.4	94.4	136.9

Notes:
1. Based on target of 70% of fastener yield stress (when cold) unless noted
2. Belleville washer recommended
3. Based on target of 20% of fastener yield stress

		Torque (N*m)[1]							
Application	**Screw Material**	**M1.6**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**
Room Temp	Brass	0.06	0.1	0.4	1.0	2.0	3.5	5.8	8.4
	Stainless Steel	0.08	0.2	0.6	1.4	2.9	4.9	8.2	11.9
Cold, clamping aluminum	Brass	0.07	0.1	0.5	1.2	2.5	4.2	7.1	10.2
	Stainless Steel[2,3]	0.11	0.2	0.8	2.0	4.0	6.8	11.3	16.4
Cold, clamping copper	Brass	0.04	0.1	0.3	0.7	1.3	2.3	3.8	5.5
	Stainless Steel[2]	0.11	0.2	0.8	1.9	3.7	6.4	10.7	15.5

Notes:
1. Based on target of 70% of fastener yield stress (when cold) unless noted
2. Belleville washer recommended
3. Based on target of 20% of fastener yield stress

How to Torque Screws to Specification

1. Identify screw material, screw size, and temperature environment the screw is in.
2. Obtain a torque screwdriver of the appropriate size for the screw. Units in either in*lbs or N*m

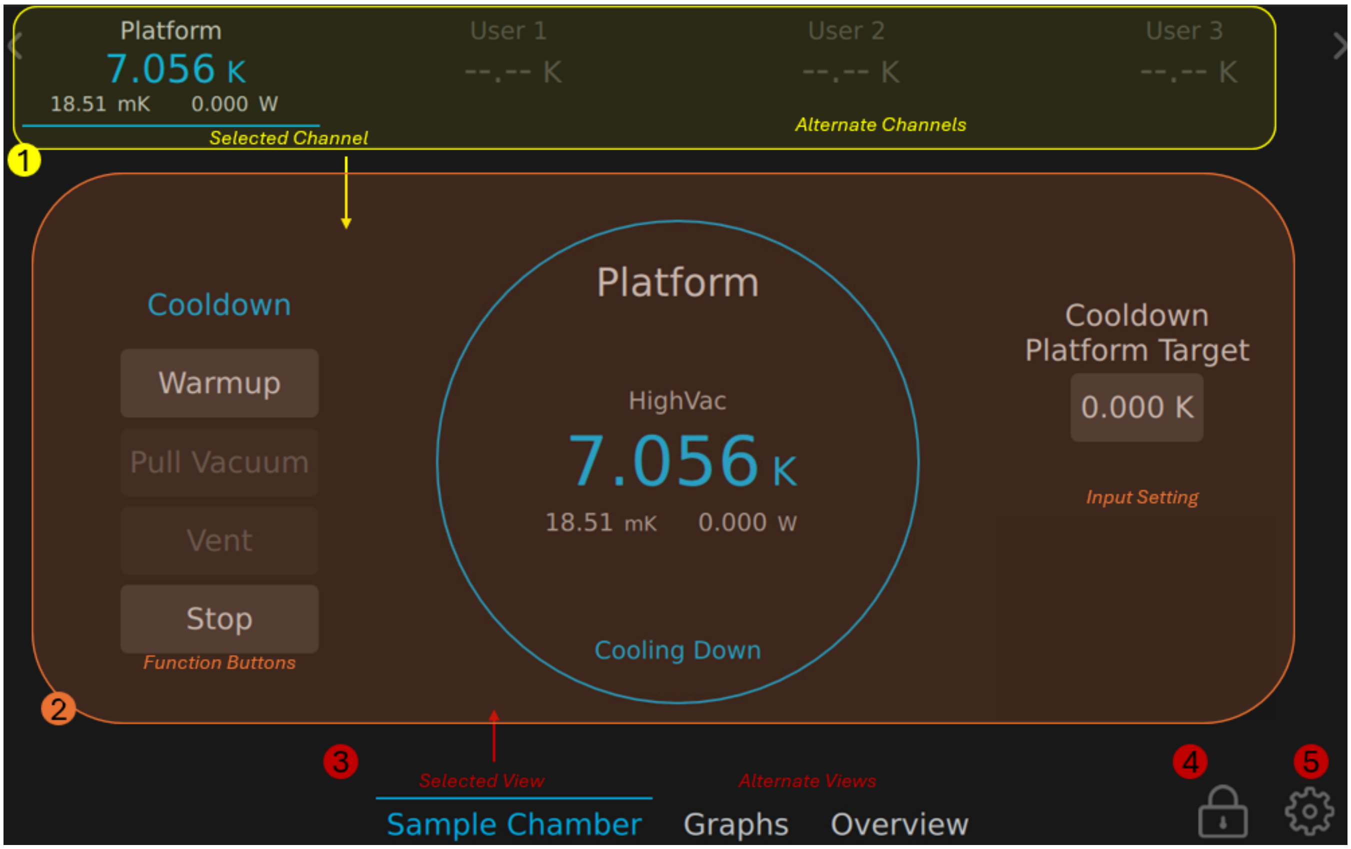
3. Set the torque screwdriver value to the correct specification from the chart. NOTE: Ensure units match between chart and screwdriver to avoid damage to screws or screws being too loose.
4. Tighten the screw (clockwise) using a torque screwdriver. The screwdriver will click once the set torque value is achieved.

Section 4 - System Usage & Operation

4.1 System Control Options

4.1.1 User Interface

The touchscreen display provides the primary user interface control of the system.



General Navigation

The example screen above shows the general layout, navigation, and controls for the UI. Not all controls and views will be available for all instruments.

1. **All Channels View:** Displays live status readouts of temperature, stability, and heater power for all attached channels of a given instrument. Press a channel to bring up its operation controls and settings. Channel names can be customized in the MENU.
2. **Selected Channel Operational View:** Displays the live status readouts and associated controls for the selected channel.

   a. **Function Buttons:** Buttons with action statements tell the system to do something.
   b. **Input Settings:** Buttons with numerical values and units show the current input settings for a given command. To set new values, use the adjustment controls (if available) or press the display box to open an input popup dialog.
3. **Display Screens:** Choose which screen view to display. Alternate screens (when available) may show different readouts or have different control settings.
4. **Screen Lock:** Lock the touchscreen.
5. **Menu:** View or customize instrument and system settings. Other sub-menu features include:
   a. **Remote Connections:** VNC and scripting parameters.
   b. **Data:** Download system data onto a connected USB Flash Drive.
   c. **Event Log:** Historical log of system-level events for reference or diagnostics.
   d. **Maintenance:** Displays any recommended maintenance procedures.
   e. **Tech Support:** Settings for assisting technical support personnel.

» NOTE
• Press and hold a command or input settings button to show on-screen help for that operation. Drag off the button before releasing to avoid executing the operation.

Application UI: Cryostation

Channel Types

- **Temperature Channel**: Displays live readouts of thermometers (temperature, temperature stability) and heaters (applied power) in the system.
    - **Platform**: The primary channel used to control the system. These commands will drive control operations across the Cryostation, compressor, and vacuum control unit.
    - **User 1**: The User 1 temperature channel displays the sample thermometer temperature readout.

» NOTE
• If the sample thermometer is not being used, it is recommended to turn it off to reduce noise on other temperature channels. • Navigate to `MENU > INSTRUMENT SETTINGS > USER 1`. Toggle the Temperature Channel Enabled switch to the left to disable.

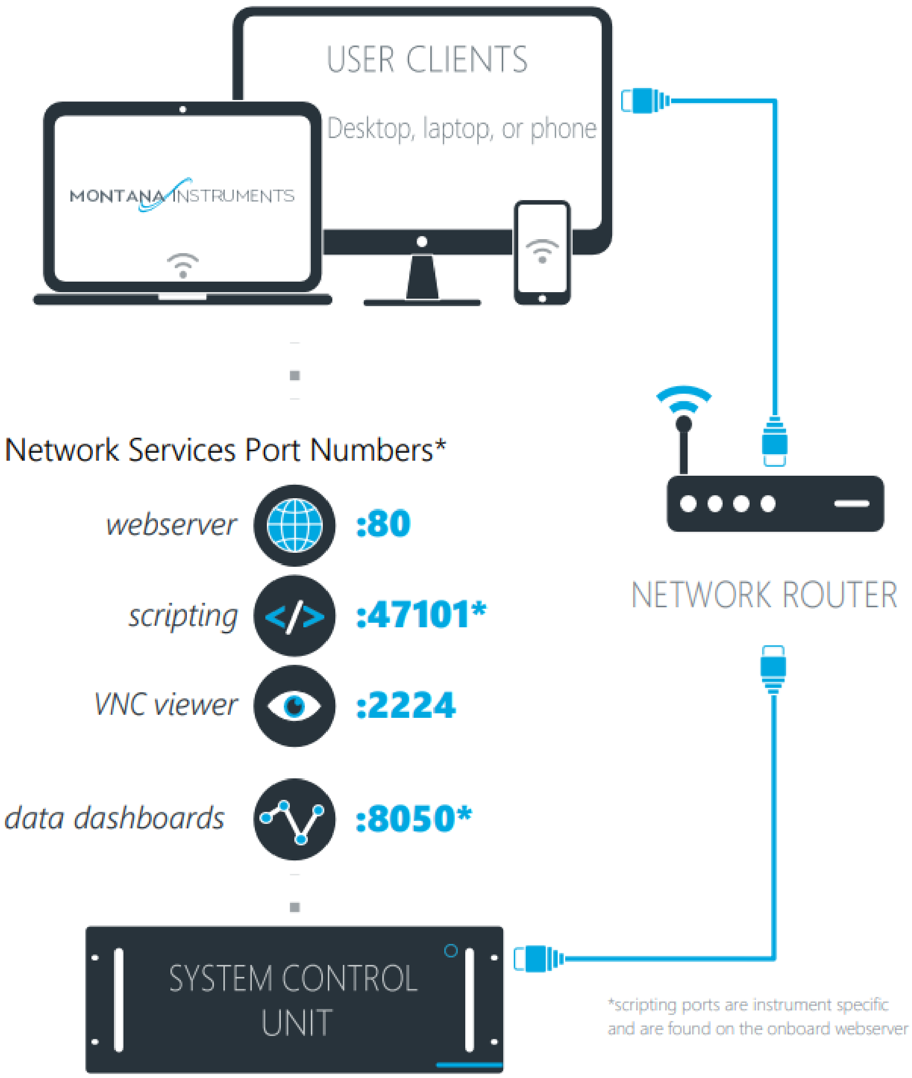
Display Screens

- **Sample Chamber:** Displays temperature channel controls and readouts. This screen is used to run most primary system operations.
- **Graphs**: Displays real-time system data in graphical form.
- **Overview:** Displays system status readouts for all connected sub-systems. Press any value to pull up detailed information and additional control settings (if available) for that parameter.
    - **Vacuum System:** status of pumps | valves | N_2 input | pressure gauges
    - **Cooler:** status of the cryocooler/compressor | Stage 1 and Stage 2 temperature channels
    - **Sample Chamber:** status of all sample chamber temperature channels

4.1.2 Network Interface

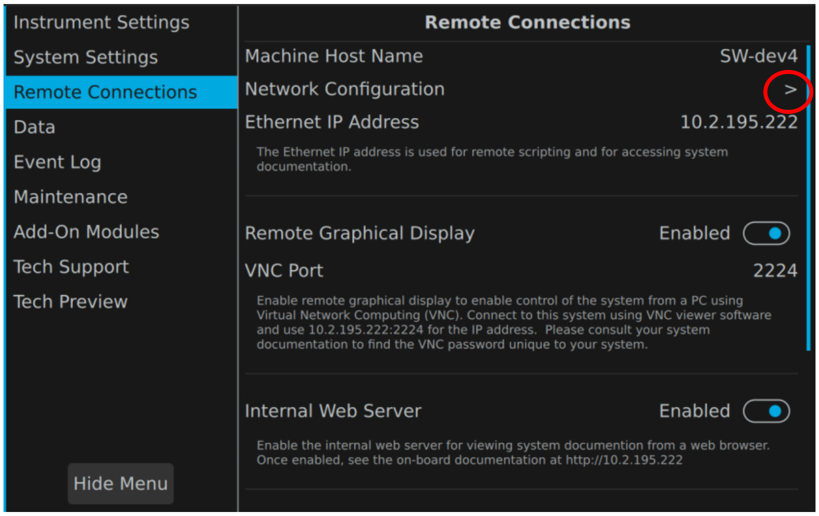
To utilize the network services provided, the system control unit must be connected to a local network using the Ethernet port on the rear face of the enclosure. This local network does not need to have internet access capabilities, nor is internet access required to use the following network services.

Each of the following services uses a different network port number for communication. You will need to work with your IT department to configure these ports to be allowed through the firewall on your network. Port numbers can be found in the heading of each of the following sections and in the connection diagram below.

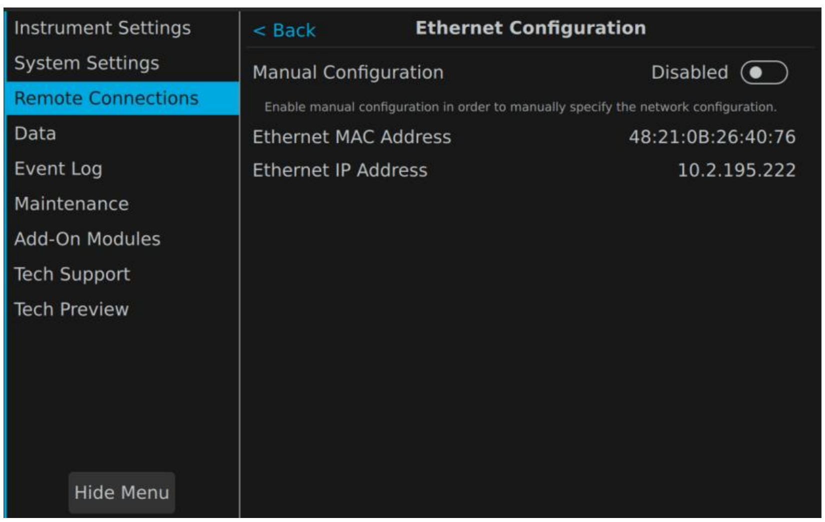


To find your system's IP and/or MAC address:

1. On the touchscreen UI, navigate to Menu > REMOTE CONNECTIONS



2. Scroll down to find the system's unique IP and MAC addresses. Your IT department may need to configure the network to provide network access to the device.

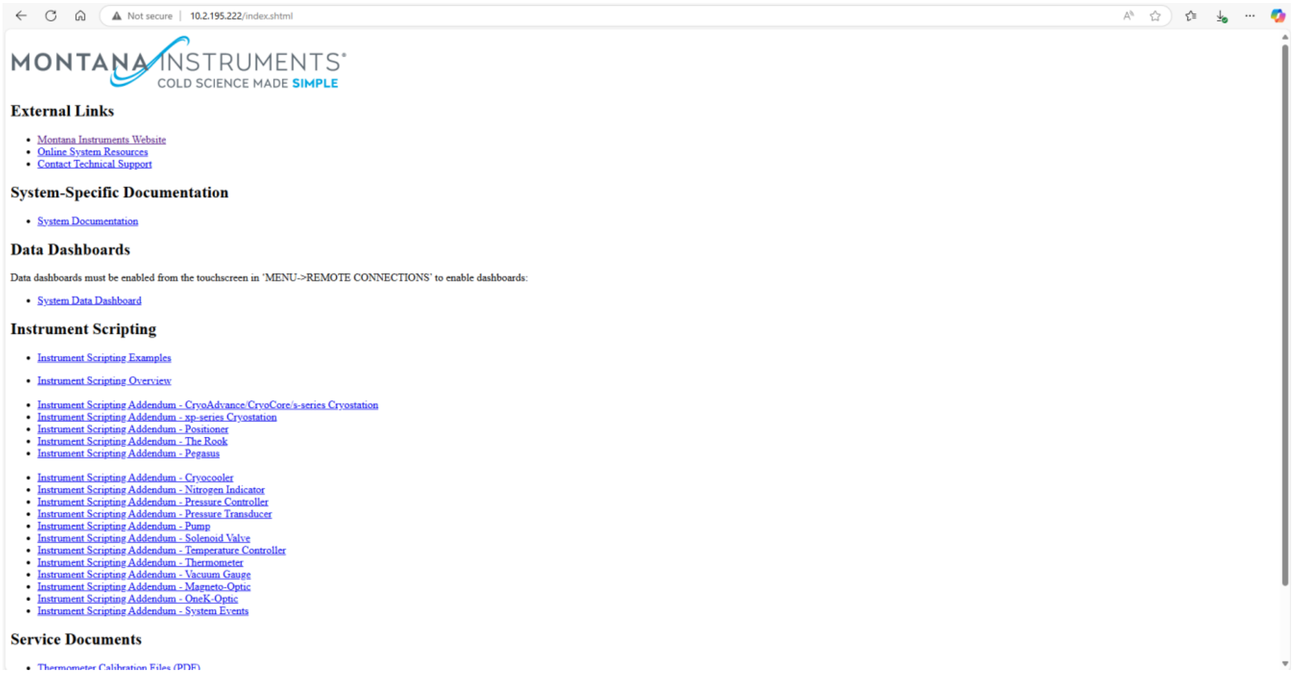


Webserver | Onboard Documentation — Standard HTTP port 80

The onboard webserver provides direct access to system-specific documentation, instrument scripting documentation and examples, web-based data dashboard links, select service documents, and other support materials.

To access the onboard documentation:

1. From an external computer connected to the same local network, use a web browser to navigate to the system's IP address (example: http://10.2.195.222).

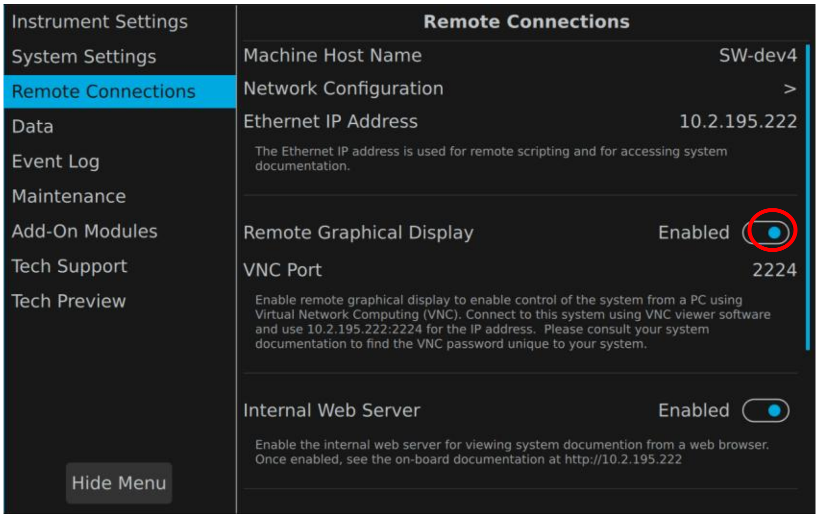


Remote Graphical Display | VNC Viewer **Non-standard HTTP port 2224**

The user interface can alternatively be viewed or controlled via an external computer using Virtual Network Computing (VNC) technology. The external computer must have a VNC viewer program installed (*several free options are available, including www.realvnc.com and www.tightvnc.com*). When Remote Graphical Display is enabled, the VNC connection will mirror the UI control screen.

To enable Remote Graphical Display:

1. On the touchscreen UI, navigate to Menu > REMOTE CONNECTIONS
2. Toggle the Remote Graphical Display switch to ENABLED.



3. Follow your chosen VNC viewer software's onscreen directions for connecting to the system IP address.

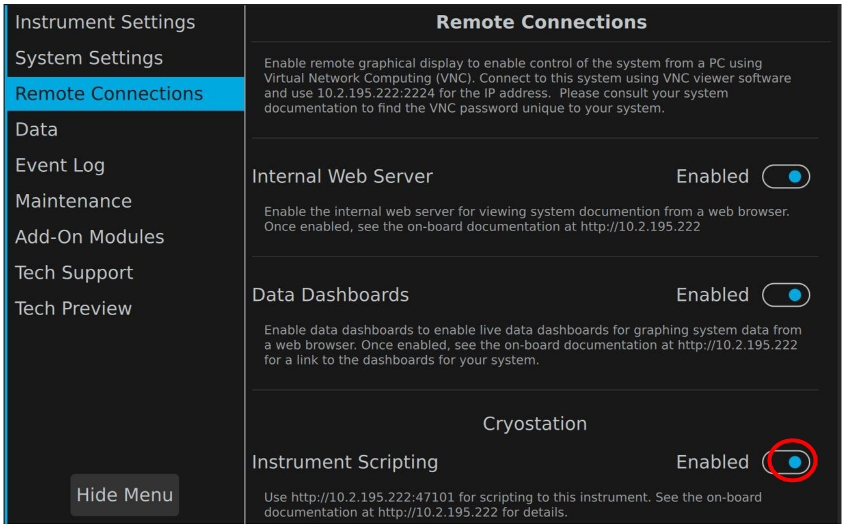
The VNC connection is password protected using a unique password for each system. The password is provided with your printed system documentation and in the onboard webserver file Quick Start Guide – Network Interface Connections. If lost, contact an authorized service representative to retrieve a copy.

Remote Scripting — Non-standard HTTP port 47101

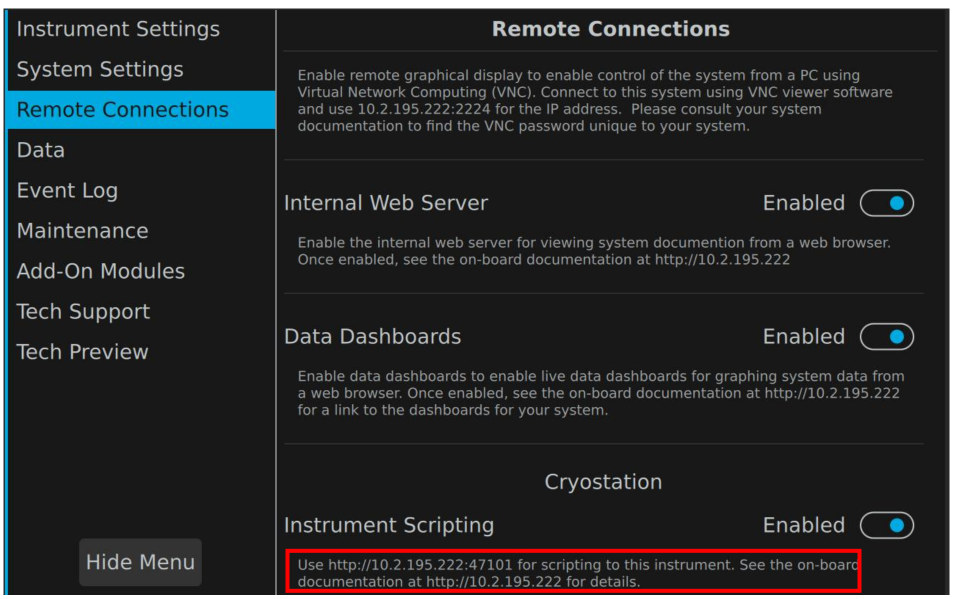
The instrument can alternatively be programmatically controlled via scripting commands using an external computer.

To use external scripting with the instrument:

1. On the touchscreen UI, navigate to Menu > REMOTE CONNECTIONS
2. Toggle the Instrument Scripting switch for the desired instrument to ENABLED



3. Follow the onscreen directions under the Scripting Toggle for opening the onboard scripting documentation, then use the available instructions for scripting with the instrument.

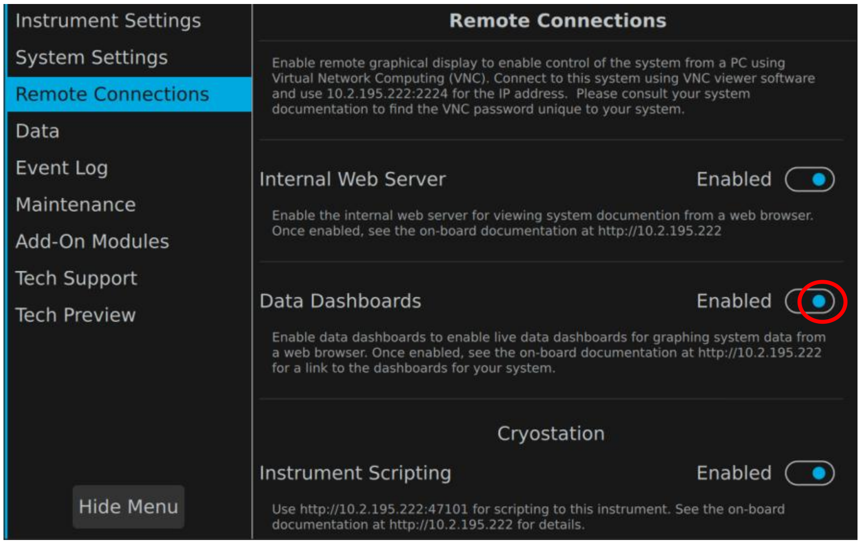


Data Dashboards — Non-standard HTTP port 8050

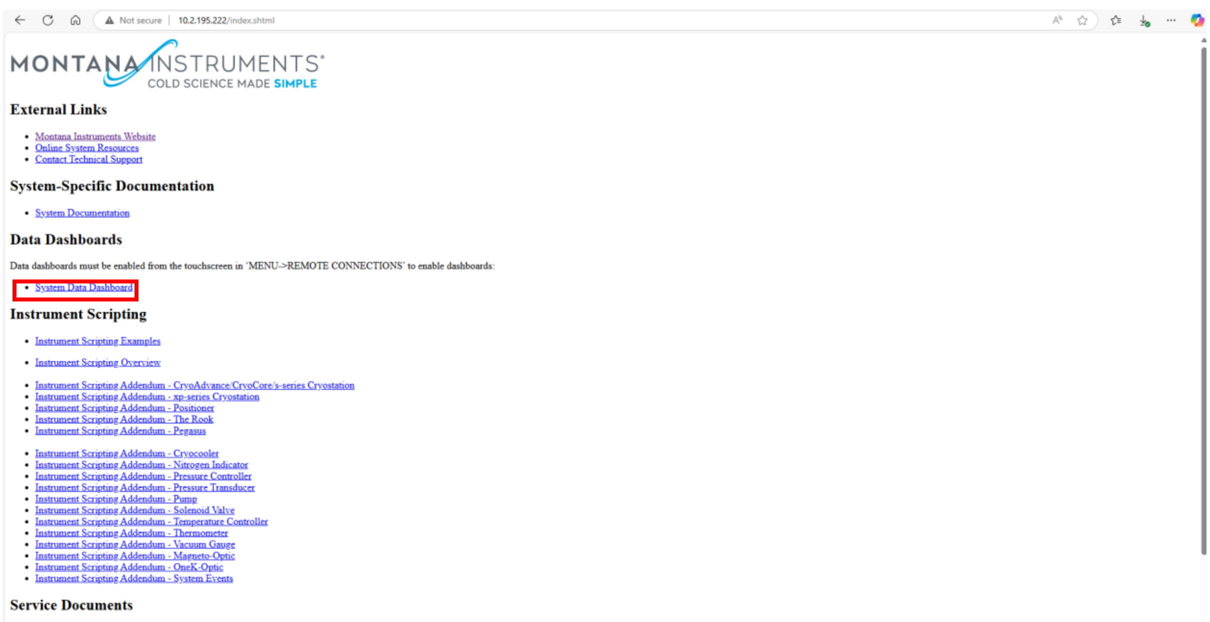
Data dashboards allow the user to view and analyze system data from a web browser.

To enable and view data dashboards:

1. On the touchscreen UI, navigate to Menu > REMOTE CONNECTIONS
2. Toggle the Data Dashboards switch to ENABLED



3. From the onboard webserver documentation (see page 47), click the System Data Dashboard link to access the system data.



MI Remote Support 🖧 Secure SSH tunnel port 2223

The Montana Instruments Remote Support connection is used by authorized service representatives to remotely access your system to provide diagnostic and troubleshooting support. If the system is behind a NAT/Firewall, the firewall must allow the system to connect a Secure SSH tunnel on port 2223 to mirs.montanainstruments.com. Work with your IT department to configure the required NAT/Firewall access.

4.2 Primary Operations

4.2.1 Turning on the System

Before starting the power-up procedure, ensure that the power switches on the back of the System Control Unit and the front of the compressor are toggled to OFF (o).

1. If a dry nitrogen source (high or ultra-high purity) is connected to the system, verify the supply pressure is set to 10-100 psi MAX. Nitrogen is required on turbo-equipped systems, 50-100 psi MAX.
2. Ensure the power button on the front of the compressor unit is toggled to ON (|).
3. Turn on the rack power unit with the red switch on the front of the control panel.
4. Turn on power to the vacuum control unit by toggling the power switch on the back of the unit ON (|).
5. Turn on power to the system control unit by toggling the power switch on the back of the unit ON (|).
6. Next, turn on the system control unit by pressing the power button on the front of the unit. This power button will glow when the unit is on.

The software will initialize and run automatically. The UI will indicate the software is `INITIALIZING` while the system checks for and establishes a connection with the attached peripheral cards. After the screen shows `READY` the system is ready for operation.

NOTICE
• Compressor ON/OFF frequency must be less than six (6) times hour, and less than 24 times per day. The restart interval must be more than three (3) minutes. Frequent ON/OFF operation may result in malfunction or damage to the compressor capsule.

4.2.2 Controlling System Temperature

The `PLATFORM` temperature channel is used to drive control operations across the Cryostation, compressor, and vacuum control unit.

Cooling Down the System

1. In the UI for the `CRYOSTATION` instrument, navigate to the `SAMPLE CHAMBER` display screen and select the `PLATFORM` temperature channel to bring up its operation controls.
2. In the `PLATFORM TARGET` input box, enter the target temperature value. To reach the lowest possible base temperature, enter 0.0 K. Press `SET` to confirm.

3. Press the `COOLDOWN` command button. On the popup, confirm or adjust the custom parameters for the cooldown, then press `COOLDOWN` again to start.

The cooldown cycle will begin.

» NOTE
• The Stage 1 and Stage 2 temperatures will drop quicker than the platform temperature. The platform will drop faster after Stage 1 reaches 40.5 K. • When the platform has reached a stable temperature, the ring surrounding the platform status readouts will change from flashing to solid.

Vacuum States During a Cooldown

- When a cooldown is initiated, the system will first establish a rough vacuum.
  - During this process, the system will automatically check for leaks. If a vacuum cannot be established, an error message will show in the UI and the cooldown process will be aborted. See *System Diagnostics* for troubleshooting information.
- After a proper vacuum level is established, the compressor will turn on; this may take up to 30 minutes.
- The pressure will continue to drop to a high vacuum state leveraging cryopumping.

» NOTE
• To achieve the best vacuum levels, set the cooldown target temperature to the system base temperature and allow the system to stabilize there before controlling to higher temperatures. This temperature set point is necessary to take full advantage of cryopumping. • The VCM24 pressure gauge can only read out to ~0.1 mTorr. If pressure is below this value, the UI readout will indicate `HIGH VAC`.

Adjusting Platform Temperature

The platform temperature may be changed at any time by setting a new value using the `PLATFORM TARGET` input box. If the user is setting incremental temperature set points, the `COOLDOWN` and `WARMUP` buttons do not need to be pushed.

Warming Up the System

A warmup operation is used to bring the system to room temperature to access the sample chamber. The system may be warmed up actively with heaters at any time, including during a cooldown.

1. In the UI, navigate to the SAMPLE CHAMBER display screen and select the PLATFORM temperature channel to bring up its operation controls.
2. Press the WARMUP command button. On the popup, press WARMUP again to confirm.

An active warmup is much faster than using the STOP command. The heaters will automatically shut off when the entire system reaches 295 K, but the sample chamber will remain under vacuum.

Stopping a Cooldown or Warmup

At any time during a cooldown or warmup, the process can be stopped.

1. In the UI, navigate to the SAMPLE CHAMBER display screen and select the PLATFORM temperature channel to bring up its operation controls.
2. Press the STOP command button. On the popup, press STOP again to confirm.

This action will stop running the compressor/cryocooler and turn off any heater power going to the cryocooler stages and sample chamber platform. The system will begin to warm up naturally, but it will remain under a vacuum.

4.2.3 Venting and Pulling Vacuum

Vent to Access the Sample Chamber

After a cooldown and warmup cycle, the system remains under vacuum until the user is ready to access the sample chamber. To access the chamber:

1. In the UI, navigate to the SAMPLE CHAMBER display screen and select the PLATFORM temperature channel to bring up its operation controls.
2. Press the VENT command button. On the popup, confirm or adjust the custom parameters for the vent procedure, then press VENT again to confirm.

The sample chamber will be vented to atmospheric conditions.

» NOTE
Choosing to “Vent Continuously” will cause nitrogen (when attached) to flow through the chamber, even after the chamber is opened. This can help to keep the vacuum space as clean as possible during quick sample exchanges. To stop the flow of nitrogen when “Vent Continuously” is used, press the STOP command.

Keep the Sample Chamber Under Vacuum

When the system is not in use, it is recommended to keep the sample chamber under a vacuum to prevent moisture and contaminants from entering the sample space. To keep the system under vacuum:

1. In the UI, navigate to the `SAMPLE CHAMBER` display screen and select the `PLATFORM` temperature channel to bring up its operation controls.
2. Press the `PULL VACUUM` command button. On the popup, confirm or adjust the custom vacuum parameters, then press `PULL VACUUM` again to start.

The sample chamber will pull vacuum until the target vacuum pressure threshold is met.

» NOTE
Since this is an independent operation without cryopumping, the system will likely only be able to achieve a rough vacuum state. To stop the vacuum pump(s), press the `STOP` command. The sample chamber will remain at the current vacuum level until a `COOLDOWN` or `VENT` procedure is initiated.

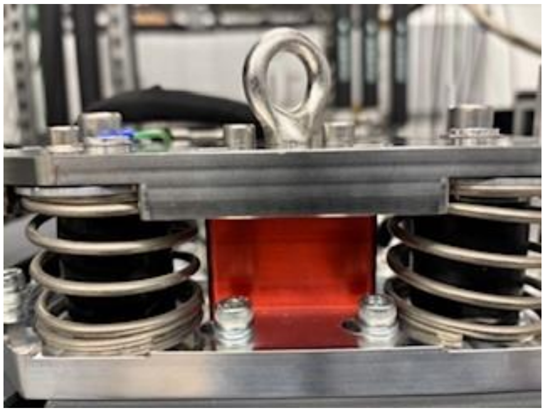
4.3 Moving the System

If the system ever needs to be moved to a different lab or location, follow the steps below or reach out to the Montana Instruments Service team for guidance:

1. Save any important data on the system.
2. Power down the unit:
    a. Tap (press and release) the power button on the front of the system control unit -or-
    b. On the touchscreen UI, navigate to `MENU` > `SYSTEM SETTINGS` and select `POWER OFF`
3. Remove the helium and vacuum hoses, paying special attention to ensure the O-rings remain in place. NOTE: Take extra precautions to keep the helium hoses clean, such as wearing gloves and capping the ends of the hoses when not installed. Failure to keep the hoses clean may lead to degraded performance or damage to the pulse tube itself
4. Remove the remaining cables and electrical connections.

If the system needs to be shipped, follow the remaining steps below

5. Reverse the steps in the Installation Procedure. Replace the red locking spacers (see below) and lock them in place. Then unbolt the system from the optical table.



Red locking spacer installed (one on each side of the system)

6. Re-pack the system in original packaging. Some components **must be** packed upright on a pallet to avoid damage.

NOTICE
• Follow all handling instructions for the individual components as outlined in the *General Hazard Information* section. • If you are uncomfortable with moving the system on your own, or if you need to order any replacement packaging, please contact an authorized service representative. • Do NOT attempt to disassemble any components of the system beyond access panels, accessory installation, or required system check items.

4.4 Moving the System Rack

After completing the steps in section 4.3 *Moving the System,* the system rack can also be moved.

1. Ensure the system is at room temp and vented to atmosphere.
2. Power down the system and any externally connected devices.
3. Disconnect helium lines following cleanliness guidelines.
4. Set the rack on the caster wheels and raise the adjustable feet.
5. Un-anchor the earthquake supports .
6. Lower the caster wheels so they can freely roll on the ground. Make sure all 4 wheels are in contact with the ground before attempting to roll the system rack.

7. Carefully roll the cart to its new location.

Note that if the rack needs to travel to a different facility or building it is recommended to re-package the rack in its shipping crate to avoid damage to the rack.

Section 5 - Diagnostics & Troubleshooting

This section contains information for basic system diagnostics and troubleshooting advice. Diagnostics or repairs outside of the scope of this section should be completed by an authorized service representative.

5.1 Expected System Performance

Each system ships with a unique Certificate of Performance to demonstrate the factory performance of that Cryostation. Note that specifications and certifications represent factory acceptance testing performed on a bare platform without additional accessories or sample mounts.

The vibrations are measured in this configuration with a capacitive sensor that is also bolted to the table. The capacitive sensor measures the peak-to-peak vibrations in nanometers to a test fixture bolted to the sample platform.

5.2 System Diagnostics

5.2.1 Performance Issues

If a degradation in performance or other failures are experienced, check for these common issues:

Problem/Symptom	Possible Cause	Solution/Suggestion
The system is unable to reach target temperature or cooldown takes longer than expected	See *Helium Lines* and Connections Pulse tube systems are more susceptible to contamination from the environment. Take extra care whenever removing lines. Install end caps to lines and connectors if the lines are removed. Wear gloves if handling or working near the connectors and line fittings. Visually inspect line ends and fittings for contaminants before reinstalling. Failure to minimize contamination in the system may result in a degradation of performance or damage to the pulse tube. Temperature Optimization *in section 5.3.1*	

<table>
<tr><td>The system does not meet vibration specifications on the sample stage</td><td colspan="2">See Vibration Mitigation in section 5.3.2</td></tr>
<tr><td>The system will not pull rough vacuum – leak check failed</td><td rowspan="2">Vacuum leak</td><td rowspan="2">See Vacuum Check in section 5.3.3</td></tr>
<tr><td rowspan="2">System condensing moisture on the sample, windows, exterior of the sample chamber, or vacuum case (black cylinder surrounding cryocooler). Exterior surfaces are cold to the touch.</td></tr>
<tr><td>Radiation (inner) and vacuum (outer) window are touching</td><td>Adjust windows so they do not touch. For low working distance setups, the windows may touch under vacuum, so be sure to check again after pulling the vacuum.</td></tr>
<tr><td>Thermometer not working</td><td>Not properly installed or activated.</td><td rowspan="2">Make sure the temperature channel is enabled. Navigate to <code>MENU > INSTRUMENT SETTINGS > USER X</code>. Toggle the Temperature Channel Enabled switch to the right to enable. Contact Customer Service for further troubleshooting & documentation</td></tr>
<tr><td>Heater not working</td><td>Not properly installed or activated.</td></tr>
</table>

5.2.2 Power and Communication Issues

If the system will not turn on, run commands, or display readouts, check for these common issues:

Problem/Symptom	Possible Cause	Solution/Suggestion
The system throws an electrical breaker	Wall power issue	1. Check the wall voltage using an AC voltmeter (digital multi-meter on the AC setting) to ensure it is in the defined ranges for each piece of equipment.
UI screen is black / does not turn on	Communication issue with system control unit	1. Make sure all cables and power cords are connected properly. See Connecting System Cables and Power section of the Installation Procedure for details.

		2. Ensure the power switch on the back of the system control unit is ON (|). 3. Ensure the power button on the front panel is ON (glowing). 4. Power cycle the system control unit. Toggle the power switch on the back of the unit OFF (o) then back ON (|). 5. Press the `RESET` button on the back of the UI touchscreen display.
	Touchscreen is faulty	1. Contact MI Service for replacement 2. Connect the external monitor to HDMI and connect a USB mouse to control the system OR 6. Use VNC to control the system remotely
UI controls are frozen or non-responsive	Touchscreen display issue	1. Press the `RESET` button on the back of the UI touchscreen display.
The system does not initialize	Communication issue with the compressor	1. Make sure all cables and power cords are connected properly. See Connecting System Cables and Power section of the Installation Procedure for details. 2. Ensure the power switch on the back of the compressor is ON (|). 3. Ensure the `ENABLE` switch on the front panel is ON (|). 4. Power cycle the compressor. Toggle the power switch on the back of the unit OFF (o) then back ON (|).
	Communication issue with vacuum control unit	1. Make sure all cables and power cords are connected properly. See Connecting System Cables and Power

Vacuum pressure reading in UI indicates "SensorErr"		section of the Installation Procedure for details. 2. Ensure the power switch on the back of the vacuum control unit is ON (	). 3. Power cycle the vacuum control unit. Toggle the power switch on the back of the unit OFF (o) then back ON (	).

5.2.3 Compressor Issues & Fault Messages

The F-70LP compressor has built-in mechanisms to check for issues.

To prevent issues relating to inlet water, ensure facility water meets the following requirements:

Chilled Water	
Cooling water connections	Swagelok bulkhead fittings, ½" MNPT.
Cooling Water Flow Rate	6.8-9 L/min. (1.8-2.4 gal./min.)
Cooling water inlet temperature:	5-25 °C (41-77 °F)
Cooling water outlet temperature:	45 °C (113 °F) maximum
Cooling water supply pressure	8 bar (116 psig) maximum
Pressure drop at 9 L/min	<1bar (<14.5 psig)

Water Quality Requirements		
	Initial Values for non-replenished (closed) system	Values for continuously replenished (open) system
Suspended solids, μg/L	<250	<250
Particle size, μm	<300	<300
pH (25 °C)	6.5 to 8.0	6.0 to 8.0
Alkalinity (ppm)	100 max.	50 max.
Hardness (ppm)	200 max.	50 max.
Chloride (ppm)	200 max.	50 max.
Sulfate (ppm)	200 max.	50 max.
Iron (ppm)	1.0 max.	0.30 max.

Sulfur ion (ppm)	None Detected	None Detected
Ammonium ion (ppm)	1.0 max.	0.20 max.
Silica (ppm)	50 max.	30 max.
Calcium (ppm)	100 max.	50 max.
Magnesium (ppm)	100 max.	50 max.

If the compressor alarm sounds or reads a fault message, check for these common issues:

For each of the errors below, the compressor may need to be restarted. To cycle the power:

1. Toggle the power switch on the front of the unit OFF (o) then back ON (|).
2. Ensure the helium pressure stabilizes in an acceptable range before proceeding (See *Helium Check section*).

Problem/Symptom	Possible Cause	Solution/Suggestion
UI indicates "Cryocooler Disconnected"	Power dropped out with compressor or communication lost	Check cable and power connections. See *Power and Communication Issues section*. Check the `EVENT LOG` in the UI `MENU` for any fault messages.
System Halted | Pressure Imbalance	Helium hose not completely connected	Check the hoses for leaks. See *Helium Hose Fittings section*.
Return Pressure Too Low	Occurs when the return pressure is below its minimum value of 0.35MPa. The likely cause for this is the cryocooler stopped running or the return line is detached.	Check the connection on the return line and ensure the cryocooler is running Check the supply and return balanced pressures (1.66MPa)
Supply Pressure Too High	Occurs when the supply pressure exceeds 2.75MPa. It is caused by similar conditions as the Return Pressure Too Low fault – the cryocooler stopped running or, in this case, the supply line is detached. In general, the Return Pressure Too Low fault will occur before this fault.	Check the connection on the supply line and ensure the cryocooler is running.
Delta Pressure Too Low	Occurs when the difference between the supply and return line pressures falls below 0.3MPa. A problem occurred in the cryocooler causing the supply and return lines to approach a common value.	Check that the supply and return lines are attached correctly and not switched. If the compressor was running and stopped it will need time to rebalance the pressures.
Capsule Over Temperature	Occurs when the capsule temperature exceeds 85^{0}C. This	Check that air flow through the compressor is not

	could indicate improper oil flow or helium flow. It could also be caused by vents on the compressor being blocked.	being inhibited by any external object.
Helium Over Temperature	Occurs when the Cool Helium temperature exceeds 50^{0}C. Similar to the capsule over-temperature fault, this is likely due to insufficient air flow through the cooling system.	Check that the compressor vents are clear of debris or impedances and that the fan is running.
Exhaust Over Temperature	Occurs when the exhaust temperature of the cooling system exceeds 55^{0}C. This is most likely due to insufficient airflow through the cooling system.	Check that the compressor vents are clear of debris or impedances and that the fan is running.
Low Oil Flow	Occurs when the oil flow ratio falls below 0.4. This alarm indicates that the flow of oil through the oil cooling coil is insufficient. Since the oil flow depends on the differential pressure of the system, this alarm is commonly caused by low differential pressure. The differential pressure across the cryocooler depends on both the speed of the cryocooler motor and the compressor speed. A very high cryocooler speed could cause a drop in the differential pressure as could a very slow compressor speed. However, this scenario is highly unlikely.	Check that the supply and return lines are properly attached, and there is nothing that is causing a bypass of the cryocooler.
Oil Sensor Failure	Occurs when there is a problem with the oil sensor electronics. This is usually due to the oil sensor line being unplugged. This alarm could also be caused by a short in the	Check that the oil sensor wire harness connector is attached to the board.

	sensor circuit. If this is suspected, contact Service	
Oil Return Failure	Occurs when the oil level falls below 30% in 30 seconds. This is indicative of a problem in the oil return line or in the oil level sensor itself.	Give the system a chance to settle and try again. If the problem continues, contact Service.
Adsorber Full	Indicates the adsorber needs to be replaced (occurs after ~30,000 hours of operation). Before this fault occurs, there will audible alarms & messages on the display to indicate a replacement may be needed soon.	Contact Service to schedule this replacement.
High Oil Level	If the oil return system is failing and the oil level continues to increase, this fault will occur when the oil level fills the pump.	Cycle the compressor power and restart the system. Contact Service if the alarm continues.
Pressure Alarm	Loss of gas charge or blocked circulation.	Check helium pressure.
Oil Level Alarm	Oil line blockage.	Check oil levels and circulation.
Water Flow Alarm	Pipes obstructed or facility water issue. Low water flow, temperature warmer than 46 C (115 F).	Verify water flow rate is 6-9 L/min. Inspect pipes for obstructions.
Water Temperature Alarm	Water supply temperature warmer than 35 C (95 F).	Ensure cooling water is between 5-25 C.
Helium Temperature Alarm	High helium discharge temperature. Temperature warmer than 93 C (200 F).	Allow system to cool before restart.
Phase Sequence/Fuse Alarm	Faulty fuse or main power.	Check fuses, main power phase sequence and power connections.
Motor Temperature Alarm	Overheating motor windings. Return pressure greater than 140 psig while compressor is on.	Allow to cool, inspect cooling system for issues.

5.3 System Checks

There are several basic checks users can do to help diagnose general problems and help the system achieve optimal performance. Please handle these checks carefully and thoroughly, neglecting any of these steps may have an impact on base temperature or vibration performance.

5.3.1 Helium Lines and Connections

Pulse tube systems are more susceptible to contamination from the environment. Take extra care whenever removing lines. Install end caps to lines and connectors if the lines are removed. Wear gloves if handling or working near the connectors and line fittings. Visually inspect line ends and fittings for contaminants before reinstalling. Failure to minimize contamination in the system may result in a degradation of performance or damage to the pulse tube.

5.3.2 Temperature Optimization

Cryostation platforms are optimized to control heat loads reaching the sample. To ensure the lowest possible base temperatures, follow the best practices below.

1. Use proper thermal lagging techniques for any wiring (including coax) entering the sample space. Ensure thermal clamps are properly tightened. See *Thermal Lagging Techniques in section 3.5.2* for details.
2. Avoid “touches” between the various stages (such as a platform component touching a Stage 2 component, or a Stage 2 component touching a Stage 1 component), as these become conductive paths for heat transfer.
    a. Ensure wiring or cabling does not contact the inside of the radiation shield.
    b. Ensure the radiation shield or radiation windows do not contact any part of the outer vacuum housing or windows. For low working distance setups, confirm that windows do not touch after the vacuum is pulled.
3. Always use the appropriate wire material and gauge for the application. See *Sample Chamber Wiring in section 3.5* for details.
    a. Avoid using copper wire unless required. The electrical conductivity of phosphor bronze is typically sufficient for most applications.
4. Ensure the screws holding the platform to the support base and the screws securing the radiation shield are in place and tightened (5 in-lb.). Failure to tighten the screws will

reduce the ability of the system to pull heat from the sample platform and may increase vibrations.

5. Ensure a thin layer of N-grease or another thermal grease is used between metal-to-metal interfaces for proper thermal connection.
6. Use inner "cold" windows or blanks on the radiation shield whenever possible. Without them, the added heat load can significantly increase the base temperature of the platform.
7. Check the helium charge pressure. If there is a helium leak, cooling performance will be hindered significantly. See *Helium Check in section 5.3.4* for details.
8. Ensure the User temperature channel heater is NOT on.

» NOTE
During a cooldown, the system will steadily ramp down in temperature to 4.2 K, then can take longer to reach and stabilize at the base temperature. Options and energy inputs (laser power) may impact cooldown times and cause slightly higher base temperatures.

Identifying Heat Loads

The expected temperatures and temperature differences between Stage 1, Stage 2, Platform, and Sample under various operating conditions can be used to identify the source of an unwanted heat load. The temperatures below are examples to illustrate the troubleshooting process and should only be used as a general reference. **It is recommended to compare with actual data from a previously successful cooldown on your system as a more accurate reference guide.**

The base temperature for a standard system under normal operating conditions is depicted below. The gradient between the platform and sample will change depending on the type of sample mount and other options.

	Stage 1	Stage 2	Platform	Sample
Temperature	27 – 28 K	2.4 – 2.7 K	2.7 – 3.0 K	2.8 – 3.2 K
Temperature Gradient			+0.2 – 0.4 K	+0.2 – 0.5K

Heat Load Between Stage 1 and Stage 2

In the example below, Stage 2 has a higher-than-normal temperature, as does the Platform and Sample. However, Stage 1 is colder than normal. The temperature gradient between Stage 2 and the Platform and the Platform and the Sample is normal. This indicates that the heat load is located between Stage 1 and Stage 2.

	Stage 1	Stage 2	Platform	Sample
Temperature	26 K	5.0 K	5.3 K	5.7 K
Temperature Gradient			+0.3 K	+0.4 K

Possible Cause: Crosslink rod touching the sidewall. Contact an authorized service representative for instructions to perform a touch test.

Heat Load Between Platform and Sample

In the example below, the Stage 2, Platform, and Sample temperatures are high. However, the most critical issue is the large temperature gradient between the Platform and Sample. The heat load is most likely located in between the Platform and Sample, and since the Sample temperature is high, the temperatures of the Platform and Stage 2 are also being pulled up.

	Stage 1	Stage 2	Platform	Sample
Temperature	28 K	3.0 K	3.3 K	5.0 K
Temperature Gradient			+0.3 K	+1.7 K

Possible Causes: The most likely culprits are those described in the Helium Lines and Connections

Pulse tube systems are more susceptible to contamination from the environment. Take extra care whenever removing lines. Install end caps to lines and connectors if the lines are removed. Wear gloves if handling or working near the connectors and line fittings. Visually inspect line ends and fittings for contaminants before reinstalling. Failure to minimize contamination in the system may result in a degradation of performance or damage to the pulse tube.

Temperature Optimization *in section 5.3.1*, such as wires touching the radiation shield, wires touching the sample mount directly after the thermal clamp, use of improper wires, loose screws, missing N-grease, or missing radiation windows.

Heat Load Between Stage 2 and Platform

In rare cases, a higher-than-normal gradient may exist between Stage 2 and the Platform. This is typically caused by loose screws underneath the platform, which should not be accessed by users. If this heat load is present, contact an authorized service representative.

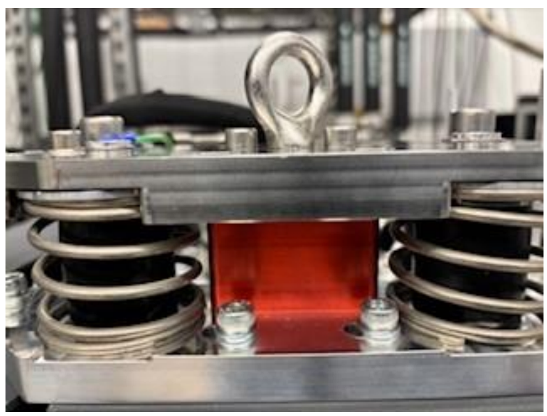
Heat Load on Sample Thermometer

If the sample is reading higher than normal, but all other temperatures are in a normal range, the most likely cause is an improperly mounted or lagged sample thermometer. Refer to *Mounting a Thermometer in section 3.3*.

5.3.3 Vibration Mitigation

The Cryostation and sample chamber have several vibration-damping design features to reduce the effects of cryocooler mechanical vibrations on the sample platform. To ensure the lowest possible mechanical vibrations, follow the best practices below.

1. Rigidly bolt the system to the optical table using all 10 available mounting locations in the baseplate (6 in the sample chamber and four in the cooling tower).
   a. Bolts should be tightened sequentially, starting from one end of the Cryostation and progressing toward the other end
2. Ensure all screws inside the sample space are tightened down.
3. The red shipping supports at the back of the Cryostation (one on each side) should be removed prior to system operation (see the below image). Having these components installed can introduce unwanted vibrations.



Shipping supports (only one pictured, both need to be removed)

4. Ensure the helium hoses are not touching the cabling or the optical table. They should also not be pressed against a wall or another surface.
5. Ensure the vacuum hose is not in contact with the optical table.
6. Ensure that optics are rigidly mounted to the table. Optics could be vibrating due to the Cryostation on the table and mounting them should be carefully considered to reduce this effect.
7. Check temperature performance. An increase in Stage 2 temperature and a decrease in Stage 1 temperature could indicate a crosslink rod touch that could inherently degrade vibrational performance.

8. Ensure the adjustable feet on the rack cart are engaged. The wheels on the cart are for shipment and moving the system only. To improve vibrational performance, ensure that the feet are all level on the floor and properly locked in place.
9. The system rack comes with earthquake brackets that stabilize the rack cart during a seismic event. These brackets are attached to anchor points that are drilled into the floor. To ensure proper installation and avoid any adverse effects on system vibrations, please refer to the Installation Guide for further details.

5.3.4 Vacuum Check

The UI displays a pressure reading for the attached vacuum gauge sensor. If a system leak check fails, or if condensation or freezing is observed on or inside the chamber, a leak may be present. Please check the following:

1. Check to ensure the vacuum gauge properly reads atmospheric pressure (~500-770 Torr) when the system is at room temperature and vented. If it is not, the gauge may not be working properly.
2. Check that the vacuum housing and lid are in place and properly seated. Ensure no wires are pinched between the O-rings.
3. Check the O-rings on 1) the sample chamber vacuum housing 2) the vacuum housing lid and 3) the vacuum housing outer "warm" windows. Ensure the O-rings have a thin layer of L-grease and are completely free of debris or fibers.
    a. All side panels also have an O-ring interface. Do NOT remove the side panels before consulting with an authorized service representative.
4. Although nitrogen is optional for standard systems, it helps keep the charcoal adsorbers clean and the inside of the Cryostation free from moisture. Using nitrogen is particularly important in humid environments. Nitrogen is required for turbo-equipped systems.
    a. Nitrogen purge cycles, as well as a platform bakeout, will help rid the chamber of contaminants before cooldown.
5. If a leak detector is accessible, use it to leak check the sample housing, Cryostation, vacuum hose, vacuum connections to find the source of the leak.

If the leak persists, please contact an authorized service representative.

There is enough charcoal in the system to freeze particles that may be introduced from a small leak. If there has been a large leak, or if a small leak persists over a period of time, the charcoal adsorbers will need to be recharged. To do this, run a `COOLDOWN` or `PULL VACUUM` operation with `PLATFORM BAKEOUT` (350 K for 60+ mins) and `DRY NITROGEN PURGE` (3+ times) enabled.

5.3.5 Helium Check

The helium pressure in the system can be checked when the compressor is idle.

1. Warm the system to room temperature and leave idle for at least one hour. Do not start a cooldown.
2. Ensure the power on the front of the unit is ON (|).
3. In the UI, navigate to the `OVERVIEW` display screen, then press the `CRYOCOOLER` reading to show compressor details.
   a. Or, on the front panel of the compressor, toggle the `DISPLAY` button until it shows values.
4. The return values should be between 15-140 psig on the return. If the return value is <15 psig, helium will need to be recharged. See *Helium Recharge Process in section 5.3.5* for details.

Helium Hose Fittings

Improper connection or missing O-rings on the helium hose fittings can cause a loss in helium pressure and hinder the cooling performance.

To inspect fittings on the back of the compressor and Cryostation:

- Ensure the fittings are not cross-threaded.
- Ensure there is a **single** O-ring at each end of the hose and each connection point. The O-rings tend to dislodge from the hose and stay on the fitting (or vice versa).
  - If this happens, the errant O-ring must be carefully removed and replaced in the correct location before reconnecting, otherwise it will not seat properly.



Hose with extra O-ring

Extra O-ring removed

Left: Fitting missing O-ring
Right: proper O-ring fitment

Helium Recharge Process

If the helium pressure is low, below 1.65 – 1.70 MPa (240 psig nominal), it should be recharged using a 99.999% (UHP) tank of pressurized helium. The accessory kit comes equipped with vent and recharge valves that can be used to flush the system and recharge. Contact an authorized service representative for instructions on this process or find the service document on the appropriate product page on the Montana Instruments website. Note that operating pressure will be higher at 2.0 -2.5 MPa (290-363 psig).

Helium Line and Fitting Cleanliness

Pulse tube systems are more susceptible to contamination from the environment. Take extra care whenever removing lines. Install end caps to lines and connectors if the lines are removed. Wear gloves if handling or working near the connectors and line fittings. Visually inspect line ends and fittings for contaminants before reinstalling. Failure to minimize contamination in the system may result in a degradation of performance or damage to the pulse tube.

NOTICE
Follow instructions carefully To avoid possible contamination, these instructions must be followed carefully.

⚠ **CAUTION**
Ear protection recommended Venting the helium lines typically creates a loud noise as pressure is released. Be prepared for venting noises when attaching the purge adapter to the helium lines.

Section 6 - Appendices

6.1 Related Documentation

For a copy of associated documentation, see below:

Document Title	Location
System Documentation	Cryostation 200 PT
General Terms and Conditions of Sale	Direct Link to latest PDF Or find the link at the bottom of our homepage
Limited Warranty Agreement	https://www.montanainstruments.com/support/warranty-information
End-User License Agreement	Direct link to latest PDF
Patent Information	Patents (montanainstruments.com)

BACL
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www.baclcorp.com

ATTESTATION OF TEST RESULTS

Date of Issue: 2025-04-28 Attestation Number: R2504073

Bay Area Compliance Laboratories Corp. (BACL) hereby declares that testing has been completed and is compliant for the product and standards below:

Product Name / Description:	Cryostat System
Model:	Cryostation 200 PT
Manufactured by:	Montana Instruments
Project Number:	R2504073

Standard	**Test Result**
EN 61326-1:2013 IEC 61326-1:2020 BS EN IEC 61326-1:2021	Compliant

BACL tested the above equipment in accordance with the requirement with the above Standards. The results were being documented in Test Report #R2504073-17 listed in above table apply only to the tested sample under the condition and modes of operation as described herein.

Attestation by: Kai Chen
Associate Project Engineer

Signature 2025-04-28
Date

MONTANA INSTRUMENTS

DECLARATION OF SIMILARITY

Date:
5/8/25

To:
Bay Area Compliance Laboratories Corp.
1274 Anvilwood Ave.
Sunnyvale, CA, 94089
Phone: (408)732-9162, Fax: (408)732-9164
http://www.baclcorp.com

Dear Sir or Madam,

We, Montana Instruments, hereby declare that the series of product models listed below are electrically identical with the same design, construction, parts, or assemblies essential to ensure conformity with the product safety compliance criteria of EN 61010-1:2010/A1:2019 and BS EN 61010-1:2010+A1:2019 as the model: Cryostation 200 PT (230 V), which is defined as the maximum configuration of the model list, and was used as the representative model to ensure the most unfavorable test results in BACL test report: R2504073-61010.

Model Number(s) of models determined to be equivalent to the tested model.

- **200PT-230V: Cryostation 200PT, 230V Vacuum, Non-Turbo**
  - Uses MIPN 4700-510-03
- **200PT-230V-T: Cryostation 200PT, 230V Vacuum, KF40 Turbo**
  - Uses MIPN 4700-510-04
- **200PT-115V: Cryostation 200PT, 115V Vacuum, Non-Turbo**
  - Uses MIPN 4700-510-01
- **200PT-115V-T: Cryostation 200PT, 115V Vacuum, KF40 Turbo**
  - Uses MIPN 4700-510-02

For model differences, the only difference for the 4 models is the electrical input rating and turbo or non-turbo.
Please contact me should there be need for any additional clarifications or information.
Best Regards,

Gene Kuntz
General Manager
101 Evergreen Drive
Bozeman, MT 59715 USA