System User Manual

Cryostation® s-series

s200 – SHI Compressor Configuration

Version: 1.2
September 2025

www.montanainstruments.com
support@montanainstruments.com
+1.406.551.2796

MONTANA INSTRUMENTS®
101 Evergreen Drive
Bozeman, MT 59715, USA

CE

This page intentionally left blank.

Specifications and product information listed in this document are accurate to the time of publishing for a standard system. Options, custom designs, and/or 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 the Montana Instruments products and systems described herein. Users include anyone who may physically interact with the system or peripheral equipment, including installing, setting up, or configuring the system or anyone who may operate system components via operating panels, the supplied user interface, or remote interfaces.

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

This manual should 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.
- Bulleted 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
- International System of Units (SI) symbols
- System of Imperial Units symbols
- Element, molecule, and compound abbreviations

1.1.2 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 to 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.

1.1.3 Graphical Symbols

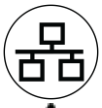
The following symbols may be used in diagrams, supporting text, and on physical parts:


Hazard Alert: General Warning


Hazard Alert: High Voltage


Hazard Alert: Laser Radiation

HDMI port


CAN bus module


USB port


Hazard Alert: Hot Surface


Hazard Alert: Magnetic Field


Waste Electrical and ElectronicEquipment (WEEE)


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 all 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:
www.montanainstruments.com/About/Warranty

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

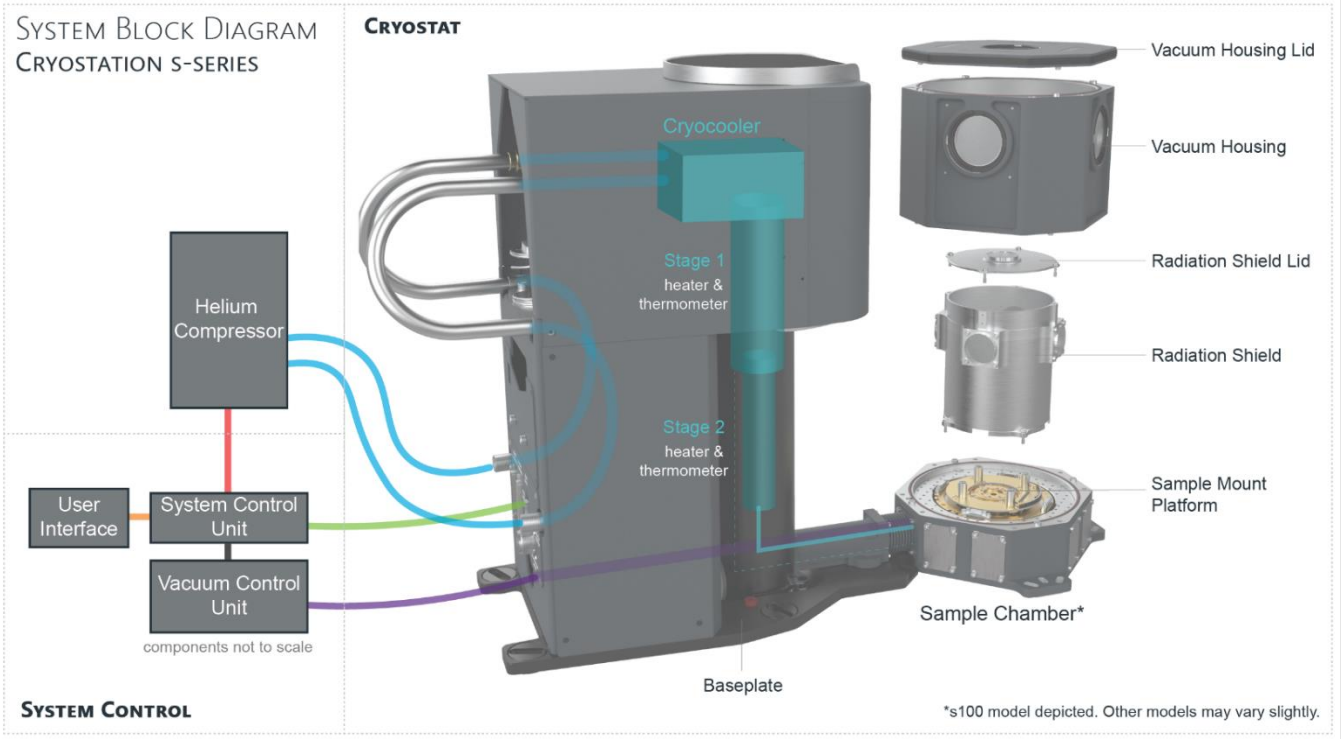
International Sales & Authorized Service

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

Section 2 - System Overview

2.1 Cryostat

Models	Part Numbers
Cryostation s50	4106-5000-00
Cryostation s100	4123-5000-00
Cryostation s200	4118-5000-00



2.1.1 Intended Use

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

The cryostat is designed to connect to the system control unit, vacuum control unit, and helium compressor provided by Montana Instruments. The back panel of the cryostat includes interface locations for these cable and hose connections.

2.1.2 Components

Cryostat

The cryostat consists of the cooling tower assembly and the sample chamber, connected by a baseplate and a semi-rigid bellows assembly. The entire cryostat 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 cryostat can be mounted on either imperial or metric optical tables.

Cooling Tower Assembly

The main cooling is provided by a proprietary cryocooler suspended inside the cooling tower assembly (inside the black vertical outer cylinder). 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 principle stages, each with thermometers to monitor temperature and heaters for warmup. Stage 1 is thermally coupled to the radiation shield inside the sample chamber. Stage 2 is thermally coupled to 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 gross thermal contraction during cooldown by using a thermal contraction-canceling design of the sample support structure.

» NOTE
Some purchased options may arrive pre-installed in or on the sample chamber. Any other options should be installed according to the directions provided in the relevant Manual Addendum.

Helium Compressor

The helium compressor is a single-phase, air-cooled compressor. A phase converter module is mounted on the back of the compressor and is used to control the cryocooler drive motor to achieve the desired cooling. The PCM is a part of the compressor.

Temperature Control Module (TCM)

A TCM peripheral card in the attached system control unit is used to control the thermometry and heaters located on the cryocooler stages, platform, and user channels and display those readouts in the UI. This communication interface is used to actively control the platform temperature.

The DSUB37 port (`HEATER/THERMOMETER CONTROL`) on the TCM card is used to interface with the cryostat. The split cable connects to ports on the back panel of the cryostat.

2.1.3 Technical Specifications

Environmental Specifications

Temperature of Environment	5 – 40 °C
Humidity	5 – 80% non-condensing
Altitude	<2000 m

Power Specifications

Model		Compressor: SHI F-20L or SHI FA-20L
Mains Power Connector on Unit		IEC 60320 C20
Line Voltage		208 – 240 VAC
Frequency		50 – 60 Hz
Maximum Power Consumption		3.12 kW
Water Quality (for F-20L)		Refer to the SHI Compressor Manual
Wall Outlet / Receptacle	N. America & non-EU	NEMA L6-20R single-phase (see note below)
	CEE Europe (non-UK)	CEE 7/3 or CEE 7/5 w/ common ground terminal
	UK	IEC 60309-6H (16 A)
	Israel	SI 32 (IS1-16P)

» NOTE
The NEMA L6-20R is a special outlet in the United States. An electrician must set up this circuit for single-phase 208-240 VAC with a 20 A breaker. **The circuit cannot be three-phase**.

⚠ WARNING

Risk of damage to water cooled compressor

All water quality and inlet/outlet requirements for the F-20L compressor must be followed or the compressor may be damaged. Follow all SHI requirements listed in the compressor manual linked above.

Physical Dimensions

Component	L x W x H	Mass
Cryostat		
Cryostation s50	56.3 cm x 23.2 cm x 49 cm	29 kg
Cryostation s100	64 cm x 23.2 cm x 49 cm	29 kg
Cryostation s200	58 cm x 27 cm x 49 cm	47 kg
Compressor (Water-Cooled)	46 cm x 45 cm x 57 cm	73 kg
Compressor (Air-Cooled)	46 cm x 45 xm x 88 cm	101 kg

2.1.4 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 cryostat.

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 cryostat

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

Risk of product damage due to improper use

- Never disconnect the vacuum hose while the temperature of any stage of the cryostat is below 285 K. Never open the case or vent valves when the temperature of any stage is below 285 K.
- Only use dry nitrogen gas with the cryostat. 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 cryostat 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.

2.2 System Control Unit

Models
ECA24

System Control Unit with User Interface Touchscreen

Front of Enclosure

2.2.1 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.

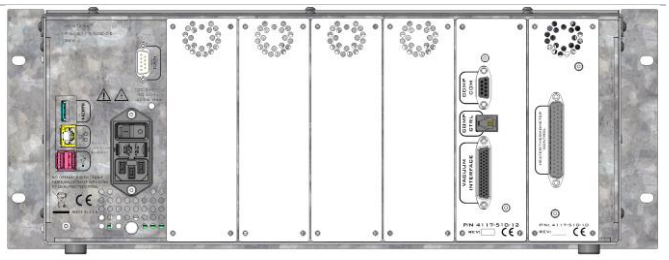
2.2.2 Components

The system control unit consists of an outer enclosure, single-board computer, peripheral cards, a touchscreen user interface display, and several communication ports. The enclosure is compatible with a standard 19-inch 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



SC1160 (no peripheral cards) rear enclosure *SC1160 (two peripheral cards) rear enclosure*

HDMI

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

USB

Two USB ports are available on the rear face of the enclosure. One of these 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 communicating with external storage drives.

Ethernet

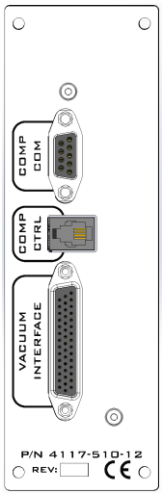
An ethernet port is available on the rear face of the enclosure for connecting with a local network or computer. A local network connection is required for controlling the instrument via the remote graphical display or scripting features, and a network internet connection is required for remote technical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

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)

A TCM peripheral card in the system control unit is 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 card connects to the DSUB37 port on the back panel of the Cryostation.

2.2.3 Technical Specifications

Environmental Specifications

Temperature of Environment	5 – 25 °C
Humidity	5 – 80% non-condensing
Altitude	<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
Wall Outlet / Receptacle	N. America & non-EU	Standard NEMA 5-15
	CEE Europe (non-UK)	CEE 7/3 or CEE 7/5 w/ common ground terminal
	UK	BS1363 (UK) w/ common earth ground terminal
	Israel	I-32-3 w/ common earth ground terminal
	Cart Power Module	IEC 60320 C13

Physical Dimensions

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

2.2.4 Safety Information

The following hazards may be typical for this product:

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 getting cut by these 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.

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

NOTICE

Peripheral cards must not exceed 600 W to avoid product damage

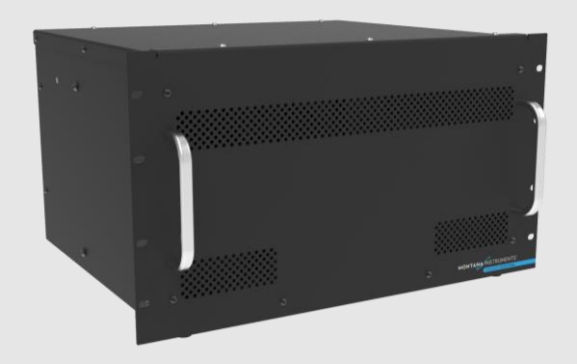
- The system control unit can supply a maximum power of 600 W across all installed peripheral cards. Ensure the cumulative power of all installed peripheral cards (maximum power rating of all cards added together) does not exceed 600 W.

Transportation and installation

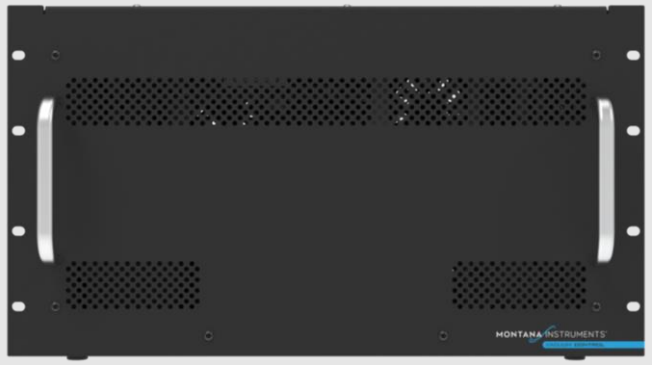
- When not in a rack unit, the enclosure should not be stacked on any other equipment, nor should other equipment be placed on it.
- Allow 8 cm minimum clearance from any ventilated face (sides, front) and 20 cm clearance in the rear for cables and hoses.
- Do NOT move the unit while operational. Remove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

2.3 Vacuum Control Unit

Models
ECA24
ECA24 Turbo Option



Vacuum Control Unit



Front of Enclosure

2.3.1 Intended Use

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

2.3.2 Components

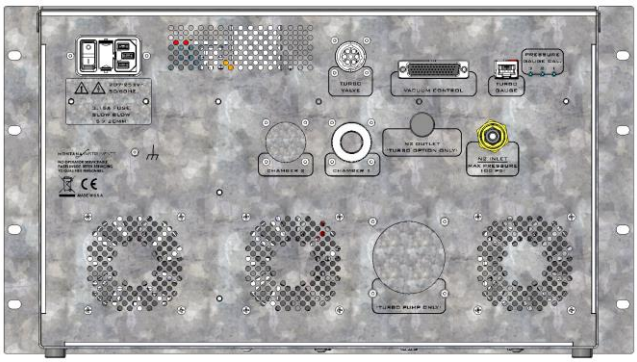
The standard VCM24 Vacuum Control Module consists of an outer enclosure, a Edwards mXDS3s Mini-Scroll (roughing) pump, KF16 vacuum connection, one case valve, one vent valve, and several communication ports. The enclosure (6U) is compatible with a standard 19-inch-wide rack and can be mounted with other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

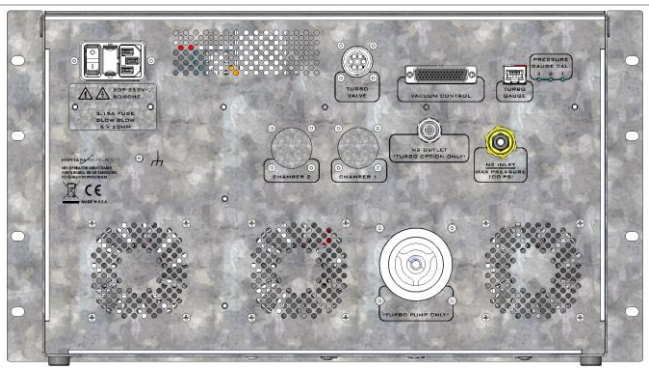
The VCM24 Turbo Option Vacuum Control Module consists of an outer enclosure, a Edwards mXDS3s Mini-Scroll (roughing) pump, Edwards nEXT85D Turbo Pump, KF40 turbo pump vacuum connection, one turbo case valve, one vent valve, and several communication ports. The enclosure (6U) is compatible with a standard 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.

Enclosure Communication Ports



VC1110 rear enclosure



VC1130 (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.

Ethernet (VCM24-Turbo only)

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

Circular 7-Pin Connnector

The circular 7-pin connector is used to connect and communicate with the with 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.

2.3.3 Technical Specifications

Environmental Specifications

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

Power Specifications

Model		VCM24/VCM24-Turbo	
Model		115 VAC	230 VAC
Mains Power Connector on Unit		IEC 60320 C14	
Line Voltage		104-126 VAC	207-253 VAC
Frequency		50 – 60 Hz	
Maximum Power Consumption		420 W	
Wall Outlet / Receptacle	N. America & non-EU	Standard NEMA 5-15	
	CEE Europe (non-UK)	CEE 7/3 or CEE 7/5 w/ common ground terminal	
	UK	BS1363 (UK) w/ common earth ground terminal	
	Israel	I-32-3 w/ common earth ground terminal	
	Cart Power Module	IEC 60320 C13	

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)

2.3.4 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 to be 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 getting cut by these 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.

- Prior to accessing the enclosure or when otherwise servicing the unit (authorized service personnel only), completely power down the system and unplug the power cable.
- 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 prior to operation.
- Do NOT disturb vacuum tubing while the turbopump (if included) 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 while operational. Remove all cables prior to moving. Lift the enclosure by using both handles on the front face.

Section 3 - Sample Chamber Configuration

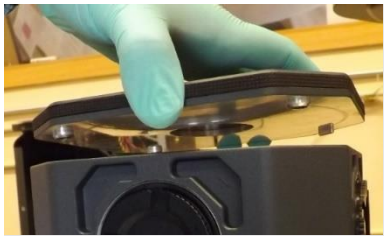
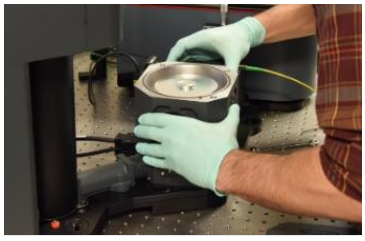
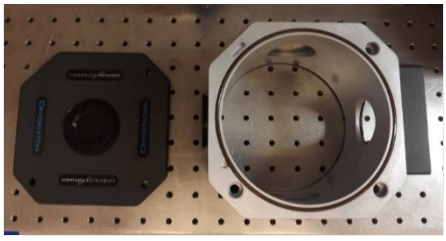
3.1 Accessing the Sample Space

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

NOTICE
Keep sample chamber and surfaces clean • Always wear clean gloves when working in the sample chamber to avoid getting oils on the surfaces. • Take care not to touch the optical windows on the lid, window assembly, or the internal radiation shield. Window covers are provided to keep the windows clean. • Be sure to keep the O-ring seals clean and free from debris. Do NOT set the housing down on an O-ring seal 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 down into the chamber assembly.

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

1. Carefully lift the top lid from the sample chamber and place it on the table with the protruding bosses down. The lid may sit on the bosses without compromising the clean surface inside the lid.
2. Using two hands, carefully lift the window assembly from the sample chamber. Place the window assembly on the table so that it rests on a flattened corner (not on a window). This will keep the interior surfaces and windows clean and free from scratches. The s100 and s200 models include bosses on the window housing assembly so that they may be placed on the table with the protruding bosses down.

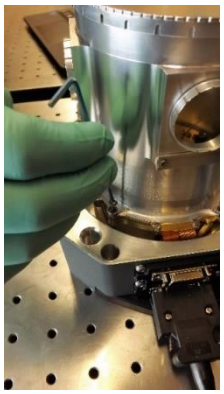




Step 1: Lifting off the lid with protruding bosses on the underside

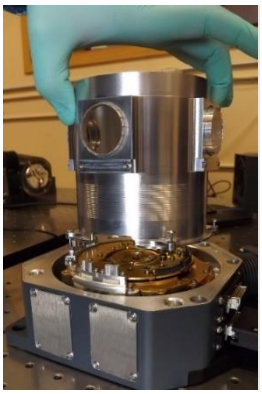
Step 2: Lifting off the window assembly

Sample housing lid (left) and window housing assembly (right)

3. Lift the cap from the radiation shield to remove it. Some models have M3 screws securing the radiation shield lid which must be removed first.
4. Unfasten the M3 button head screws on each side of the radiation shield. Depending on the model, there may be 4-8 screws. Lift up and over any sample mount structures to remove.



Step 4: Removing screws



Step 4: Lifting off radiation shield assembly

NOTICE

Take care when reassembling the sample chamber

- Before replacing the vacuum housing & lid, carefully check O-rings for any loose fibers or debris (this could affect vacuum performance).
- Take care not to overtighten screws when replacing the radiation shield. If a torque wrench is accessible, set the tension to 5 in-lbs.

3.2 Sample Mounting

Most systems ship with a user-specified sample mount, depending on the option(s) purchased. Refer to your system's Manual Addendum for specific instructions regarding your sample mount.

Following the instructions in your Manual Addendum, carefully remove the sample mount from the platform.

1. Remove the previous sample from the face of the mount. Clean off residual grease with a Kimwipe or lens tissue (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 in a thin layer, taking care not to scratch the surface.

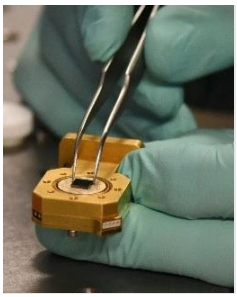
NOTICE
Do not use N-grease for temperatures above 300 K Apiezon® N-grease softens at 305 K. If the user plans to operate above 300 K, it is recommended to use an alternative sample mounting material to ensure a vertically mounted sample does not slide off the sample mount.

» 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.

*Sample mount with the sample. *User sample mount may differ.*

Step 1: Clean surface & apply grease



Step 3: Attaching new sample

» NOTE

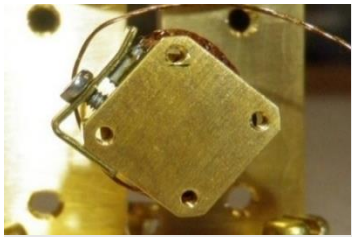
To check if the sample is secure, hold the sample mount horizontally so the sample faces down and forcibly tap the mount with a finger.

3.3 Mounting a Thermometer

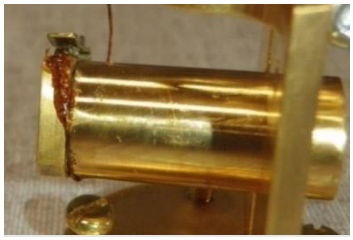
Many users choose to remove the sample thermometer and mount it elsewhere in the system or install a user thermometer. To do this:

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

1. 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).
    c. **With Plug:** Some sample mounts have a hole location for thermometers; in these cases, the sensor will come pre-mounted to a thermometer holder. Apply a thin layer of N-grease around the holder and slide it into the hole. To remove, use an Allen key to press out of the hole from the opposite side.



Step 3a: Thermometer clamped to the mounting surface

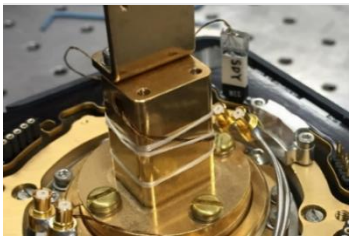


Step 3a: Thermometer clamped to the mounting surface

Step 3c: Thermometer installed in the 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). Apply VGE to approximately the first 0.5 inches (1 cm) of wire and press to a metal surface to properly lag the wire. Do not encase the wire in VGE.

» 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 sample chamber has five (s50 and s100) or eight (s200) optical access locations. 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
If the system is running, use care when removing the window covers, as this may loosen the retaining ring holding the window in place.

3.4.2 Window Replacement

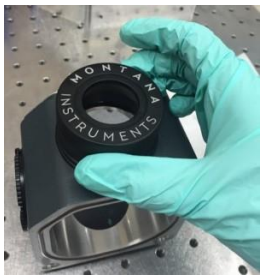
Vacuum Windows

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

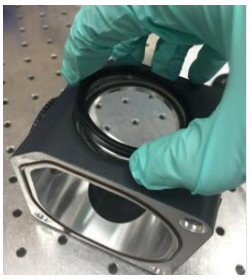
1. Align the tabs on the window tool with the corresponding notches in the Delrin retaining ring holding the window in place.
2. Use the window tool to loosen the retaining ring by turning counter-clockwise.
3. Remove the retaining ring to access the window.
4. Prior to reinstalling the window, check 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. Reinstall the window by carefully setting it centered on the O-ring, ensuring the O-ring is fully covered by the window. Avoid having to re-position the window, as this may spread L-grease onto the clear aperture.

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. • Take care not to use too much force on the window tool as this could cause it to slip and damage the window.

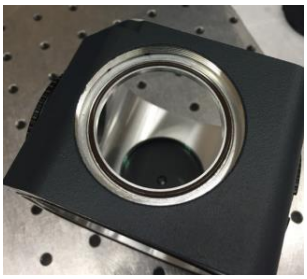
Removing window covers



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



Step 3: Removing the retaining ring

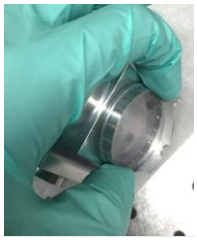


Window centered on O-ring

Radiation Shield Windows

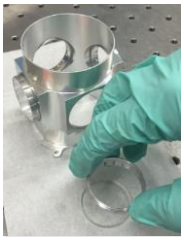
The inner (cold) windows on the radiation shield are held in place with a tension ring.

1. Depending on the model, the radiation window holders are removed by unscrewing the threaded tension ring or removing the four M2 screws surrounding the window.
2. Remove the window from the tension ring by pressing it out of the spring fingers. Some force may be required.
3. Prior to 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.
4. Reinstall the window by press-fitting the tension ring onto the window. Ensure the spring fingers hold the window tightly and evenly.
5. 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



Pressing tension ring onto the window

» 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 collide with one another.
- 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 several degrees 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).

- **40 AWG Manganin wire**: *very low thermal conductivity and good for low power signal transmission*
  - Recommended use: Wiring the platform heater or for user heaters
  - Raises temperature ~0.5 mK per wire
- **32 AWG Phosphor Bronze wire**: *low thermal conductivity and good for moderate power transmission*
  - Recommended use: Building additional wiring harnesses
  - Raises temperature ~5.0 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 the Cryogenic Wiring Guide for more information: www.montanainstruments.com/help/Wiring-Guide/

3.5.2 Thermal Lagging Techniques

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

Select cryostat models (s100 & s200) provide “pre-lagged” connections for some user inputs and wiring. These wires, which plug directly into the 4 K circuit board “wedge” inside the sample space, do not need additional thermal lagging.

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

1. Unscrew the two M2.5 screws on the top of the thermal clamp. Remove the top cover.
2. Wrap a small piece of Kapton® tape around the wires 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 5 inches (12.5 cm) is outside of the thermal clamp and the remaining 5 inches (12.5 cm) is inside of the 4K sample space.

3.5.3 User Wiring Interfaces

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

NOTICE
Do NOT remove sample chamber circuit boards • The standard 4 K circuit board "wedge" (contains USER, SAMPLE THERM, etc.) available on some models (s100 & s200) should not be removed, as it can lead to the disconnecting of the platform thermostat and heater. If this wedge needs to be removed for any reason, please contact an authorized service representative for detailed instructions. • The black printed circuit board on the s50 model should not be removed. The black Delrin screws holding it in place should remain loose. Overtightening can cause the board to flex and make it difficult to obtain a proper vacuum seal. • The Operational wiring and cables 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 accessory kit comes with pin connectors for interfacing user inputs to the external connectors.

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.

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

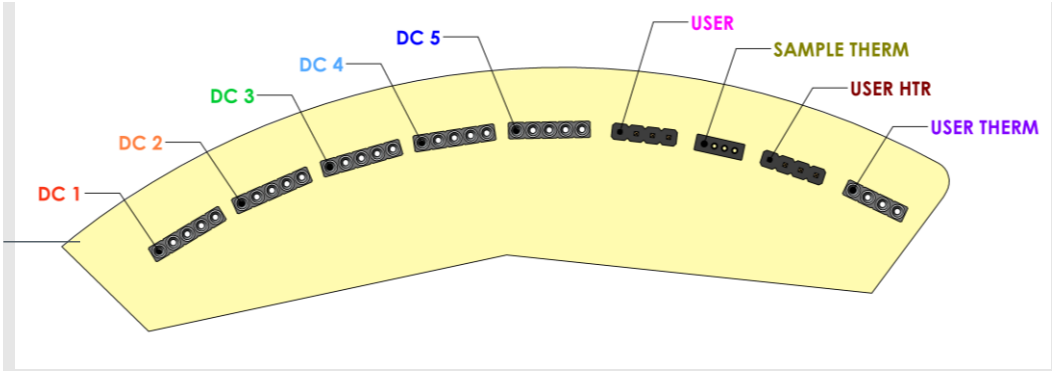
3.5.4 Wiring Schematics

The wiring schematics for the s200 are outlined on the following pages.

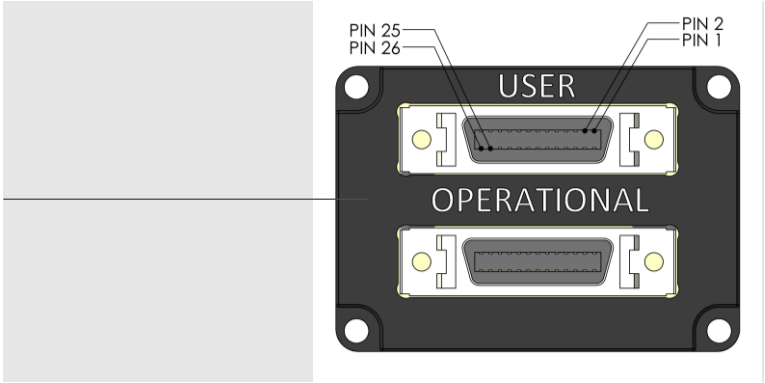
Cryostation s200

Cryostation s200 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.

Internal Sample Chamber PCB @ 4 K



External DC Connector ‘USER’ Side Panel



4K PCBA CONNECTOR PIN#		SIGNAL NAME	SIDE PANEL USER PIN#	SIGNAL DESCRIPTION
J1 [DC 1]	1	DC1.1	13	70VDC, 100mA
	2	DC1.2	12	70VDC, 100mA
	3	DC1.3	25	70VDC, 100mA
	4	DC1.4	11	70VDC, 100mA
	5	DC1.5	24	70VDC, 100mA
J2 [DC 2]	1	DC2.1	10	70VDC, 100mA
	2	DC2.2	23	70VDC, 100mA
	3	DC2.3	9	70VDC, 100mA

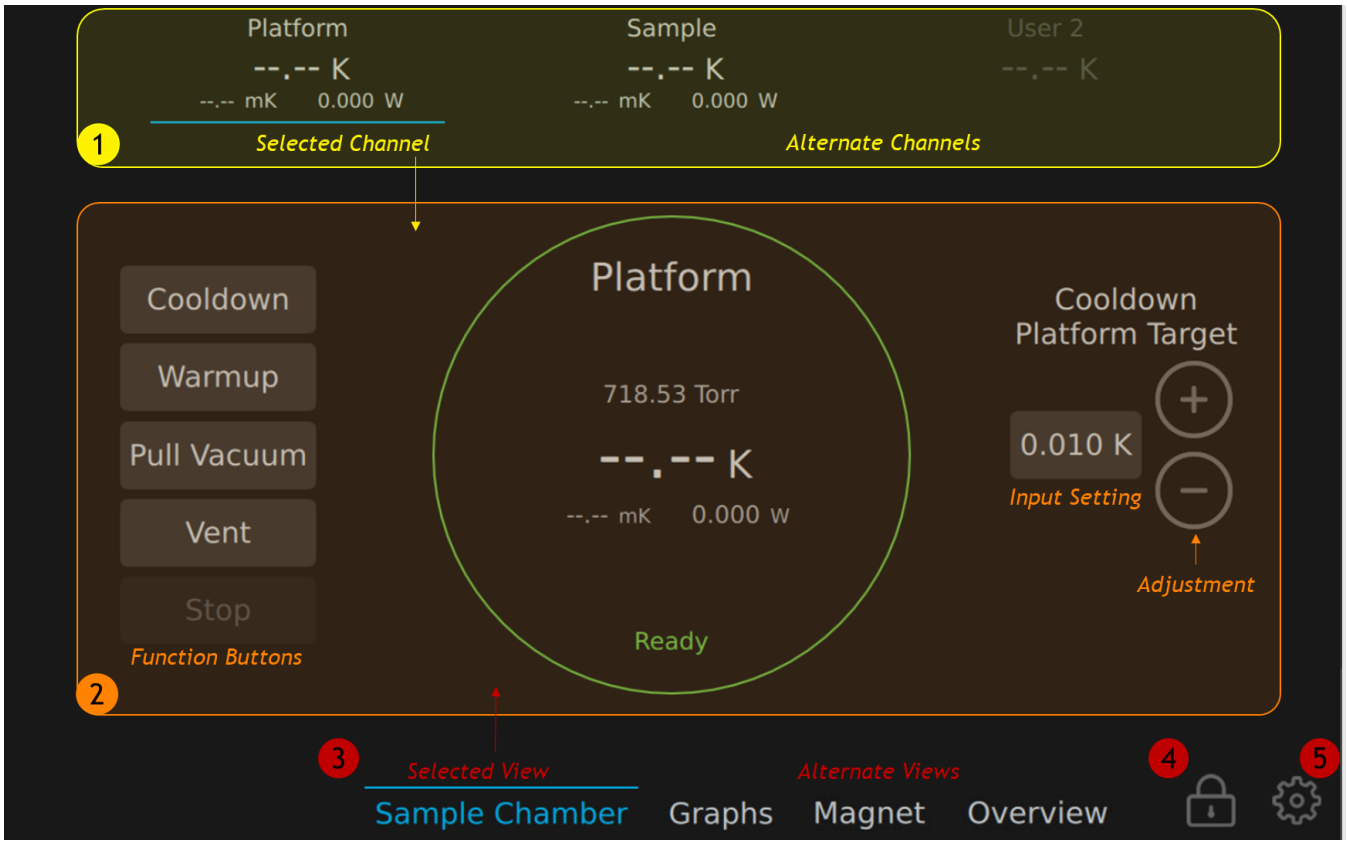
	4	DC2.4	22	70VDC, 100mA
	5	DC2.5	8	70VDC, 100mA
J3 [DC 3]	1	DC3.1	21	70VDC, 100mA
	2	DC3.2	7	70VDC, 100mA
	3	DC3.3	20	70VDC, 100mA
	4	DC3.4	6	70VDC, 100mA
	5	DC3.5	19	70VDC, 100mA
J4 [DC 4]	1	DC4.1	5	70VDC, 100mA
	2	DC4.2	18	70VDC, 100mA
	3	DC4.3	4	70VDC, 100mA
	4	DC4.4	17	70VDC, 100mA
	5	DC4.5	3	70VDC, 100mA
J5 [DC 5]	1	DC5.1	16	70VDC, 100mA
	2	DC5.2	2	70VDC, 100mA
	3	DC5.3	15	70VDC, 100mA
	4	DC5.4	1	70VDC, 100mA
	5	DC5.5	14	70VDC, 100mA

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. **Adjustment Buttons:** Circular buttons with icons provide operational control.
   c. **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. • The control buttons do not have on-screen help. Pressing and holding will execute the associated operation.

Application UI: Cryostation s-series

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 cryostat, compressor, and vacuum control unit.
  - **User 1/2**: User temperature channels can manually control a user thermometer and heater pair with the system control unit, such as a thermometer mounted near the sample or an ATSM (thermometer + heater).

» NOTE

- User temperature channels operate as a thermometer/heater pair. Thermometers can be used without heaters, but heaters require a functional thermometer.
- If a user temperature channel is not being used, it is recommended to turn it off to reduce noise on other temperature channels.
  - Navigate to `MENU > INSTRUMENT SETTINGS > USER "X"`. Toggle the Temperature Channel Enabled switch to the left to disable.

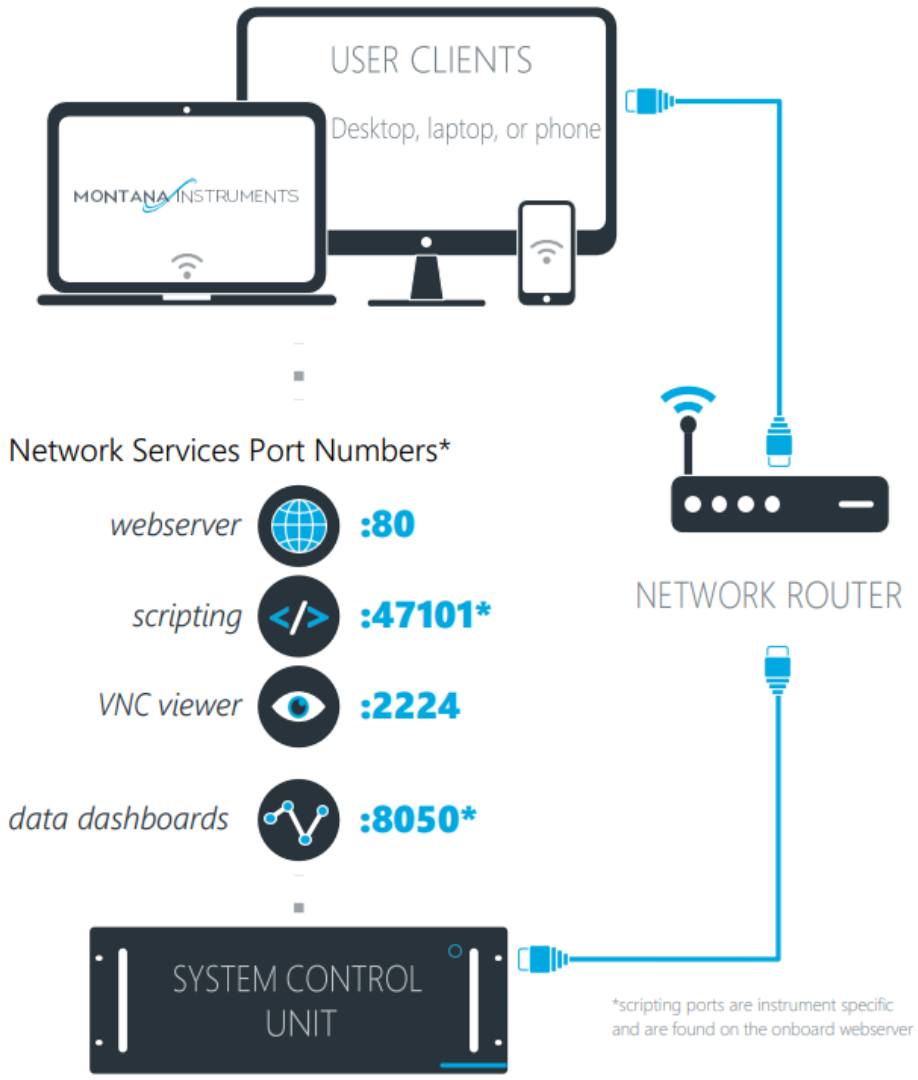
Display Screens

- **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

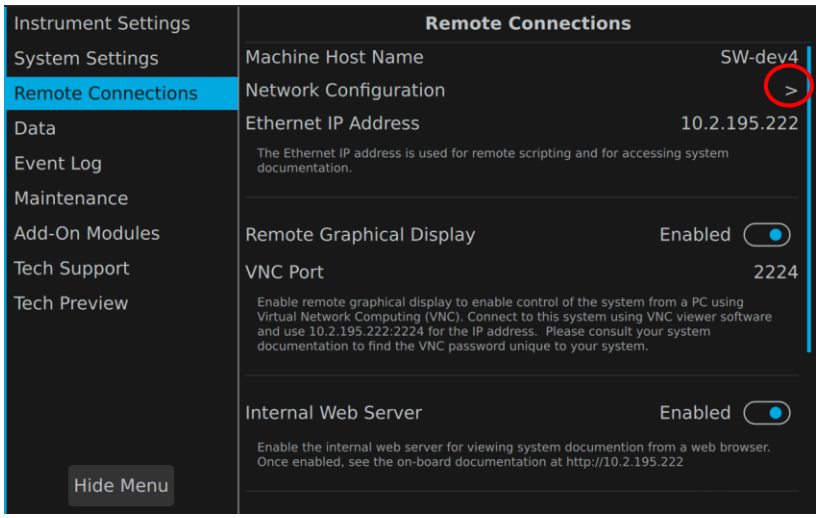
To utilize the network services provided, the system control unit must be connected to a local network using the Ethernet port on the rear face of the enclosure. This local network does not need to have internet access capabilities, nor is internet access required to use the following network services.

Each of the following services use 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.

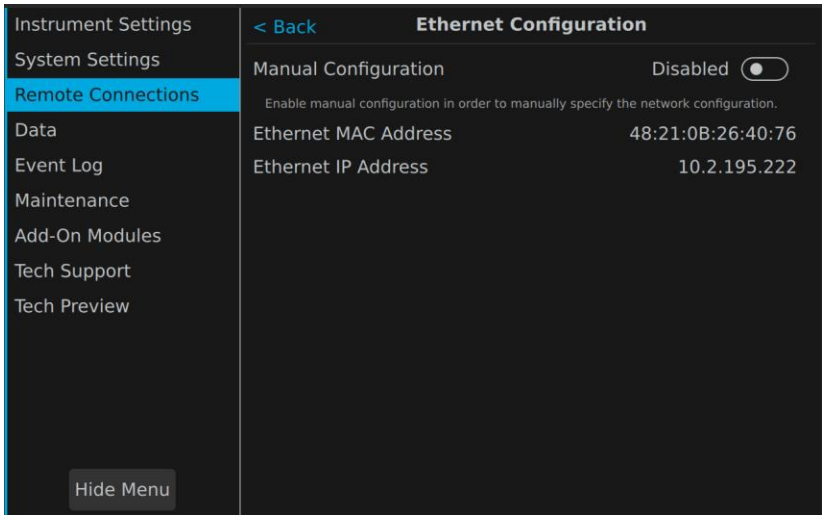


To find your system's IP and/or MAC address:

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.

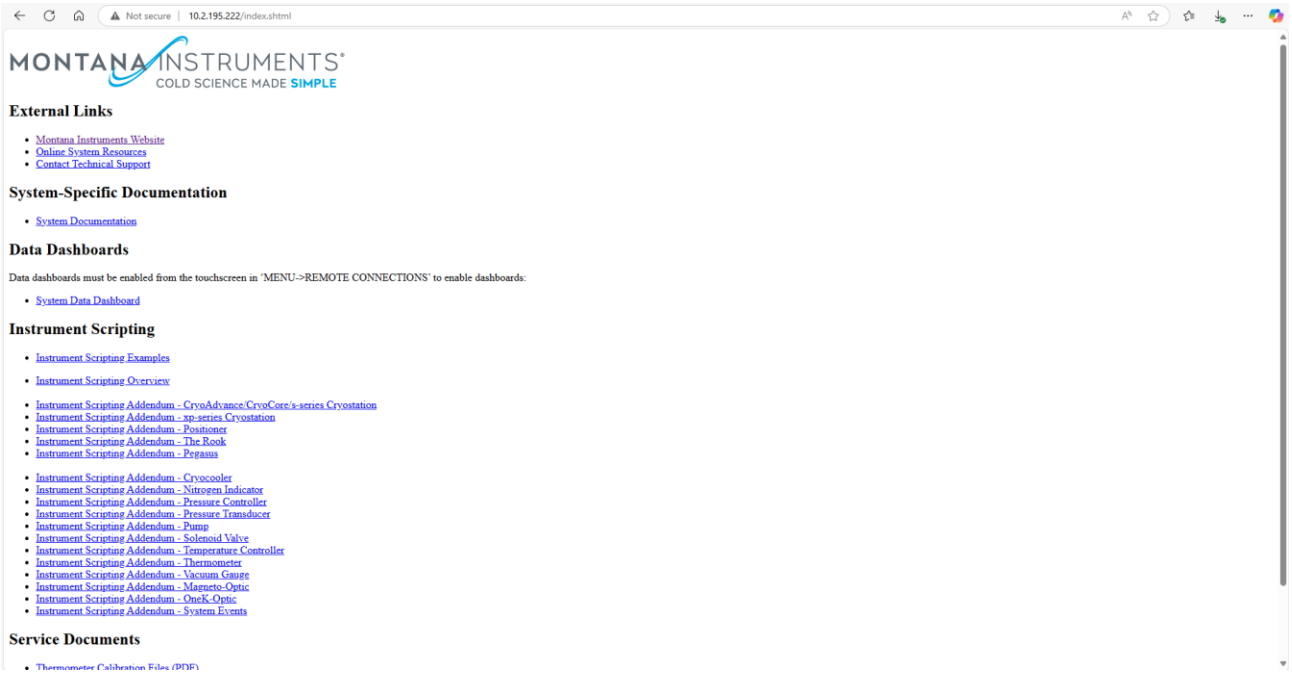


Webserver | Onboard Documentation Standard HTTP port 80

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).

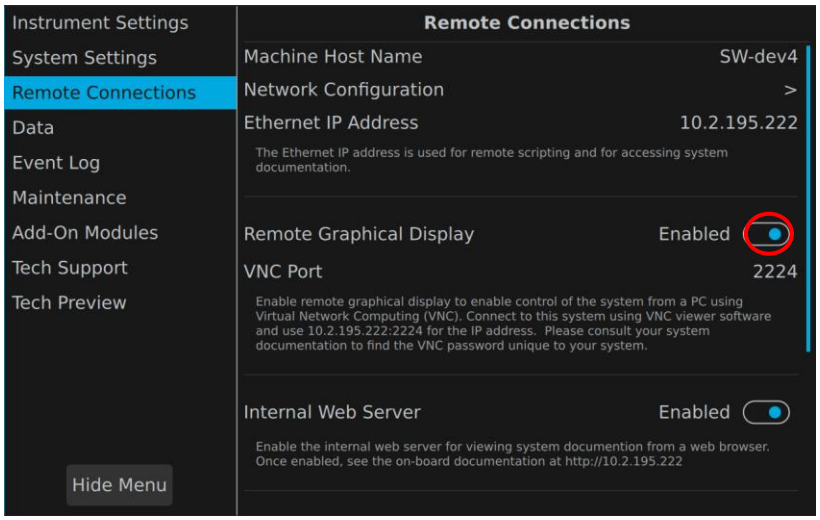


Remote Graphical Display | VNC Viewer 🖧 Non-standard HTTP port 2224

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.

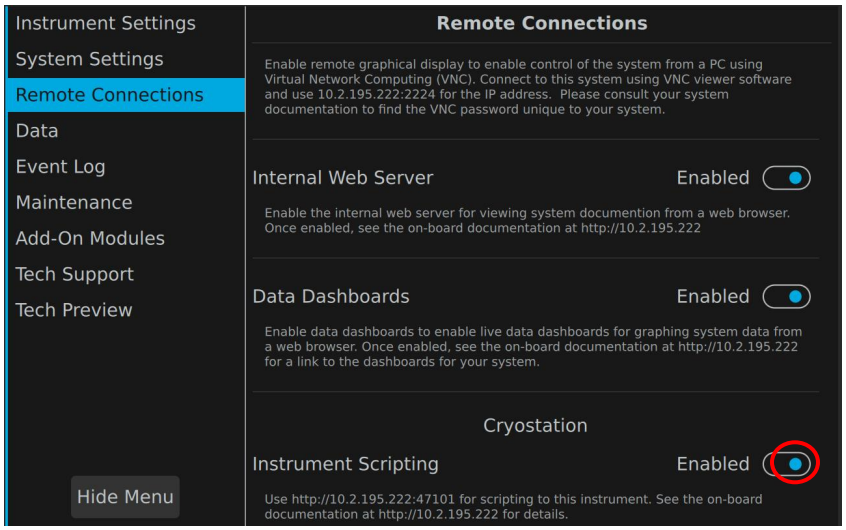
The VNC connection is password protected using a unique password for each system. The password is provided with your printed system documentation and in the onboard webserver file Quick Start Guide – Network Interface Connections. If lost, contact an authorized service representative to retrieve a copy.

Remote Scripting Non-standard HTTP port 47101

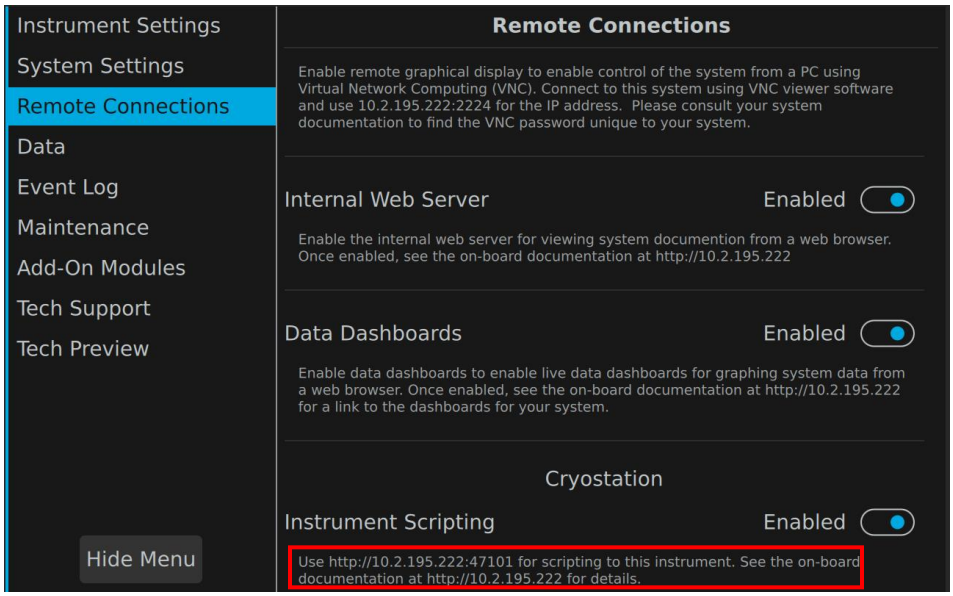
The instrument can alternatively be programmatically controlled via scripting commands using an external computer.

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.



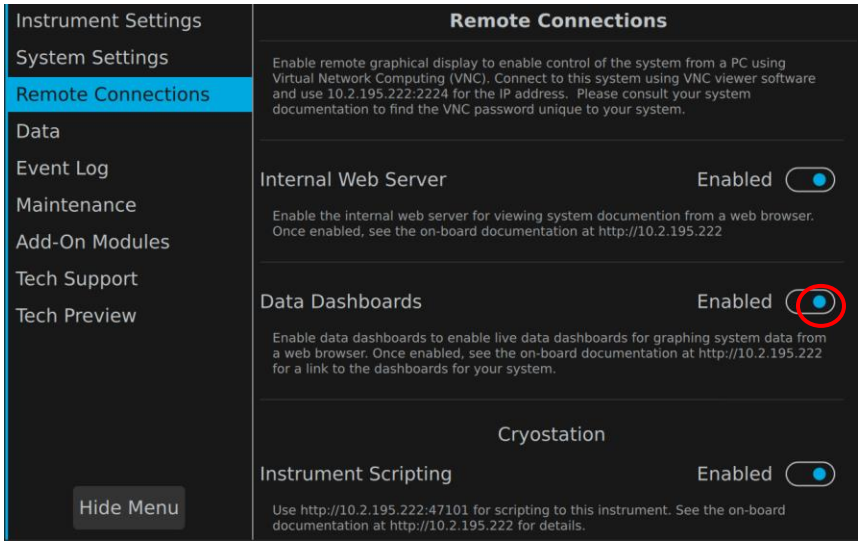
Remote scripting commands can be sent using an encrypted SSH tunnel. Refer to the onboard Instrument Scripting documentation on the webserver for further details.

Data Dashboards Non-standard HTTP port 8050

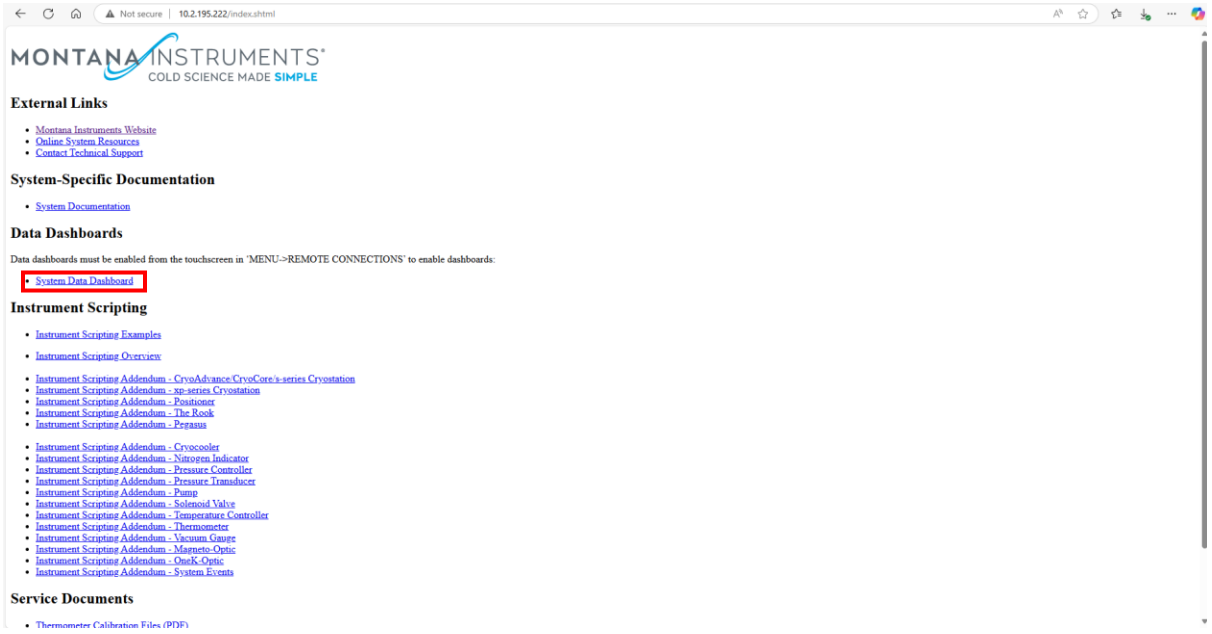
Data dashboards allow the user to view and analyze system data from a web browser.

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.



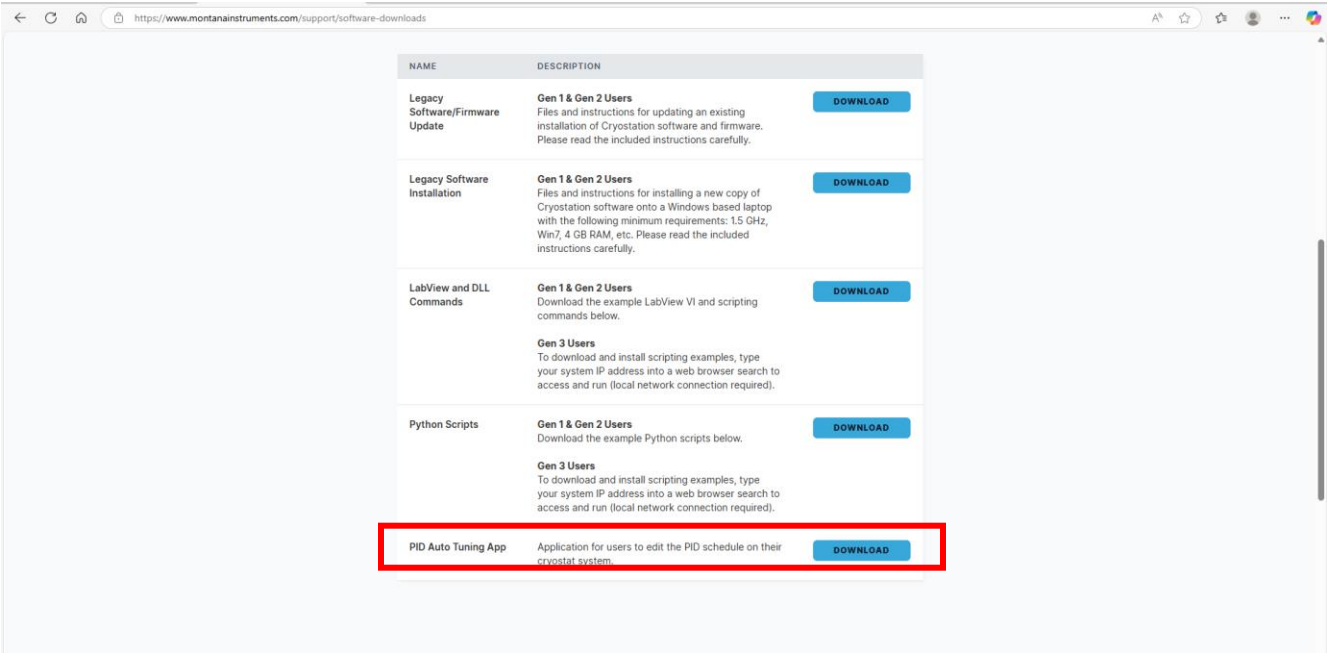
MI Remote Support 🖧 Secure SSH tunnel port 2223

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

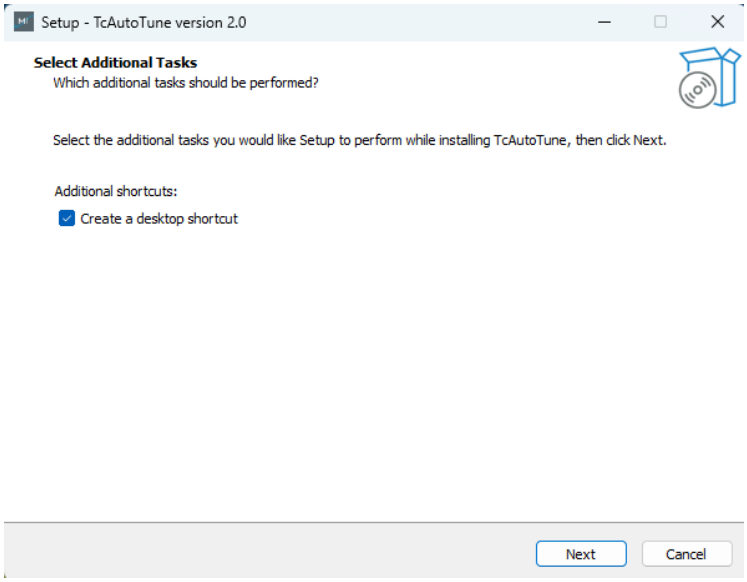
Secure SSH tunnel on port 2223 to mirs.montanainstruments.com. Work with your IT department to configure the required NAT/Firewall access.

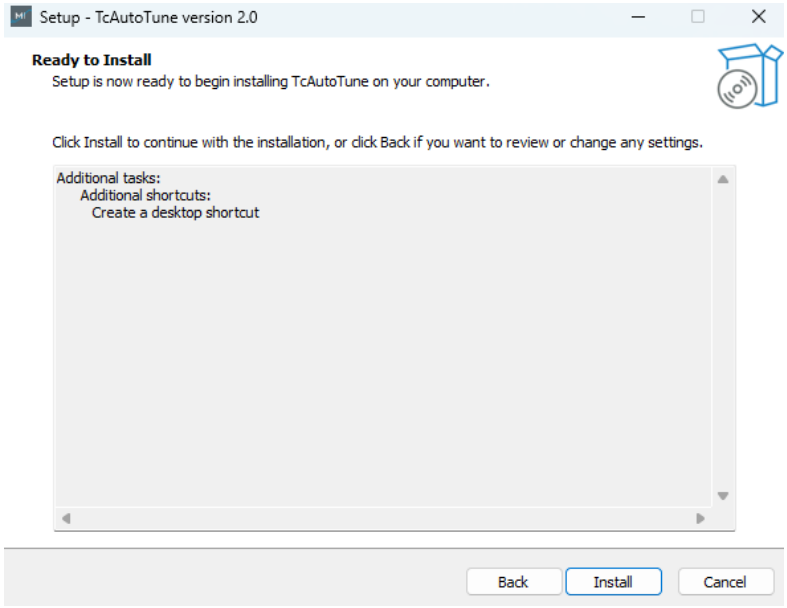
4.1.3 PID Tuning

Montana Instruments cryostat system controls use a PID schedule to continuously control temperature (except when target temperature is set to 0K). Users can tune the PID schedule to better fit their research needs or to address issues occurring when trying to maintain temperatures above base. This process can be done directly on the User Interface or by downloading the PID Auto Tune application from the website. Steps for tuning the PID schedule using the application are below.



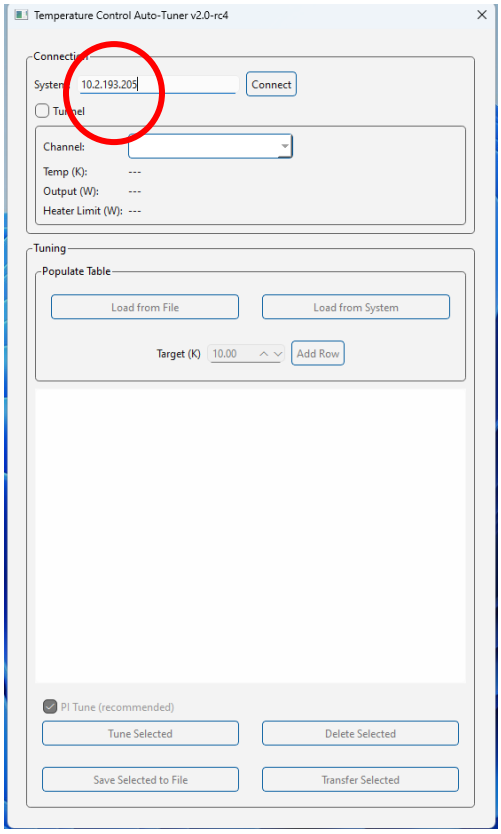
The installer takes approximately 15 minutes to complete the program installation.



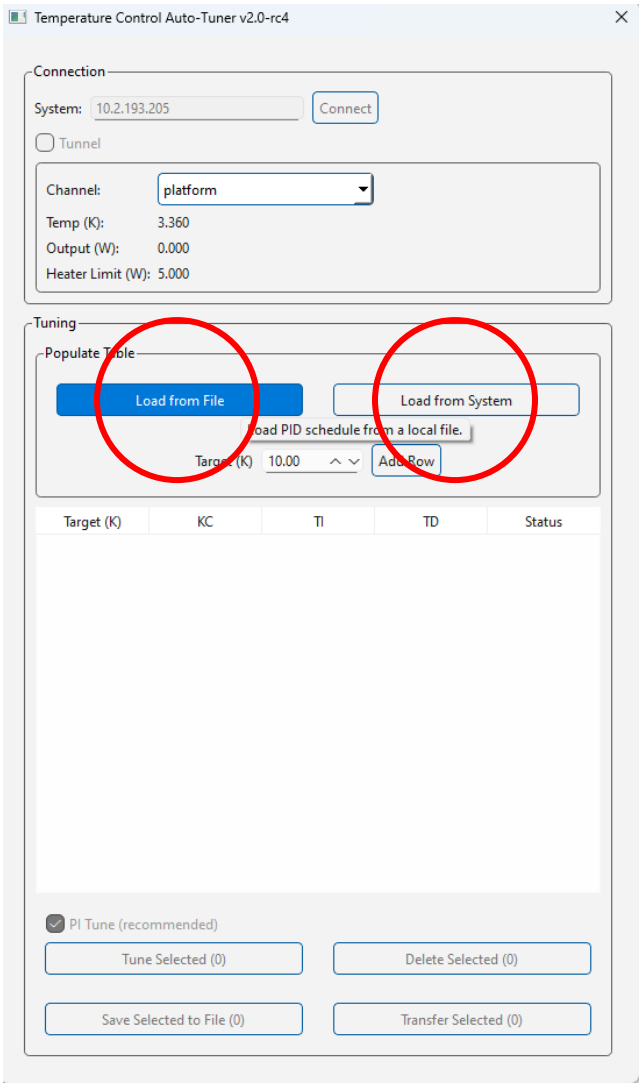


Before beginning tuning, ensure that your system is cooled to base temperature. The system will prevent tuning and show a warning if the system is still above base temperature.

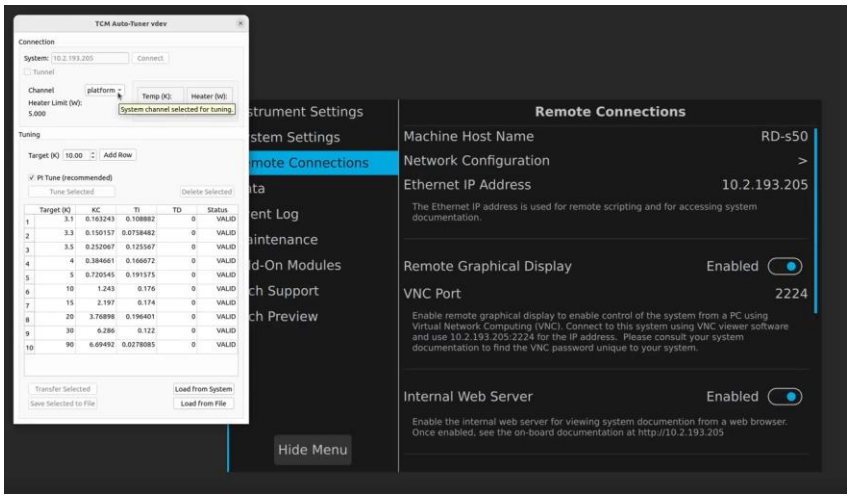
After opening the autotune application, enter the IP address of the system you are tuning on (local network connection required).



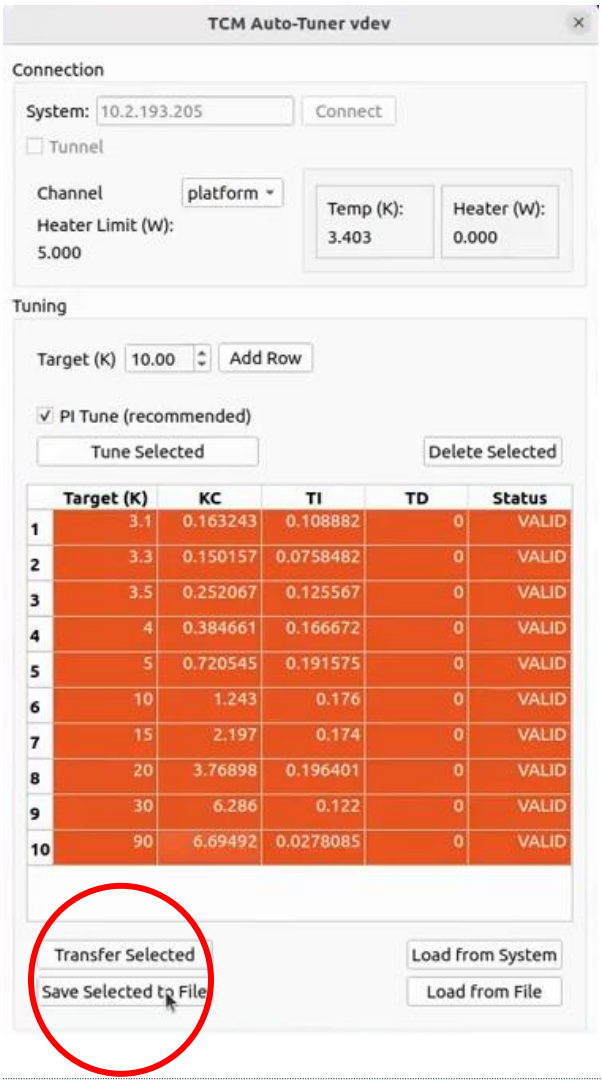
Once connected to the system, the PID schedule can be edited by either loading a file or loading directly from the system interface.



Individual target values or the entire PID schedule can be changed.

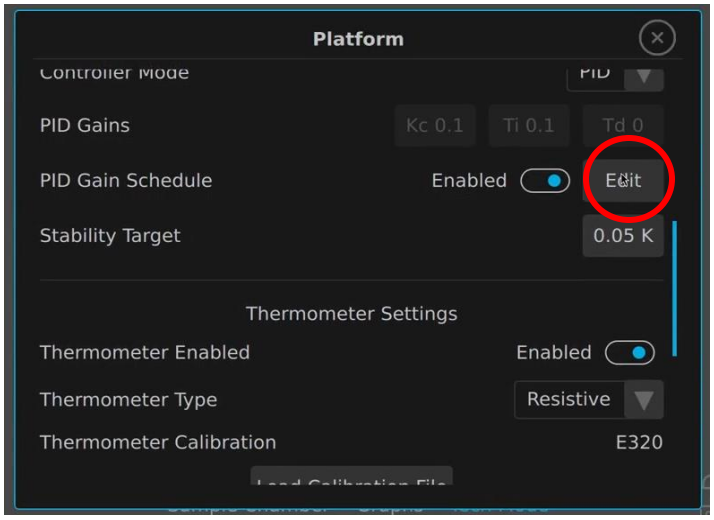


Once a tune has been edited, it can be saved.



	Target (K)	KC	TI	TD	Status
1	3.1	0.163243	0.108882	0	VALID
2	3.3	0.150157	0.0758482	0	VALID
3	3.5	0.252067	0.125567	0	VALID
4	4	0.384661	0.166672	0	VALID
5	5	0.720545	0.191575	0	VALID
6	10	1.243	0.176	0	VALID
7	15	2.197	0.174	0	VALID
8	20	3.76898	0.196401	0	VALID
9	30	6.286	0.122	0	VALID
10	90	6.69492	0.0278085	0	VALID

Current PID schedule can also be viewed and edited on the GUI.



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 is connected to the system, verify the supply pressure is set to ~15 psi.
2. Ensure the black circuit breaker switch on the front of the compressor unit is toggled to ON (|).

NOTICE

The green power switch should remain OFF (o) during operation as this is controlled by the remote ON/OFF control.

3. Turn on power to the vacuum control unit by toggling the power switch on the back of the unit ON (|).
4. Turn on power to the system control unit by toggling the power switch on the back of the unit ON (|).
5. 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.

4.2.2 Controlling System Temperature

The PLATFORM temperature channel is used to drive control operations across the cryostat, 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.

NOTICE

If a Cryo-Optic is installed ensure "Cryo-Optic Control" is enabled before every cooldown!

- Before every cooldown, check the UI to verify the Cryo-Optic is enabled and actively reading theobjective temperature. Operating the cryostat with the Cryo-Optic disabled may damage the objective.

Check nanopositioner position before cooling down

- For the vertical Cryo-Optic configuration, ensure the Z-stage of the nanopositioners is all the way down prior to cooling down. Contraction of components during cooldown could

» NOTE
Default setting for cooldown mode is "Auto." Auto is set within normal operating parameters.

The cooldown cycle will begin.

» NOTE
• Stage 1 and Stage 2 temperatures will drop quicker than the platform. The platform will drop faster after Stage 1 reaches 30 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 on page 72* for troubleshooting information.
- Once the system reaches a rough vacuum state (2 Torr), the compressor will: a) turn on and run for 30 minutes or b) run until it achieves a pressure of 300mtorr. The compressor will turn on once either of the two prior conditions has been met.
- 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`. The VCM24-Turbo uses a wide range gauge and will continue to report vacuum from the gauge location (near the turbo case valve).

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.
4. Remove the remaining cables and electrical connections.

If the system needs to be shipped or moved from its current table, follow the remaining steps below:

5. Reverse the steps in the Installation Procedure. Replace the red locking rings and c-spacers and lock the red shipping supports down on the tri-flange. Then unbolt the system from the optical table.
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 the original state as shipped from the Montana Instruments factory.

Section 5 - Care & Maintenance

5.1 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.

5.1.1 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 contaminants 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, N-grease, and the adhesive GE Varnish (VGE).
- 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. Too much grease can outgas and contaminate 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 ensure the clamps are not too tight. Make sure wires do not touch the radiation shield or contact the sample mount directly after the thermal clamp.

5.1.2 When You Will Not Be Using Your Cryostat

- Keep the lid on the sample chamber to keep it free from dust.
- Supply a slight 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.

5.1.3 Standard Checks Before Every Cooldown

- Ensure the radiation shield is bolted down and secured. Make sure all radiation shield windows are in place.
- 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 the thermometers. The temperature channel values should be slightly fluctuating, indicating the thermometer readings are active.
- Check helium pressure to ensure values are within appropriate values per the table below:

Configuration	Equalization Pressure
F20-L/FA-20L, any hose length	Refer to SHI Compressor Manual for charge pressure

5.1.4 Periodic Checks Every 6-12 Months

- Inspect VGE joints and repair if needed. VGE can flake off after several thermal cycles.
    1. Clean off old VGE with acetone or isopropyl alcohol then add a thin layer of VGE in the same location.
- Replace extra VGE yearly. VGE has a limited shelf life of one year.

5.1.5 10,000 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

The GM cryocooler normally needs maintenance every 10,000 hours of operation. After extended use, some of the bearings and bushings will wear down

Other indicators of needing cryocooler maintenance include:

- The system begins to have trouble cooling. The achievable base temperature drastically degrades.
- The system begins to make a cogging or grinding noise in the cryocooler that persists continually.

» NOTE

Periodic chirping as the cryocooler runs is normal as the bearings wear in.

Compressor Filter and Adsorber

Refer to the system manual for the applicable SHI compressor model.

» 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.

5.1.6 Edwards mXD3s Mini Scroll Maintenance Schedule

The maintenance schedule is provided for the Edwards mXD3s mini-scroll pump; 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

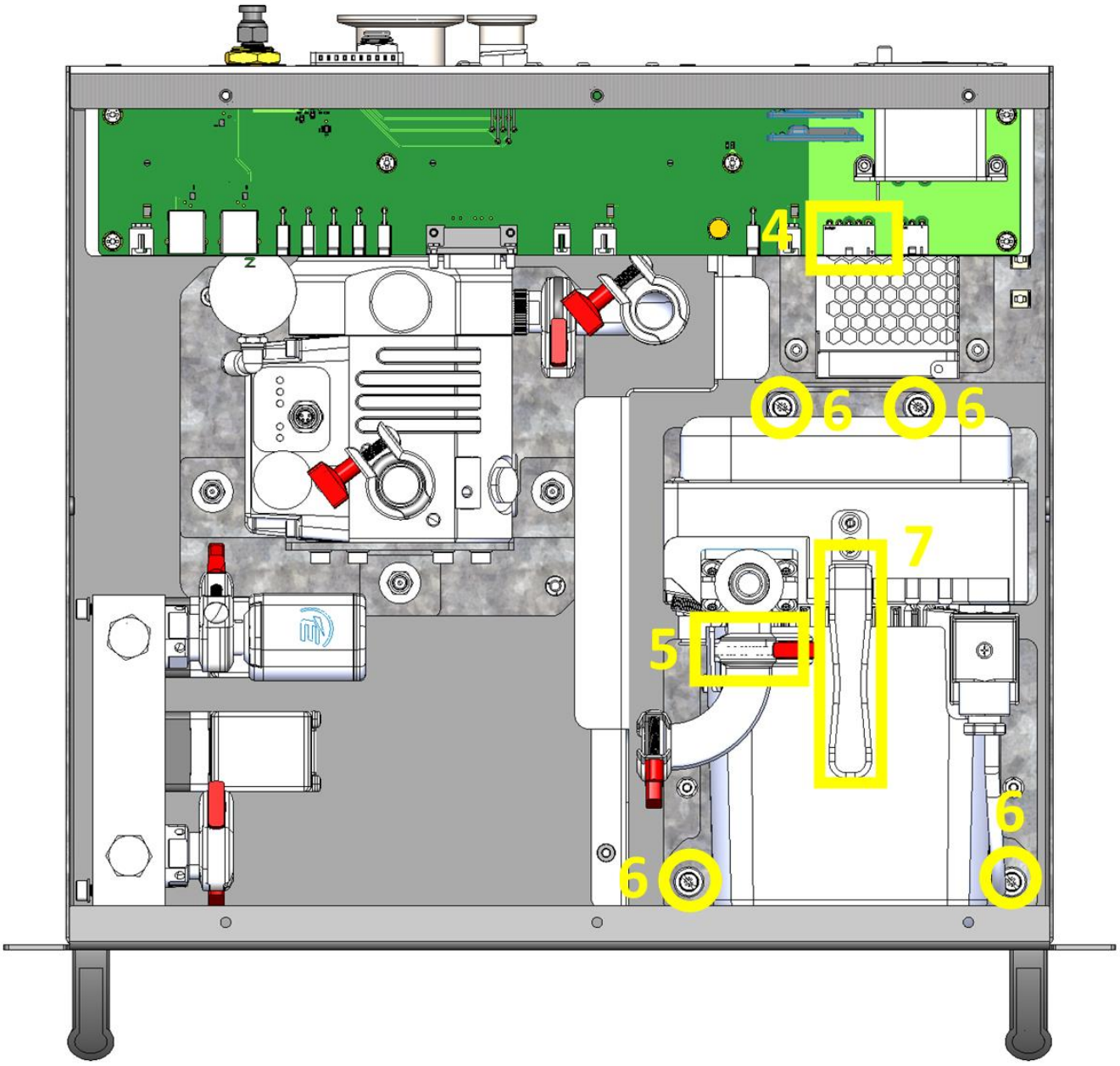
1. Unplug the Montana Instrument Vacuum Control Unit from the AC Power.
2. Disconnect the vacuum line, DSUB HD44 connector (VCM interface cable), and N2 purge if connected. For the Turbo version you will also need to disconnect the Turbo Valve cable, Turbo Guage cable, and N2 outlet connection.

⚠ 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 screen driver



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

5.1.7 Hardware Torque Specifications

All hardware in a Montana Instruments cryostat 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 cryostat 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 6 - 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.

6.1 Expected System Performance

Each system ships with a unique Certificate of Performance to demonstrate the factory performance of that particular platform. The base temperature, stability, and vibrations tests are typically conducted on the standard platform with the cryostat mounted to the optical table (without any options installed). 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.

If custom options are integrated into the base system, then the base temperature of the sample will also be recorded. Any other requested measurements can be found in the custom option tests section of the Certificate of Performance.

The system should achieve the base temperatures and stability listed on the Certificate of Performance on the first cooldown. Please contact an authorized service representative if the specifications are not met.

6.2 System Diagnostics

6.2.1 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 the target temperature or cooldown takes longer than expected	See *Temperature Optimization on page 74*	
The system does not meet vibration specifications on the sample stage	See *Vibration Mitigation on page 76*	
The system will not pull rough vacuum – leak check failed	Vacuum leak	See *Vacuum Check on page 77*
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.	Radiation (inner) and vacuum (outer) window are touching	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 a vacuum.
Thermometer not working	Not properly installed or activated.	Make sure the temperature channel is enabled. Navigate to `MENU > INSTRUMENT SETTINGS > USER X`. Toggle the Temperature Channel Enabled switch to the right to enable.
Heater not working	Not properly installed or activated.	
Optional Turbo Pump Case Valve is not engaging	Lack of Nitrogen supply	To engage the pnematic valve the system uses the customer supplied Nitrogen.

6.2.2 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 ***Error! Reference source not found.*** *on page* ***Error! Bookmark not defined.*** 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.
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		1.
	Communication issue with vacuum control unit	1. Make sure all cables and power cords are connected properly. See ***Error! Reference source not found.*** *on page* ***Error! Bookmark not defined.*** 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 (|).
Vacuum pressure reading in UI indicates "SensorErr"		

6.3 System Checks

For the system to achieve optimal performance, several aspects of the system must be handled carefully. Neglecting any one of these may have a significant impact on the base temperature or vibration performance. There are several basic checks users can do to help diagnose general problems.

6.3.1 Temperature Optimization

The cryostat platforms are optimized to control heat loads coming into 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 tightened down. See *Thermal Lagging Techniques on page 40* 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 sources of heat flow.
    a. Ensure wiring or cabling does not come in contact with the inside of the radiation shield.
    b. Ensure the radiation shield or radiation windows do not come in contact with any part of the outer vacuum housing or windows. For low working distance setups, the windows may touch after the vacuum is pulled.
3. Always use the appropriate wire and size for the application. See *Sample Chamber Wiring on page 40* 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-lbs). 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. The added heat load can significantly increase the base temperature of the platform.
7. Check the helium pressure. If there is a helium leak, cooling performance will be hindered significantly. See *Helium Check on page 78* 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 (i.e., laser power) may impact cooldown times and cause slightly higher base temperatures.

Identifying Heat Loads

The expected temperatures and temperature gradients of Stage 1, Stage 2, Platform, and Sample under various operating conditions can be used to identify the source of an unwanted heat load. These temperatures should only be used as a general reference. **It is recommended to use actual data from a previously successful cooldown on your system as a more accurate reference guide.**

The base temperature for a standard Cryostation s50 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 coming in 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 coming in between the Platform and Sample, and since the Sample 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 *Temperature Optimization section on page 74*, 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 on page 35*.

6.3.2 Vibration Mitigation

The cryostat 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 available mounting locations in the baseplate.
2. Ensure all screws inside the sample space are tightened down.
3. Ensure that the red shipping rings and spacers beneath the shipping rings have been removed. The red shipping supports at the back of the cryostat should be locked in the upper position off the tri-flange. See ***Error! Reference source not found.*** *on page* ***Error! Bookmark not defined.*** for details. Having any of these components installed can introduce vibrations on the order of several microns.
4. Ensure the helium hoses are not touching other cabling or the optical table. They should also not be pressed against a wall or another surface. There should be a gentle 180°

bend in the hoses to avoid any lateral tugging on the cryostat as helium runs through them.

5. Ensure the vacuum hose is not in contact with anything moving, as this hose is somewhat springy.
6. The vibrational performance will vary depending on the operating speed of the cryocooler. The Galaxy software now provides the user with the ability to manually select 'Auto' mode, or High/Medium/Low speeds. High speed maximizes cooling while low speed minimizes vibrations.
7. Ensure that optics are rigidly mounted to the table. Optics could be vibrating due to the cryostat on the table and mounting them should be carefully considered to reduce this effect.

6.3.3 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 atmosphere (~600-770 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. For the Cryostation s50 model, ensure the black Delrin screws holding the sample PCB in place are loose. If overtightened, these can cause the board to flex and compromise the O-ring seal.
5. Although nitrogen is optional, it helps keep the charcoal adsorbers clean and the inside of the cryostat free from moisture. Using nitrogen is particularly important in humid environments.
    a. Nitrogen purge cycles, as well as a platform bakeout, will help rid the chamber of contaminants prior to cooldown.

6. If a leak detector is accessible, use it to leak check the sample housing, cryostat, 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.

6.3.4 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 it idle for at least one hour. Do not start a cooldown.
2. Ensure the power on the back of the unit is ON (|) and the `ENABLE` switch on the front panel is ON (|).
3. In the UI, navigate to the `OVERVIEW` display screen, then press the `CRYOCOOLER` reading to show compressor details.
4. Refer to the current SHI manual on the Montana Instruments website for recommended supply and return pressure values. If the supply or return values are low, helium will need to be recharged. See *Helium hoses should* first be tightened by hand. Use a crescent wrench to continue to tighten the fitting, stopping as soon as force is required. Ensure the hoses are sufficiently tight, as loose hoses can hinder cooling performance.
5. Helium Recharge Process *in section 5.3.4* for details.

Helium Hose Fittings

Improper attachment 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 front of the compressor and cryostat:

- Ensure the fittings are straight.
- 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

Fitting missing O-ring (left) and with proper O-ring (right)

Helium hoses should first be tightened by hand. Use a crescent wrench to continue to tighten the fitting, stopping as soon as force is required. Ensure the hoses are sufficiently tight, as loose hoses can hinder cooling performance.

Helium Recharge Process

If the helium pressure is low, 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 and current SHI manual on the Montana Instruments website.

Section 7 - Appendices

7.1 Related Documentation

For a copy of associated documentation, see below:

Document Number	Document Title	Location
DOC102	General Terms and Conditions of Sale	www.montanainstruments.com/About/Terms
DOC103	Limited Warranty Agreement	www.montanainstruments.com/About/Warranty
DOC104	End User License Agreement	http://www.montanainstruments.com/about/EULA
N/A	Patent Information	https://www.montanainstruments.com/patents

7.1.1 Declarations of Conformity

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

ATTESTATION OF TEST RESULTS

Date of Issue: 2024-02-08 Attestation Number: R2312151-17

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 Control
Model:	ECA24 (Embedded Control Architecture)
Manufactured by:	Montana Instruments
Project Number:	R2312151

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 #R2312151-17 listed in above table apply only to the tested sample under the condition and modes of operation as described herein.

Attestation by: Giriraj Gurjar
EMC Lead

Signature

2024-02-08
Date

Attachment 4: Declaration of Similarity

MONTANA INSTRUMENTS
COLD SCIENCE MADE SIMPLE

DECLARATION OF SIMILARITY

February 15, 2024

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 Incorporated*, hereby declare that product: Cryostat System Control, model(s): 4400-510-10, 4400-510-11, 4400-510-12, 4400-510-13, are electrically identical with the same electromagnetic emissions and electromagnetic compatibility characteristics as model: CSC24 *(ECA24+VCM24)* tested by BACL, the results of which are featured in BACL projects R2312151(Model: ECA24) and R2312152 (Model: VCM24).

A description of the differences between the tested model and those that are declared similar are as follows:

- 4400-510-10: CSC24; Cryostat System Control, 115V Vacuum, Non-Turbo
  - 4117-500-02: ECA24; Embedded Control Architecture
  - 4117-520-10: VCM24; Vacuum Control Module, 115V Non-Turbo, KF16
- 4400-510-11: CSC24; Cryostat System Control, 115V Vacuum, KF40 Turbo
  - 4117-500-02: ECA24; Embedded Control Architecture
  - 4117-520-11: VCM24; Vacuum Control Module, 115V Turbo, KF40
- 4400-510-12: CSC24; Cryostat System Control, 230V Vacuum, Non-Turbo
  - 4117-500-02: ECA24; Embedded Control Architecture
  - 4117-520-12: VCM24; Vacuum Control Module, 230V Non-Turbo, KF16
- 4400-510-13: CSC24; Cryostat System Control, 230V Vacuum, KF40 Turbo
  - 4117-500-02: ECA24; Embedded Control Architecture
  - 4117-520-13: VCM24; Vacuum Control Module, 230V Turbo, KF40

Please contact me should there be need for any additional clarification or information.

Best Regards,

Gene Kuntz, General Manager
Montana Instruments Corporation
101 Evergreen Drive,
Bozeman, Montana 59715, USA

-- END OF REPORT ---

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

ATTESTATION OF TEST RESULTS

Date of Issue: 2024-02-08 Attestation Number: R2312152-17

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 Control
Model:	VCM24 (Vacuum Control Module)
Manufactured by:	Montana Instruments
Project Number:	R2312152

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 #R2312152-17 listed in above table apply only to the tested sample under the condition and modes of operation as described herein.

Attestation by: Giriraj Gurjar
EMC Lead

Signature

2024-02-08
Date

MONTANA INSTRUMENTS
COLD SCIENCE MADE SIMPLE

DECLARATION OF SIMILARITY

February 15, 2024

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 Incorporated*, hereby declare that product: Cryostat System Control, model(s): 4400-510-10, 4400-510-11, 4400-510-12, 4400-510-13, are electrically identical with the same electromagnetic emissions and electromagnetic compatibility characteristics as model: CSC24 *(ECA24+VCM24)* tested by BACL, the results of which are featured in BACL projects R2312151(Model: ECA24) and R2312152 (Model: VCM24).

A description of the differences between the tested model and those that are declared similar are as follows:

- 4400-510-10: CSC24; Cryostat System Control, 115V Vacuum, Non-Turbo
  - 4117-500-02: ECA24; Embedded Control Architecture
  - 4117-520-10: VCM24; Vacuum Control Module, 115V Non-Turbo, KF16
- 4400-510-11: CSC24; Cryostat System Control, 115V Vacuum, KF40 Turbo
  - 4117-500-02: ECA24; Embedded Control Architecture
  - 4117-520-11: VCM24; Vacuum Control Module, 115V Turbo, KF40
- 4400-510-12: CSC24; Cryostat System Control, 230V Vacuum, Non-Turbo
  - 4117-500-02: ECA24; Embedded Control Architecture
  - 4117-520-12: VCM24; Vacuum Control Module, 230V Non-Turbo, KF16
- 4400-510-13: CSC24; Cryostat System Control, 230V Vacuum, KF40 Turbo
  - 4117-500-02: ECA24; Embedded Control Architecture
  - 4117-520-13: VCM24; Vacuum Control Module, 230V Turbo, KF40

Please contact me should there be need for any additional clarification or information.

Best Regards,

Gene Kuntz, General Manager
Montana Instruments Corporation
101 Evergreen Drive,
Bozeman, Montana 59715, USA

-- END OF REPORT ---