Option User Manual

Magneto-Optic Module

Cryostation s50 – MO

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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

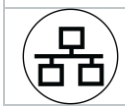
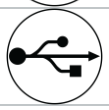
Command or Product Safety Notice
Potential hazards which, if not avoided, could result in product damage.

» 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		Hazard Alert: Magnetic Field
	Hazard Alert: Hot Surface		HDMI port
	CAN bus module		USB port

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 surface with 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 - Option Overview

2.1 Magneto-Optic

Models	Part Numbers
Cryostation s50 - MO	4101-122

Front View of Magneto-Optic

Top View of Magneto-Optic

2.1.1 Intended Use

The Magneto-Optic module is an add-on option for the Montana Instruments Cryostation s50 model that integrates a bipolar electromagnet with the sample space. The assembly allows the user to place their sample between the magnet poles above the cryogenic platform.

2.1.2 Components

The Magneto-Optic module consists of an electromagnet housing and a bipolar power supply and cooling unit. The main system user interface touchscreen provides the operational control of the magnet and power supply.

Electromagnet and Sample Chamber

The electromagnet housing replaces the upper vacuum housing on the cryostat sample chamber. The assembly consists of an upper vacuum housing with two magnet poles entering on opposite sides. The magnet poles tips are interchangeable to focus the field intensity. The left and right solenoids surrounding the housing are built above a rigid base structure (yoke) that sits on the optical table.

The standard configuration includes two primary optical access windows on the upper vacuum housing perpendicular to the magnet axis. The vacuum housing lid also contains a 50 mm window for overhead optical access. A 6 mm bore through the center of the magnet poles provides in-plane optical access into the sample chamber.

An adjustable radiation shield inside the sample chamber has side walls that can be moved in or out to accommodate various sample geometries and pole tip spacing. The radiation shield includes five “cold” windows for optical access.

Power Supply

The power supply provides a 500 W linear bipolar current source with 20 bit resolution for fine control of the field strength. The power supply unit also contains the cooling system for the magnet and three fans to dissipate heat. The unit connects to the electromagnet, system control unit, and compressor.

Magneto-Optic Power Supply

Magneto-Optic with Hall Probe Sensor

The power supply communication ports and connections are outlined below:

BNC (ANALOG INPUT)

The analog input is an optional input whereby a signal generator or other compatible voltage source may be used to modulate the field. This input will directly modulate the current used to create the field with the transfer function described in the *Technical Specifications on page 13*. Due to saturation-related non-linearities in the coil, the relationship between the current and the field is also non-linear. See *Figure 1 on page 14* for an illustration of this relationship. The maximum voltage to be applied to this terminal is ±10 V; exceeding this value may result in damage to the equipment. The analog input cannot be used while a calibration of the magnet is in progress.

DSUB9 (CAN-BUS PORT A / B)

The two upper DSUB9 ports on the rear face of the enclosure are used to interface with the Montana Instruments helium compressor (Port A) and system control unit (Port B). These provide communication with the CAN bus module for controlling the instrument via the user interface.

DSUB9 (AUXILIARY I/O PORT & AUXILIARY MAGNET I/O)

The two lower DSUB9 ports on the rear face of the enclosure are to be used only with expansionary devices and accessories offered by Montana Instruments. For more information about the usage and capabilities of these ports, contact an authorized service representative.

DSUB13W3 (MAGNET INTERCONNECT)

A combination 13W3 combination D-Subminiature port is used to connect the electromagnet housing and power supply. This connection provides the field current and monitors temperature of the electromagnet housing.

Hall Probe Sensor

A Hall probe sensor is provided for running calibration routines on the unit. The Hall probe sensor fits onto the top of the magnet housing and connects to the front of the power supply via the supplied cable.

2.1.3 Technical Specifications

Environmental Specifications

Temperature of Environment (Storage)	5 – 40 °C
Temperature of Environment (Operational)	15 – 40 °C
Humidity	5 – 80% non-condensing

Power Specifications

Model		4101-132
Mains Power Connector on Unit		IEC 60320 C20
Line Voltage		100 – 240 VAC
Frequency		50 – 60 Hz
Maximum Current Draw		13 A
Maximum Power Consumption		1300 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

Electrical Connections

Magnet Interconnect	13W3 D-Subminiature
Communications	9-pin D-Subminiature MI CAN Bus
Grounding Terminal	4mm Banana Jack and Screw Terminal

Physical Dimensions

Component	L x W x H	Mass
Power Supply (4101-132)	51 cm x 21 cm x 110 cm	15 kg (dry)
Magnet Housing	15 cm x 26 cm x 15 cm	10 kg (dry)

Magneto-Optic Specifications

Field

With 12 mm Pole Tips		
Range		-0.7 to 0.7 Tesla
Resolution		<5 µTesla
Accuracy		<2% of Range[NOTE 1]
Noise and Ripple		<10 $\mu Tesla_{RMS}$[NOTE 2]
Uniformity	Axial	1% - ±0.1 inch from Center; 0.1% - ±.05 inch from Center
	Radial	1% - ±0.25 inch from Center; 0.1% - ±0.15 inch from Center
Full Field De-Rating		2% of Range / °C for Ambient >25°C[NOTE 3]
Temperature Coefficient		<±0.3% / °C Ambient

1) *Accuracy specified immediately following a True Zero operation at operating temperature*
2) *Noise and Ripple measured from 45 to 800 Hz*
3) *Higher field is possible for a limited time but may result in over-temperature fault and 'Safe Mode' trigger*

Analog Input

Input Impedance	~5 kΩ
Input Range	±10 V MAX
Current Gain	-3.1 A/V

Cooling System

Pressure	Atmospheric
Required Coolant	Propylene Glycol (Koolance 705 Liquid Coolant Part No. LIQ-705CL-B)

2.1.4 Performance Data

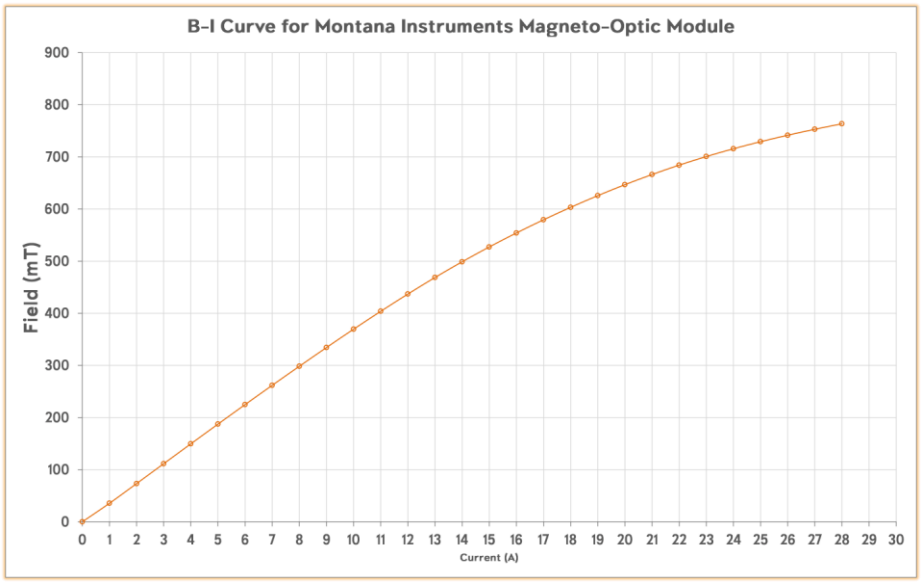


Figure 1: Field vs. Current

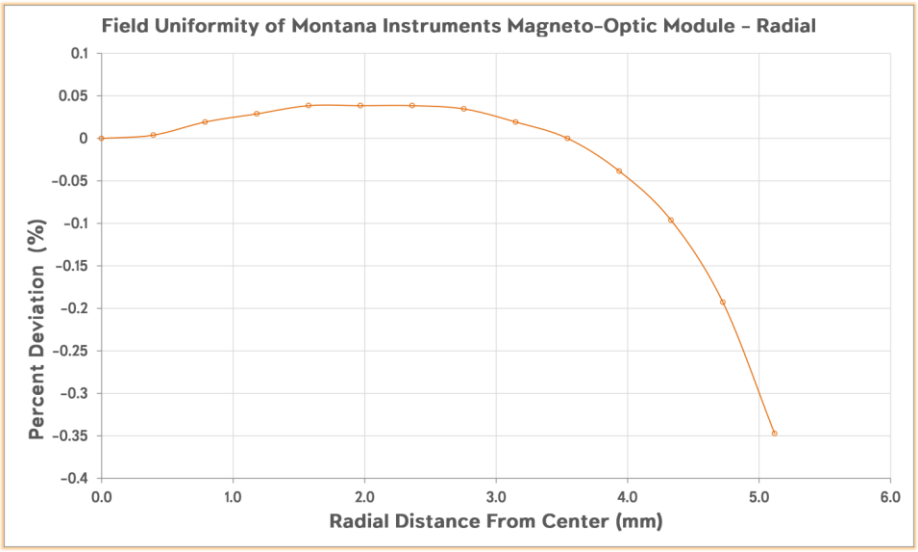


Figure 2: Radial Field Uniformity, 0.1% uniformity at 4mm for ±4mm from center

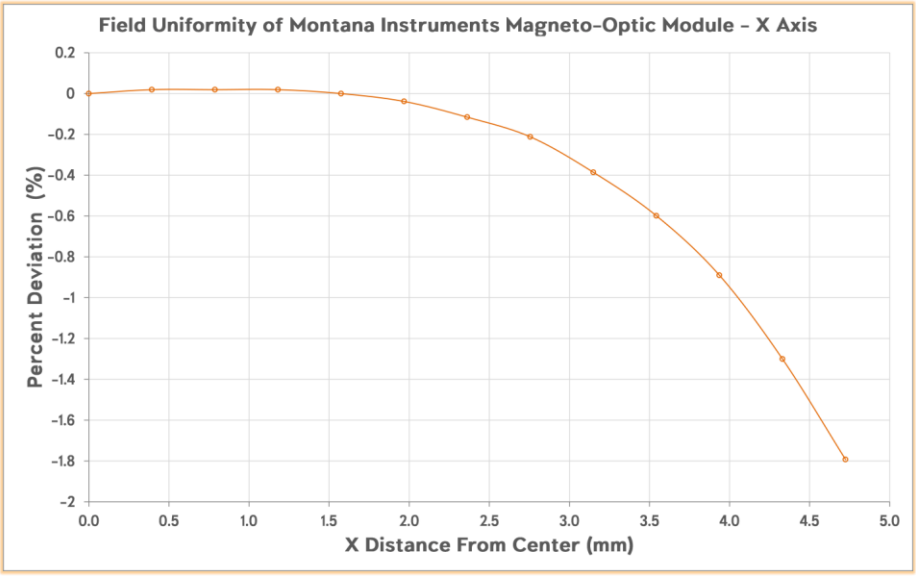


Figure 3: X distance from center field uniformity, 1% uniformity at ±4mm, and 0.1% uniformity at ±4.5mm

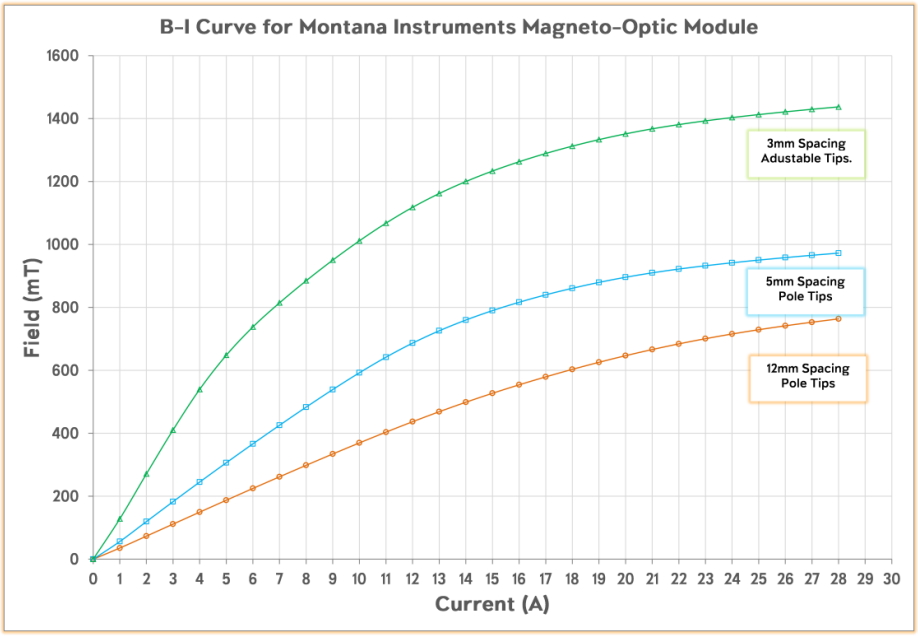


*Figure 4: Field vs. Current for various pole spacings**

» NOTE

***Pole tip spacing of <5mm will increase base temperature**

To achieve a 5mm pole tip spacing, the radiation shield will need to be removed. Doing so will increase the base temperature by several Kelvin.

2.1.5 Safety Information

The following hazards may be typical for this product:

- The module must be used in a normal condition only in which all means of protection are intact.

⚠ WARNING

Strong static magnetic field: Potential hazards of magnetic origin may result in minor to moderate injury and/or equipment damage.

This device generates strong magnetic fields. Fields in excess of 1 Tesla may be inside the sample chamber during operation, and fields in excess of 0.04 Tesla may be generated immediately outside the sample chamber area.

- Fields of this intensity may cause medical pacemakers and neurostimulators to malfunction. **Persons relying on medical pacemakers, neurostimulators, medical implants, or other sensitive electronic devices should not be allowed near the instrument.**

This device generates a high magnetic field which will interact with ferromagnetic objects.

- If ferromagnetic objects are brought into the vicinity of the magnet, they may be pulled into the field with significant force and velocity, causing damage to the instrument and/or personal harm.

⚠ WARNING

Risk of injury due to hot surfaces

The electromagnet poles generate a significant amout of heat. The poles may be hot to the touch during operation and stay hot for a period of time after the magnet is powered down.

⚠ WARNING

Risk of injury due to sharp edges

The interior of the power supply 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.

There are up to 30 amperes of electrical current flowing between the magnet power supply and the magnet.

- Do NOT apply power to the instrument until all connections are firmly in place and secured with the provided tool.
- **Do NOT attempt to remove any connections while the instrument is in operation.**

NOTICE

Take caution to avoid shorts

- Do not short the magnet to ground. Do not short the leads of the magnet to each other. Both of these conditions may result in permanent damage to the power supply.

Maintain adequate coolant level

- The level of coolant should always be maintained above the orange region on the fluid level indicator on the front of the power supply. The reservoir is at max fill capacity at the uppermost blue line – do not fill past this level. Coolant will need to be added if the level falls into the orange region. See *Adding Coolant to the Reservoir on page 30* instructions.

Transportation and installation

- The power supply must remain upright and can be placed on the floor or a nearby shelf. The unit should not be stacked on any other equipment nor should other equipment be placed on it.
- Allow 10 cm minimum clearance on all sides of the power supply during operation to provide proper ventilation and allow heat to exit the unit. Ensure the power switch on the back of the unit can be accessed at all times.
- The power supply should not be placed in the vicinity of any heat source. Doing so will compromise its cooling ability and maximum field strength.

Section 3 - Option Installation & Handling

3.1 Packaging Contents

The Magneto-Optic components will arrive packed on their own pallet. One box contains the electromagnet, cables, and magnet accessories. The other box contains the power supply. The electromagnet is shipped within a protective hard case that can be re-used for storage or transport.

NOTICE

Inspect shipment upon receipt

Before unpacking the system, please note the condition of the boxes, shock watch sensors and tilt watch sensors. The boxes should be intact and strapped to the pallets. If there is any visible damage or if the sensors have been tripped, contact an authorized service representative immediately and do NOT proceed with unpacking.

Shock watch

Tilt watch

Retain equipment packaging for future use

We recommend saving the original equipment packaging (foam, box, and pallets). The packaging is specially designed to support and stabilize the equipment and will be required if the unit needs to be transported in the future. Some components must be packed upright on a pallet to avoid damage.

3.2 Component Placement and Layout Plan

Prior to unpacking the system, it is recommended to pre-plan the placement of components in the lab space. Refer to the System User Manual for a detailed overview of all major components.

The magnet is set on the optical table surrounding the cryostat sample chamber. The power supply must remain upright and can be placed on the floor or a nearby shelf. It must be located within 10 ft (3 m) of the system control unit and compressor, and within 10 ft (3 m) of the magnet on the sample chamber. With the long hose option, the power supply and compressor can be up to 50 ft (15 m) apart, depending on the length purchased.

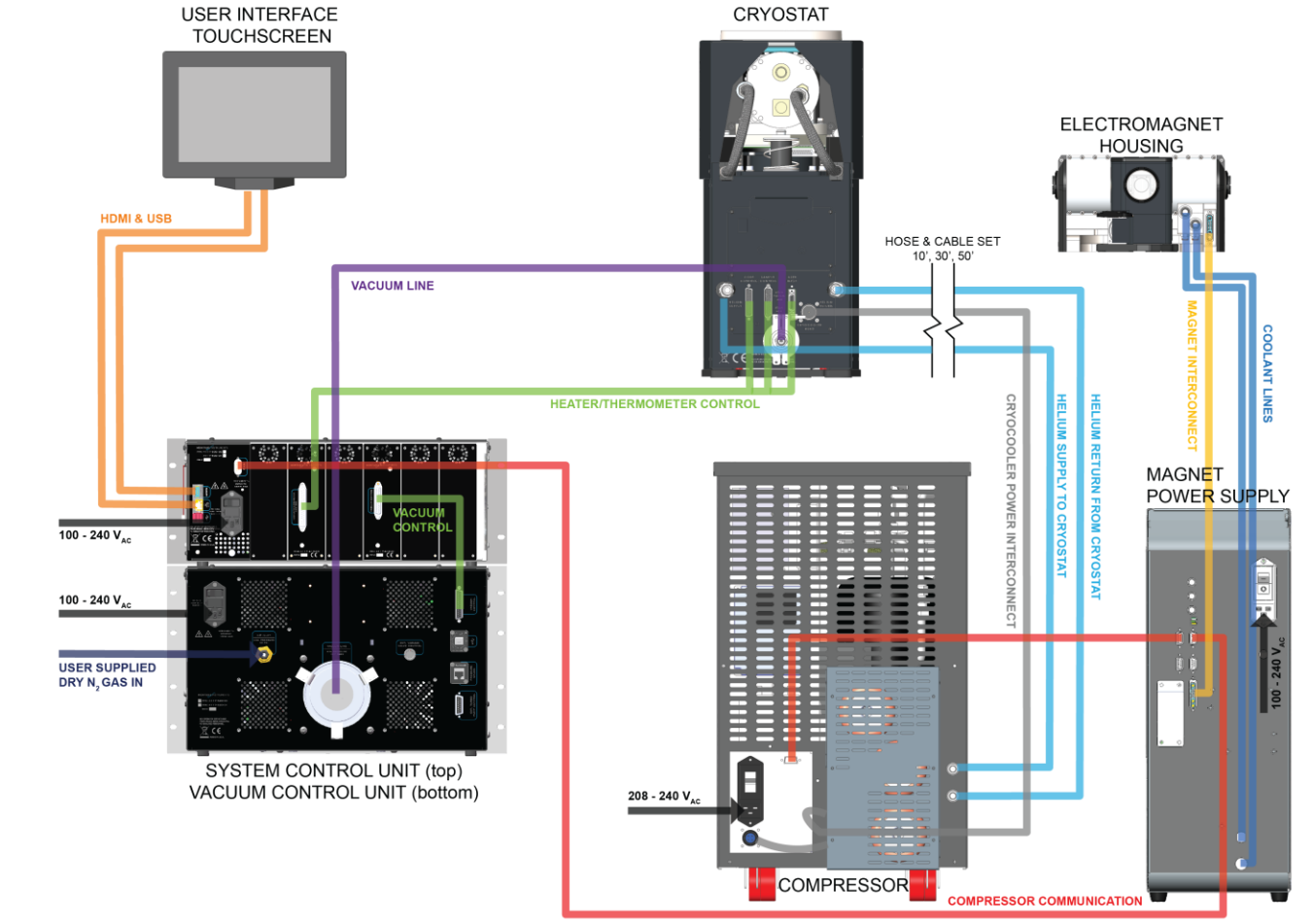
3.3 Unpacking the Magnet Power Supply

Locate the power supply box.

1. Remove the box wrap and cut the bands securing the box to the pallet. Carefully lift the box off the pallet and set on the floor or a nearby surface.
2. Open the side of the box and slide out the power supply and foam.
3. Lift off the top piece of foam.
4. Reach under the unit and lift it out of the lower foam. A second person can assist with this step.
5. Keeping the unit upright, move to the desired location.

3.4 Connecting System Cables and Power

NOTICE
Only use cables and hoses provided or approved by the manufacturer Only use the cables and hoses in the manner described below.



Other than the DSUB9 compressor communication cable, the standard communication cables and hoses between system components do not change. Refer to the System User Manual for instructions on connecting the standard system cables and other components.

Compressor Communication:

1. Locate the DSUB9 M-F series cable. Connect the M end to the `CAN-BUS PORT A` location on the back of the power supply. Connect the F end to the `QD-CAN IN` location on the back of the compressor. Tighten both connections with thumbscrews to secure.
2. Locate the DSUB9 F-F series cable. Connect one end to the `CAN-BUS PORT B` location on the back of the power supply. Connect the other end to the `CAN` location on the back of the system control unit. Tighten both connections with thumbscrews to secure.

Magnet Interconnect:

3. Locate the DSUB13W3 combination M-F cable. Connect the F end to the MAGNET INTERCONNECT location on the back of the power supply. Connect the M end to the connection point on the back side of the electromagnet assembly. Fully tighten the retaining screws on both connections with a screwdriver to secure.

⚠ WARNING

High voltage: danger of electric shock

There are up to 30 amperes of electrical current flowing between the magnet power supply and the magnet.

- The retaining screws on the MAGNET INTERCONNECT cable should be hand-tightened then fully seated using the provided screwdriver.
- Do NOT operate the unit until this connection is fully secured. **Do NOT attempt to remove any connections while the instrument is in operation.**

Coolant Lines:

The power supply will ship without coolant. During the initial installation, coolant will need to be added to the reservoir before connecting the coolant lines. See *Adding Coolant to the Reservoir on page 30* for instructions.

4. Locate the coolant lines. Connect one end to either the COOLANT SUPPLY or COOLANT RETURN location on the back of the power supply. Connect the other end to a coolant port on the back side of the electromagnet assembly. Repeat for the other line.

» NOTE

The coolant lines may be interchanged, as the orientation of the coolant flow does not matter. The lines are labeled SUPPLY and RETURN to facilitate an easier drain process.

Unit Power:

After all other cables are connected, the power supply can be connected to wall power.

1. Locate the C19 main power cord. Ensure the rocker switch on the back of the power supply is off (o).
2. Connect the main power cord to the C20 inlet located on the rear of the unit.
3. Connect the power plug to the appropriate 100 – 240 VAC wall outlet power source.

Section 4 - Option Configuration

Refer to the System User Manual for instructions on unpacking, mounting, and installing the cryostat. Complete these steps before configuring the Magneto-Optic.

NOTICE

Keep sample chamber and surfaces clean

- Always wear sterile gloves when working in the sample chamber to avoid getting oils on the surfaces.
- 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.
- Before replacing vacuum housings and lids, carefully check O-rings for loose fibers or debris. If necessary, clean with a dry lens tissue and re-grease with a thin layer of L-grease.

Before connecting or disconnecting wiring inside the system, ensure the power to the system is off.

- Tap (press and release) the power button on the front of the system control unit, then turn off power to the unit completely by toggling the power switch on the back of the unit OFF (o).
- Ensure the Magnet is `DISABLED` in the user interface.
- Toggle the power switch on the back of the power supply unit OFF (o).

4.1 Configuring the Magnet Housing

The entire electromagnet housing assembly is an independent unit from the rest of the sample space. The components include:

- Lower and upper radiation shields with radiation shield lid
- Electromagnet housing assembly with left and right solenoids, upper vacuum housing, and yoke
- Interchangeable pole tips (style depends on configuration)
- Vacuum housing lid (this is the same lid as the standard sample chamber configuration)

4.1.1 Installing the Magnet Housing

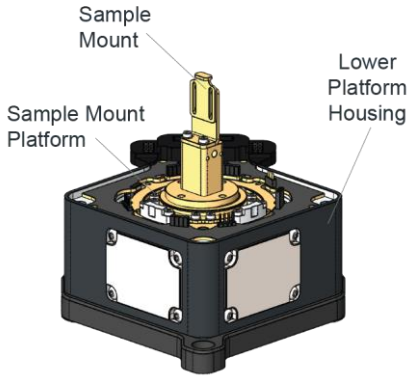
The upper vacuum housing of the magnet will seat against the lower vacuum housing of the sample chamber. The pole tips slide into the indented walls of the upper radiation shield. The yoke either sits on a special spacer (if applicable) or directly on the optical table.

To install the magnet assembly on the sample chamber:

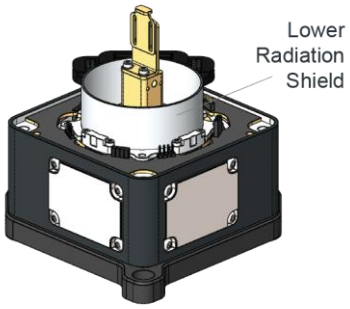
1. Configure the sample chamber options, sample wiring, and sample mount.
    a. Refer to the Manual Addendum for any specific instructions regarding the sample mount configuration. Ensure all wiring runs under the sample platform radiation ring thermal clamps.
2. Place the lower radiation shield onto the sample mount platform. Secure into place with four M3 x 6mm socket head screws.

a. Check to ensure there are no wires or components touching the inside of the radiation shield. Adjust if necessary.

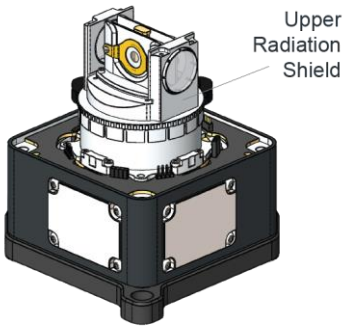
3. Press the upper portion of the radiation shield into place on top of the lower radiation shield.
    a. Ensure the adjustable inner walls of the radiation shield are properly positioned to accommodate the installed pole tips. The pole tips should not contact the walls of the radiation shield. If the walls need to move, loosen the two M1.6 x 6mm screws on the lower flange of each wall, slide the walls into the desired position, then re-tighten the screws.



Step 1



Step 2



Step 3

4. If your configuration includes a magnet spacer plate, place this on the optical table around the housing underneath where the yoke will sit.
    a. (optional) Secure the spacer plate to the optical table.
5. With the radiation shield top lid and vacuum housing lid off, carefully lift and lower the magnet into place on the lower sample chamber. The pole tips should slide into the indented walls of the upper radiation shield and the vacuum housings should seat together. The yoke should either rest flat on the optical table or on the magnet spacer plate.

NOTICE

Take care to manage wires and connectors

- Ensure wires inside the sample chamber are not pinched or otherwise damaged while lowering the magnet into place.
- Ensure any cables attached to the magnet are managed while lowering the unit into place.

Take care to avoid side panel connectors

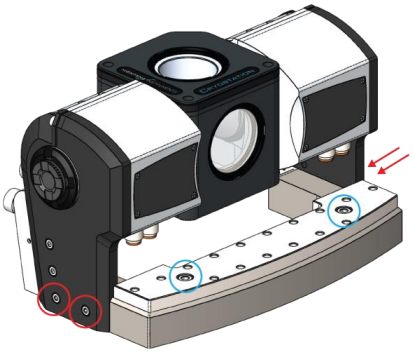
- If there are any side panels or side panel connectors on the lower housing or on an interface extension housing, the magnet must be installed over and around those. Take care to ensure the magnet does not contact these connectors when lowering into place. An alternative installation method may be needed for configurations where the side panel prohibits lowering the entire assembly into place (see *Installing the Magnet Housing without Yoke on page 25* for instructions).

» NOTE

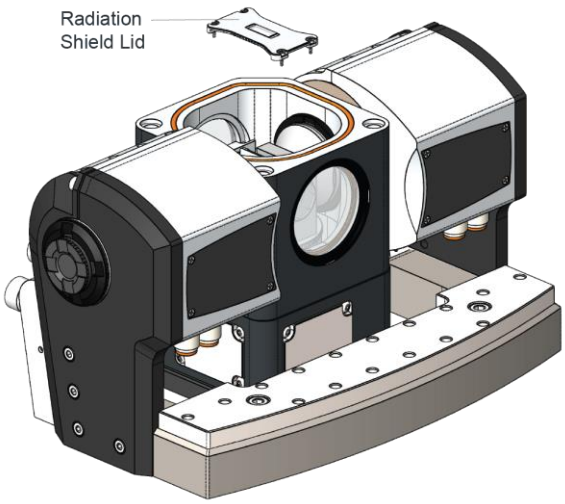
If the yoke does not sit flat on the optical table when the magnet is set into place:

1. Loosen the two lower screws on either side of the assembly slightly (indicated red in figure to the right).
2. Finish setting up the sample chamber, then pull vacuum to ~1 Torr. Once under vacuum, re-tighten the side bolts.

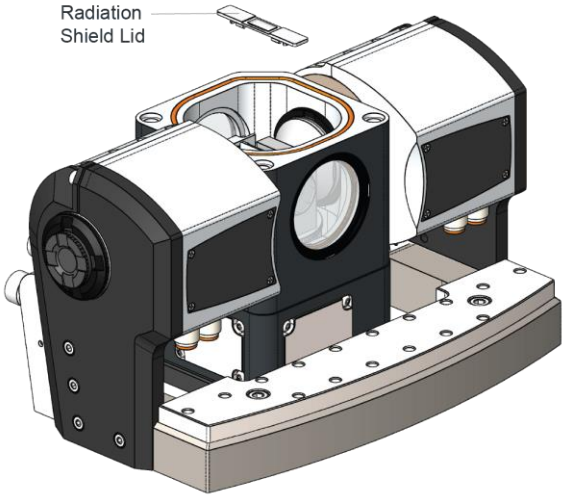
The position of the side yoke pieces adjust slightly downward as the O-rings compress under vacuum. It is NOT necessary to loosen the bolts again after vacuum is released.



6. Add the top lid of the radiation shield.
    a. Style A: This style is secured in place with four M1.6 x 6mm socket head screws. Take care to avoid dropping screws into the sample chamber when installing.
    b. Style B: This style is held in place with N-grease. Add a thin layer of N-grease to the contact points and press firmly into place.

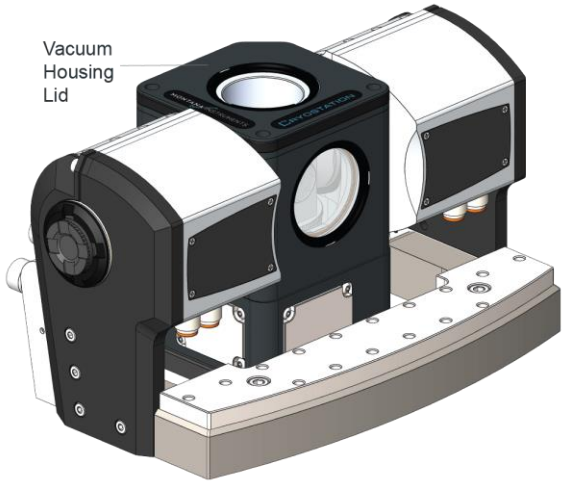


Step 6: Style A



Step 6: Style B

7. Place the vacuum housing lid on top of the sample chamber.

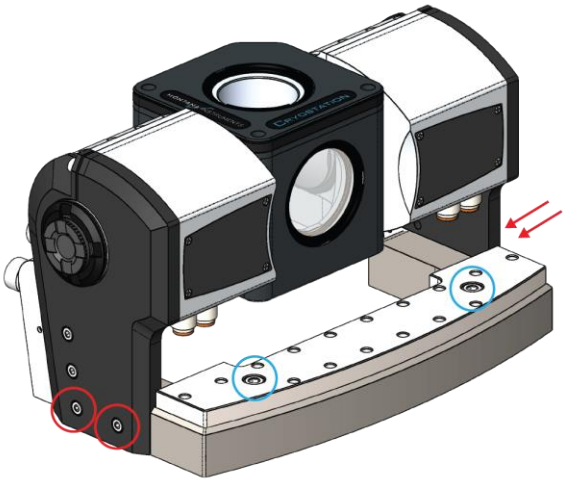


Step 7

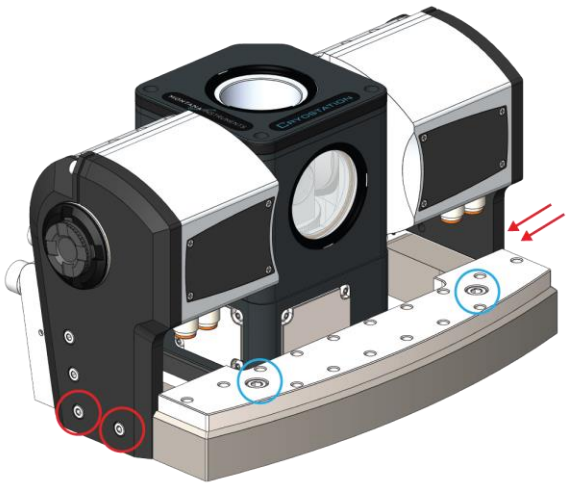
Installing the Magnet Housing without Yoke

If a side panel or other connector obstructs the ability to lift the magnet housing onto the sample platform, the yoke can be removed and re-installed once the magnet is seated.

1. Remove the two lower bolts on either side of the assembly (indicated red in figure below).
2. Remove the two bolts on the top face of the yoke plate (indicated blue in figure below).
3. Slide the yoke away from the rest of the magnet assembly.
4. Set the magnet housing into place on the lower sample chamber according to the instructions above.
5. Slide the yoke back into place and re-attach the side and top screws.



Remove screws to remove yoke



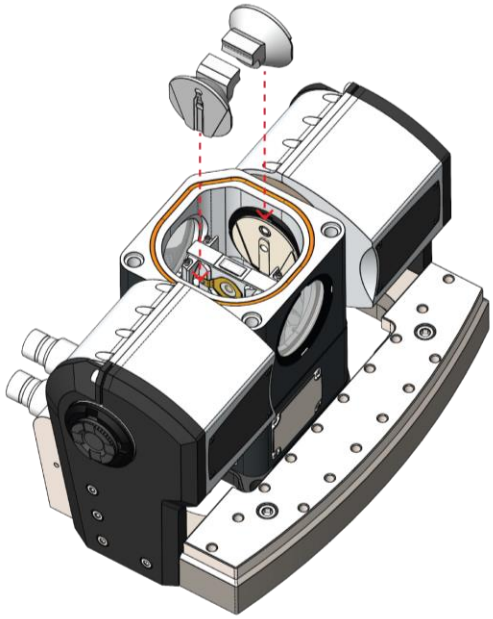
Replace screws to re-attach yoke

4.1.2 Installing or Changing Pole Tips

The pole tips are removable and slide in and out of the magnet on a grooved attachment point inside the vacuum housing.

1. To slide the poles into place, start with the pole directly over the attachment location and slide straight down into the groove until seated. If the pole approaches at an angle, it will not engage the slot properly.
2. To slide the poles out, pull directly up on the pole.

Some poles also have adjustable, threaded tips. These can be removed and replaced by screwing in or out.



4.1.3 Window Replacement

Radiation Shield Pole Tip Optical Windows

The cold windows in-plane with the magnet poles are held in place with brass cover pieces on the radiation shield. To replace these windows:

1. Remove the upper radiation shield from the sample space.
2. Unscrew the two M1.6 x 3mm slotted head screws holding the brass cover into place.
3. Gently remove and replace the window.
4. Replace the brass cover piece and re-tighten the screws to hold the new window in place.
5. Repeat on the other side as needed.

Radiation Shield Top Lid Optical Window

The cold window on the top of the radiation shield lid is held in place with N-grease.

1. Dab a small amount of N-grease on either tab and carefully press the window into place.
2. (Alternate Method) Dab a small drop of VGE to one side of the window only and use N-grease on the other side. Carefully press the window into place.

NOTICE
Do NOT use VGE on both sides of the window, as this can cause the window to crack as it cools down.

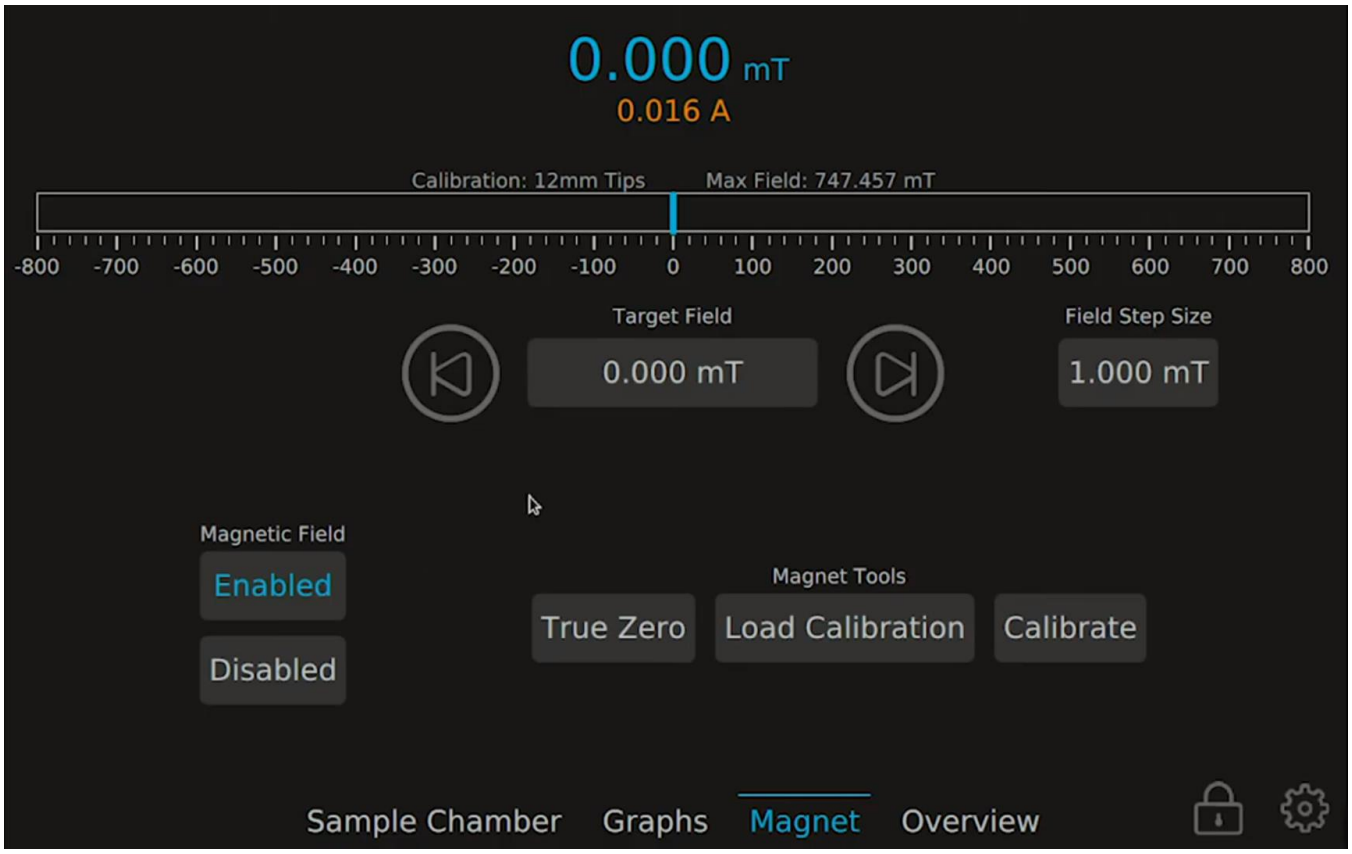
Section 5 - Option Usage & Operation

5.1 Primary Operations

The primary operations below cover magnet-specific settings for the instrument. Refer to the System User Manual for detailed user interface control functions.

5.1.1 Turning on the System

The magnet power supply can be turned on before or after powering on the other components. To turn on the power supply, toggle the power switch on the back of the unit ON (|).



5.1.2 Controlling Field Strength

Load Calibration File

To get started, first load the correct calibration file for the pole tips that are currently installed on the magnet.

1. In the UI for the CRYOSTATION instrument, navigate to the MAGNET display screen to bring up its operation controls.
2. Press the LOAD CALIBRATION command button. On the popup, select the desired calibration file and press LOAD CALIBRATION to confirm.

The name of the current calibration and the maximum field strength available for that calibration will be shown above the magnetic field gauge at the top of the UI.

Setting a Target Field

The magnetic field can be controlled by setting a specific target value.

1. In the UI for the CRYOSTATION instrument, navigate to the MAGNET display screen to bring up its operation controls.
2. Press the ENABLED command button to turn on the magnetic field.
3. In the TARGET FIELD input box, enter the target field value. Press SET to confirm.

Stepping the Magnetic Field

The magnetic field can also be stepped in increments through the available range.

1. In the UI for the CRYOSTATION instrument, navigate to the MAGNET display screen to bring up its operation controls.
2. Press the ENABLED command button to turn on the magnetic field.
3. In the FIELD STEP SIZE input box, set the desired step size. Press SET to confirm.
4. Press the right or left arrow buttons to step the field up or down by the increment defined above.

» NOTE
The field can also be controlled by pressing along the field gauge. Press anywhere along the slider gauge to move the field to that value. This method may be less precise than the methods described above.

Turn Off the Magnetic Field

At any time during operation, the magnetic field can be turned off by pressing the DISABLED command button on the MAGNET display screen.

5.1.3 True Zero

The true zero function is used to remove any field stored in the iron poles that is introduced while using the magnet. To start the true zero process:

1. In the UI for the CRYOSTATION instrument, navigate to MAGNET display screen. Ensure the Magnetic Field is set to ENABLED.
2. Press the TRUE ZERO command button. On the popup, press TRUE ZERO to confirm and start the operation.

The process will alternate the field in a decaying sinusoid to de-gauss the poles and remove as much hysteresis from the magnet core as possible. This process may take several minutes. Press CANCEL at any time to stop the process.

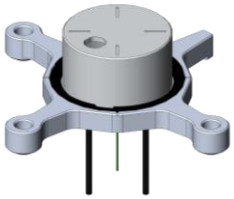
5.2 Hall Probe Calibration

NOTICE
• Only use the Hall probe sensor provided by the manufacturer • Never insert any other connector into the HALL SENSOR port on the front of the power supply

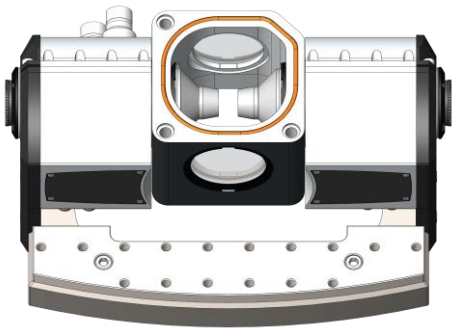
Installing the Hall Probe Sensor

To run a calibration routine, first install and connect the Hall probe sensor.

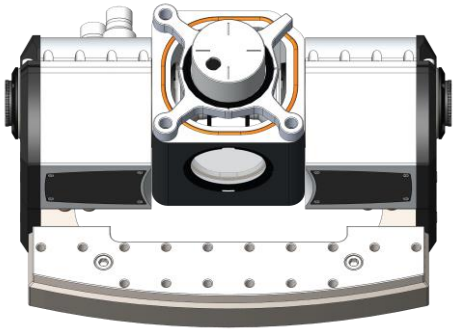
1. Remove the vacuum housing lid and radiation shield top lid, then carefully lift the electromagnet housing off of the sample chamber platform.
2. Place the Hall probe sensor on top of the electromagnet housing. The holes on the three extension arms should align with the holes on the top of the sample chamber.



Hall probe sensor



Top of electromagnet housing without lid



Placement of Hall probe sensor

3. Connect the cable from the top of the sensor to the HALL SENSOR port on the front of the power supply.

Running a Calibration Routine

After the sensor is properly installed, the calibration routine is completed in the user interface.

3. In the UI for the CRYOSTATION instrument, navigate to MAGNET display screen. Ensure the Magnetic Field is set to ENABLED.
4. Press the CALIBRATE command button. On the popup, choose whether to create a New Calibration or update a Previous Calibration by selecting one of the options.
    a. For a New Calibration, press RENAME to change the name of the calibration file.
5. Press START CALIBRATION.

The process will first de-gauss the magnet poles by running a 'True Zero' operation. Next, it will step the magnet through several current levels while measuring the field strength. This process may take several minutes. Press CANCEL at any time to stop the process.

After the calibration routine is completed, the new calibration will automatically be applied. The scale of the slider gauge will adjust to the limits of the new configuration along with the value for the maximum field.

Section 6 - Maintenance & Troubleshooting

6.1 Care & Maintenance Procedures

⚠ WARNING

Risk of serious injury due to coolant exposure

The coolant consists of Koolance low electrical conductivity liquid coolant. The coolant contains propylene glycol.

- Coolant may cause serious irritation to the eyes and skin. Wear protective gloves, clothing, and eye protection when handling coolant.
  - In case of skin contact: Remove contaminated clothing. Rinse and wash the area thoroughly with soap and water for at least 20 minutes.
  - In case of eye contact: Rinse continually with water for several minutes. Remove contact lenses if present and easy to do so. Continue rinsing for at least 20 minutes.
  - If skin or eye irritation persists, seek medical attention immediately.
- Coolant may be harmful if swallowed. If ingested, rinse mouth with water and seek medical attention immediately.

Refer to the Koolance LIQ-705 Coolant Fluid Safety Data Sheet for complete safety information.

⚠ WARNING

High voltage: danger of electric shock

When adding or draining coolant, ensure the power supply is off.

- Toggle the power switch on the back of the power supply unit OFF (o).

NOTICE

Proper storage/disposal of coolant required

Follow local regulations for proper disposal methods. Do not dispose of down the sink or in the environment.

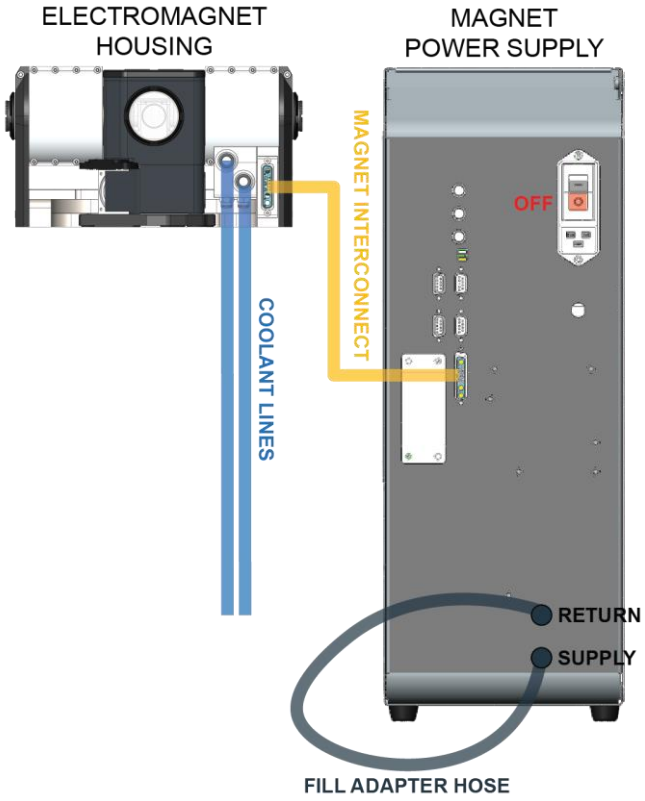
6.1.1 Adding Coolant to the Reservoir

The system will ship without coolant in the power supply. The provided coolant will need to be added to the reservoir before connecting the coolant lines and powering on the unit.

1. Turn the power supply off by toggling the power switch on the back of the back of the unit OFF (o).
2. Unscrew the fill port pressure relief cap at the top front of the power supply.
3. Attach the provided filling adapter hose (short hose with two female ends) to the `COOLANT SUPPLY` and `COOLANT RETURN` locations on the back of the power supply.

The orientation of the filling adapter hose is not important. This adapter will reduce the amount of air through the lines during the initial fill of the power supply.

Pressure relief cap / fill port



Adapter hose connected to supply and return

4. With the power to the power supply switched off, fill coolant using the fill port on the front of the power supply. Fill coolant until the coolant level indicator is in the blue region.
5. Next, turn on the power supply by toggling the power switch on the back of the unit ON (|). The coolant level should drop slightly.
6. Tilt the power supply back and forth gently to help move the coolant through the filling adapter hose.

Keep the power supply on for at least one minute to circulate the coolant and remove air from the power supply. Repeat tilting step as necessary.

7. After approximately one minute, turn the power supply off again by toggling the power switch on the back of the back of the unit OFF (o).
8. Remove the filling adapter hose and replace with the coolant lines that run to the electromagnet housing assembly. Verify the `MAGNET INTERCONNECT` cable is also connected to ensure that the electromagnet housing has an established ground. Refer to *Connecting System Cables and Power on page 20* for instructions.

9. Once the lines and cables are connected, turn the power supply back on by toggling the power switch on the back of the unit ON (|). The coolant level will drop substantially as the coolant lines and magnet fill.

Keep the power supply on for at least one minute to circulate the coolant and remove air from the lines.

10. After approximately one minute, turn the power supply off again by toggling the power switch on the back of the back of the unit OFF (o).
11. With the power switch off, fill coolant again using the fill port on the front of the power supply. Fill coolant until the coolant level indicator is in the blue region. Do not fill past the top blue line.
12. Once full, replace the fill port pressure relief cap.

The power supply is now ready for use. Store the coolant and filling attachments in case this procedure needs to be repeated in the future.

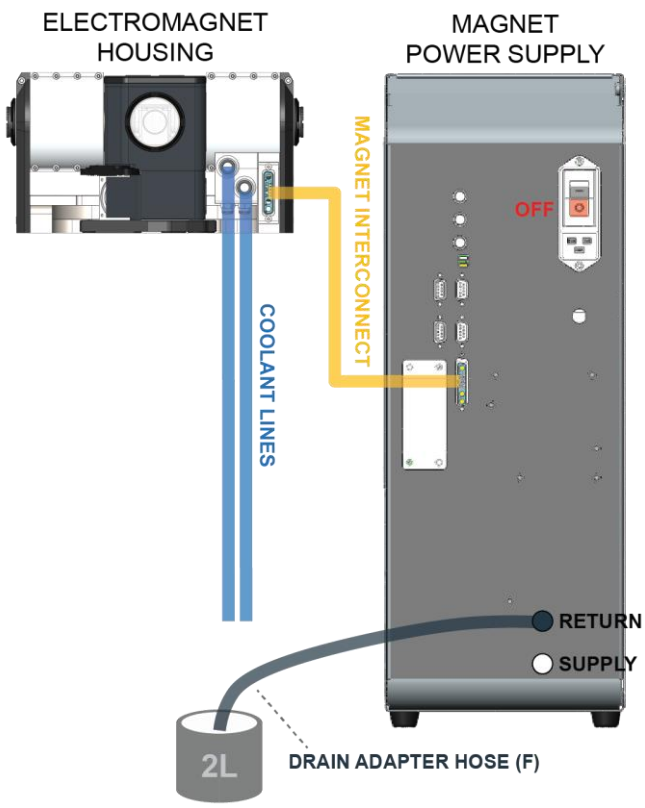
6.1.2 Coolant Drain Procedure

The magnet and power supply must be drained of coolant for long-term storage or if the unit ever needs to be transported or shipped. Supplies needed for this procedure:

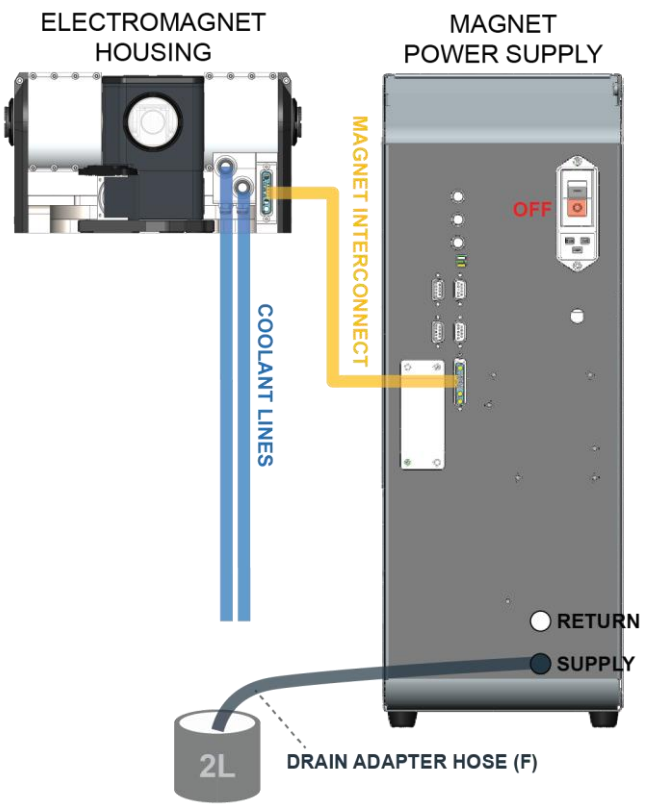
- Drain adapter hoses (two short hoses with open ends) and nitrogen adapter from the Magneto-Optic accessory kit
- Two liquid storage vessels with 2-liter (minimum) capacity each
- 2-liters of distilled water

Part 1: Gravity Drain

1. Turn the power supply off by toggling the power switch on the back of the back of the unit OFF (o).
2. Disconnect the coolant lines from the back of the power supply.
3. Locate the open-ended drain adapter hose with female connector.
    a. Place the open end of the hose into a liquid storage vessel. Hold or fasten into place (a partner can assist with this step).
    b. Attach the female connector to the `COOLANT RETURN` location on the back of the power supply. The coolant will start to slowly drain into the vessel.
4. To drain as much coolant as possible, lower the end of the hose and vessel below the fitting.
    a. Unscrew the fill port pressure relief cap at the top front of the power supply to allow air to flow through the unit for a faster gravity drain.
    b. If needed, tip the power supply 15 degrees backwards to help move the coolant through the lines.



Gravity drain on return connection



Gravity drain on supply connection

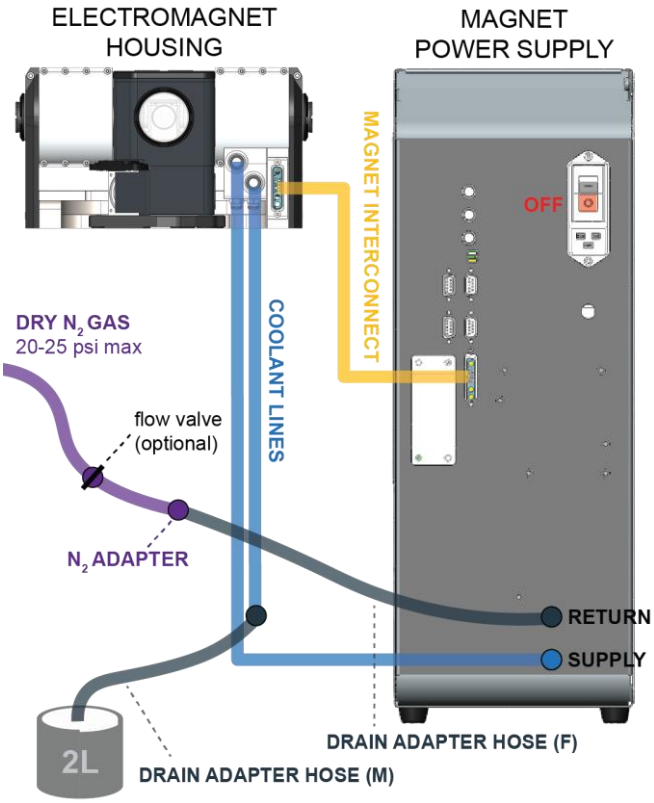
5. When most of the coolant is drained from the reservoir, disconnect the drain adapter hose.
6. Repeat steps 3-5 for the `COOLANT SUPPLY` connection.
7. Verify that the coolant level indicator on the front panel reads empty. Then, disconnect the drain adapter hose and replace the fill port pressure relief cap.

Part 2: Nitrogen Flush

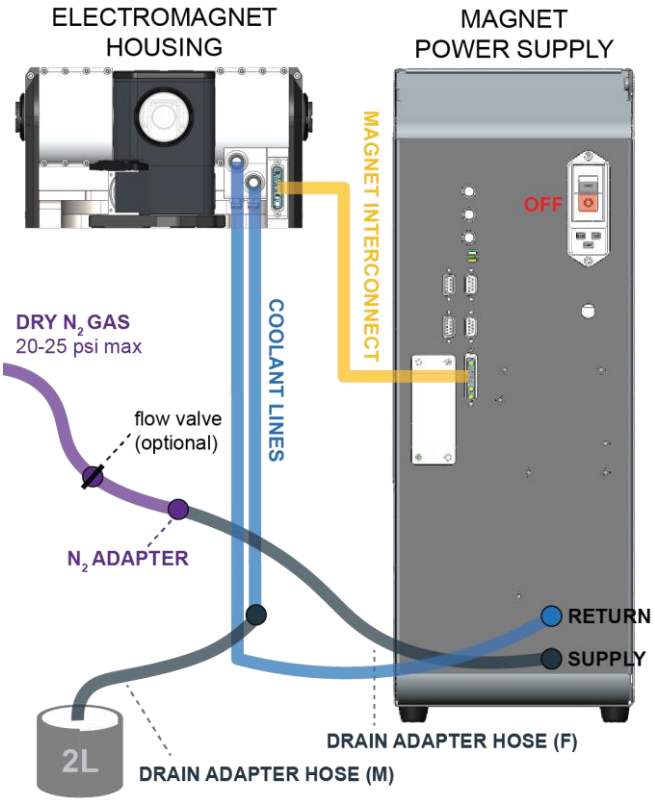
8. Reconnect all cables and coolant lines per the instructions on *Connecting System Cables and Power on page 20*.
    a. Ensure the fill port pressure relief cap is closed.
    b. Ensure the power switch on the back of the power supply is OFF (o).
9. Disconnect the coolant return line from the `COOLANT RETURN` location on the back of the power supply.
10. Locate the open-ended drain adapter hose with male connector.
    a. Place the open end of the hose into a liquid storage vessel. Hold or fasten into place (a partner can assist with this step).
    b. Attach the male connector to the female end of the coolant return line. The coolant will start to slowly drain into the vessel.
11. Locate the open-ended drain adapter hose with female connector and the nitrogen adapter.
    a. Connect the nitrogen adapter to the open end of this adapter hose.

b. Connect the female connector of the drain adapter hose to the `COOLANT RETURN` location on the back of the power supply. Connect the other end to a nitrogen source via the adapter. **Ensure the nitrogen source is off before connecting.**
c. If available, place a flow adjustment valve between the nitrogen source and nitrogen adapter. The valve should be closed when installing.

12. With the open-ended drain hose held securely in the storage vessel, slowly open the nitrogen tank up to 20-25 psi until coolant begins to drain. **Do not overpressure the system!**
    a. If using a flow adjustment valve, set the nitrogen tank pressure to 20-25 psi then slowly open the flow valve until coolant begins to drain.
13. Leave the nitrogen on until most of the coolant has drained and nitrogen is the primary substance coming through the hose. Then, turn off the flow valve and nitrogen supply.



Nitrogen flush first orientation

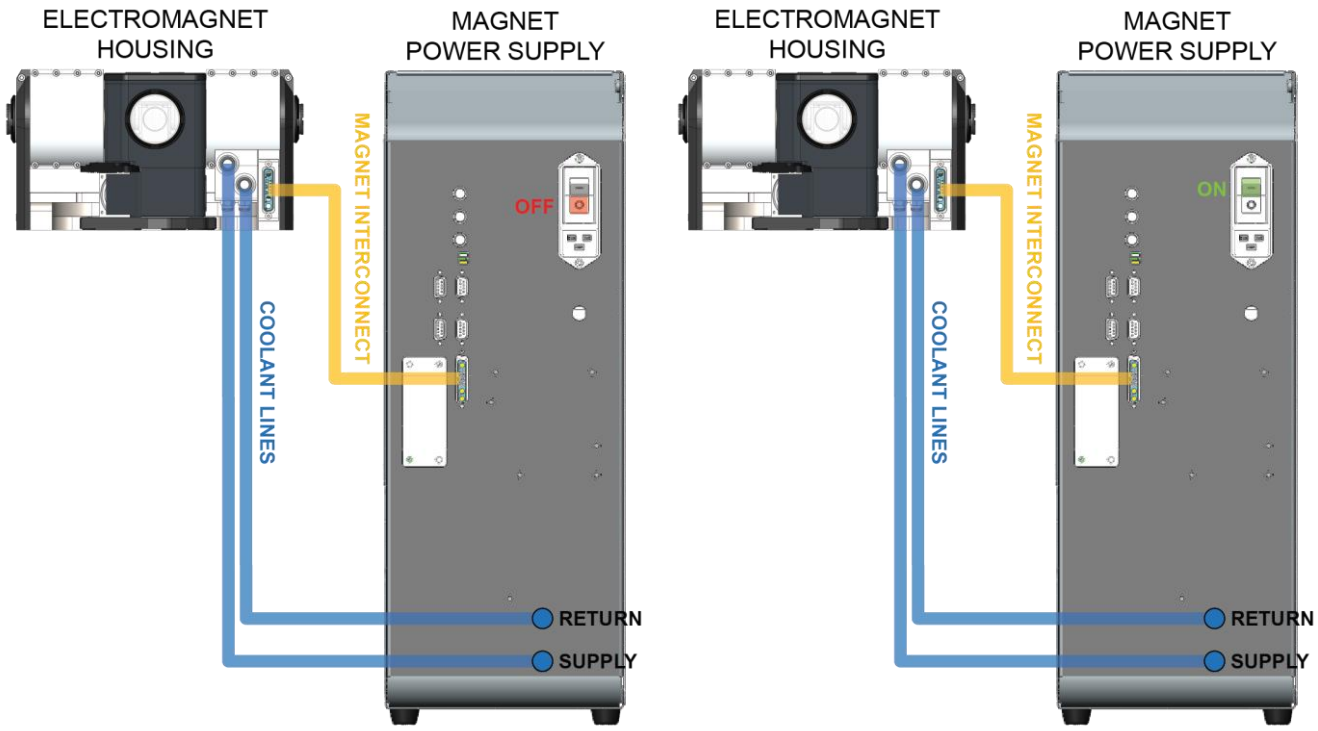


Nitrogen flush swapped lines

14. Swap the two connections on the back of the power supply.
    a. Disconnect the coolant supply line from the `COOLANT SUPPLY` location on the back of the power supply.
    b. Disconnect the female drain adapter hose (the one with the nitrogen source) from the `COOLANT RETURN` location on the back of the power supply.
    c. Reconnect each to the alternate location.
15. With the connections swapped, repeat steps 12-13 to drain the remaining coolant.

Part 3: Distilled Water Flush

16. Disconnect both adapter hoses. Then, reconnect the supply and return coolant lines to the `COOLANT SUPPLY` and `COOLANT RETURN` locations on the back of the power supply.
17. Unscrew the fill port pressure relief cap at the top front of the power supply. Fill the reservoir with 1-liter of distilled water and replace the cap.
18. Next, turn on the power supply by toggling the power switch on the back of the unit ON (|).



OFF when filling *ON to circulate*

Keep the power supply on for at least one minute to circulate the water. This will help to remove any coolant inside the lines.

19. After approximately one minute, turn the power supply off again by toggling the power switch on the back of the back of the unit OFF (o).

Repeat

To complete the drain procedure and completely clean the lines to prepare the system for shipping or storage, the steps above need to be completed multiple times.

- **First Time:** Complete parts 1-3 (steps 1-19) to drain the system of original coolant and flush with distilled water.
- **Second Time:** Complete parts 1-3 (steps 1-19) to drain the system of the water then flush one more time with clean, distilled water.
- **Third Time:** Complete only parts 1-2 (steps 1-15) one final time to drain the system of the second round of distilled water.

NOTICE

Use new storage vessel for the second and third flush
If you would like to save and re-use the original coolant drained during the first flush, use a different storage vessel for the second and third flush when the drained substance is primarily distilled water.
Coolant and contaminated water require proper disposal
Dispose of all drained substances per local regulations.

When completed, remove all coolant lines, adapter hoses, and other cables. The system is now ready for shipping or storage.

6.2 Diagnostics & Troubleshooting

6.2.1 Magnet Errors

Safe Mode

The magnet power supply is actively cooled using a chiller. If any errors are detected with the cooling system during operation, the magnet will automatically enter a 'Safe Mode' to prevent damage to the system. In this mode, the magnet is set to the `DISABLED` state in the software and the power electronics are also disabled. The fans and pump will continue to operate in order to cool the magnet.

The condition which triggered the fault will typically be displayed in a popup in the UI and can also be found under `MENU > EVENT LOG`.

Once the fault has been resolved, re-enable the magnet to resume normal operation.

1. In the UI for the `CRYOSTATION` instrument, navigate to `MAGNET` display screen.
2. Set the Magnetic Field back to `ENABLED`.

6.2.2 Magnet Diagnostics

Over Temperature Condition

If the electromagnet reaches or exceeds 60°C, the system will show an over temperature error and enter Safe Mode. If this error occurs, please check the following:

1. Check the coolant level indicator on the front panel of the power supply to ensure the fluid is in the blue region. Coolant will need to be added if the level falls into the orange region. See *Adding Coolant to the Reservoir on page 30* for instructions.
2. When the power supply is on, ensure that the fans are running. If they are not functioning, there may be a blown fuse. Contact service for further instructions.
3. The power supply radiator may need to be cleaned. Contact service for further instructions.
4. Coolant may not be circulating properly. Contact service for instructions on how to check for this condition.

If there are any other issues with the Magneto-Optic option, please contact an authorized service representative.

Section 7 - Appendices

7.1 Related Documentation

For a copy of associated documentation, see below:

Document Number	Document Title	Location
4100-DOC001	System User Manual: Cryostation s-series	www.montanainstruments.com/library/files/4100-DOC001.pdf
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

Refer to the associated product manuals listed below for important operating instructions and safety information on provided third-party components.

Original Manufacturer	Document Title	Location
Koolance	Safety Data Sheet: LIQ-705 Coolant Fluid	https://koolance.com/files/products/manuals/safety_data_sheet_koolance_liq-705.pdf

7.1.1 Declarations of Conformity

See next page(s)

MONTANA INSTRUMENTS

CE

EC Declaration of Conformity

We,

Montana Instruments Corporation
101 Evergreen Drive
Bozeman, MT 59715 USA

declare under our sole responsibility that the product,

Magneto-Optic Module Option
Model No.: 4101-122

manufactured by,

Montana Instruments Corporation
101 Evergreen Drive
Bozeman, MT 59715 USA

,to which this Declaration relates, is in conformity with the provisions of the European Commission Directives, listed below, including the latest amendments, as shown in the attached Test Reports.

2014/30/EU - *Electromagnetic Compatibility*

- **EN61326-1: 2013** ***EMC Requirements - Measurement/Control/Laboratory Equipment***
  - -EN55011 Class A Group 1 *Radiated/Conducted Emissions*
  - -IEC61000-4-2 *Electrostatic Discharge Immunity*
  - -IEC61000-4-3 *Radiated, RF, Electromagnetic Immunity*
  - -IEC61000-4-4 *Electrical Fast Transient/Burst Immunity*
  - -IEC61000-4-5 *Surge Immunity*
  - -IEC61000-4-6 *Conducted Immunity*
  - -IEC61000-4-8 *Power Frequency Magnetic Field Immunity*
  - -IEC61000-4-11 *Voltage Dips/Interruptions/Variations Immunity*
- **EN61000-3-2: 2014** ***Harmonic Current Emissions Limits***
- **EN61000-3-3: 2013** ***Voltage Fluctuations/Flicker Limits***

2014/35/EU - *Low Voltage Directive*

- **EN61010-1: 2010** ***Safety Requirements - Measurement/Control/Laboratory Equipment***

Presumption of conformity is based on the application of the harmonized standards and, when applicable or required, a European Community notified body certifications, as shown in the attached Test Reports.

(signature)

TIMOTHY JOHNSON
(name – printed)

8/14/2018
(date of issue)

CE COMPLIANCE OFFICER
(function name – printed)

Notes