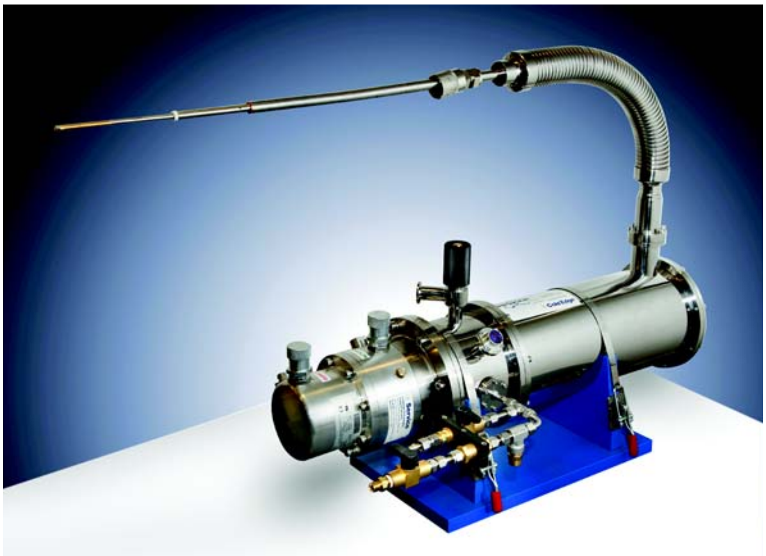
Stinger®
User's Guide



Cold Edge TECHNOLOGIES

ColdEdge
STINGER®
USER'S GUIDE

ColdEdge Technologies Inc.
Allentown, PA USA

Manual Version 1.0 December 2020

ColdEdge Stinger User's Guide:
Manual Version 1.0

This manual is part of the original documentation for the ColdEdge Stinger.

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Preface 0

ColdEdge Technologies strives to supply you with instructional and accurate documentation. We encourage you to tell us how we are doing. Please send us your suggestions for improvements, corrections, or bug reports. If there is anything you particularly liked, tell us as well. With your input and assistance, ColdEdge can continually improve its products and documentation.

You can send your messages and correspondence via e-mail, FAX, telephone, or mail. It is important to include the document name, product name, version number, and page number in your response. Here are the addresses and numbers to which you can send your messages.

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ColdEdge Technologies Inc.
905 Harrison St. Suite 146
Allentown, PA 18103 USA

Thank you for your help.

Electrical Safety 0.1

Do not remove any of the protective covers or panels of the instrument. They are fitted to protect you and should be opened by qualified service personnel only.

Power off the instrument and disconnect the line cord before starting any cleaning work in the spectrometer. Never operate the instrument with the grounding cord disconnected or bypassed. Facility wiring must include a properly grounded power receptacle.

All electrical connections must be carried out by competent personnel in accordance with current local electrical wiring regulations.

Chemical Safety 0.2

Individuals working with hazardous chemicals, toxic substances, or enclosed liquid samples must take every precaution possible to avoid exposure to these agents. As a general rule, THINK OF THE CHEMICAL LABORATORY AS A HAZARDOUS ENVIRONMENT IN WHICH YOU MUST CONTINUALLY MAINTAIN A HIGH STANDARD OF VIGILANCE. Do not assume a cavalier attitude -- the substances with which you work present very real, and very serious threats to your health and safety. Adhere to all currently recommended guidelines for standard laboratory safety as promulgated by governmental codes and contemporary laboratory practice. Inform yourself about the specific risks that are present when you handle actual or potential carcinogens (cancer-causing agents), explosive materials, strong acids, or any liquids that are sealed in glass containers.

Specifically:

- Be extremely careful when you handle sealed glass samples that are rapidly heated or cooled. The rapid cooling of some samples may result in the formation of a solid bolus in the sample tube that may make the tube prone to explosive rupture.
- Educate yourself about the temperature at which chemicals evaporate. When a sample gets close to the temperature at which it evaporates, it may quickly become volatile.
- In general, the safety threat posed by flying glass and violently escaping gases and liquids should not be underestimated.
- Wear safety glasses, face masks, and other protective clothing whenever there is any risk of spillage, breakage, or explosion. Protective shields should also be employed when there is any risk of explosion.
- Be sure that both storage and working areas are properly ventilated. They should be equipped with powerful blowers and fume heads.
- Store chemicals safely. Avoid integrating containers of chemicals that may result in dangerous combinations.
- Practice good housekeeping in work and storage areas. Clean up spills and refuse promptly. Do not leave volatile, combustible, or acidic liquids exposed on counters, benches, or other work areas.
- Make certain all chemical containers are properly labeled and classified, and that especially hazardous materials are appropriately designated with clearly understood decals or warnings.
- Never taste or inhale unmarked chemicals.
- All laboratories should be equipped with fire doors, fire extinguishers, fire smothering materials, and sprinkler systems or showers, as well as a detailed fire safety plan.

Cryogenic Safety 0.3

Cryogenic liquids are typically liquefied gases condensed to their liquid state at very low temperatures; their boiling points are below -238° F (-150° C) . Different cryogens become liquids under different conditions of temperature and pressure, but all have two common properties: they are extremely cold and small amounts of the liquid can expand into very large volumes of gas.

- Contact with skin can cause frostbite or burns. Wear loose fitting cryogenic gloves when handling liquids. Closed-tow shoes or boots and long pants should be worn.
- Provide adequate ventilation as evaporating liquids can displace oxygen and create a risk of asphyxiation

- Soft and flexible objects become hard and brittle and may crack with sharp edges that can cut or otherwise pose risk of injury

Cryogenic liquids should not be stored in sealed containers as evaporating gas can potentially build to explosive pressuresy

Introduction 1

This user’s guide for the ColdEdge Stinger® is meant to be a general guide for using the Stinger® with a compatible cryostat and/or superconducting magnet system. Users are encouraged to explore the *Additional Information* for details about the operation of the coldhead, compressors and gas lines.

Using the Stinger User’s Guide 1.1

How to Find Things 1.1.1

Preface First, you should read the safety guide in the preface of the manual. Microwaves can be dangerous, particularly to your eyes. Cryogenic liquids can cause frostbite or burns. Superconducting magnets can attract items with surprising strength. With normal precautions, the risk for injury can be minimized.

Chapter 2 Users are given a brief introduction to the basic principles of operation of the Stinger®

Chapter 3 Installation of the Stinger® and interfacing the Stinger® to the Cryostat

Chapter 4 Operation of the Stinger®

Chapter 5 Maintenance and Troubleshooting

Chapter 6 Additional Information

Fonts 1.1.2

Special fonts are used in the text to differentiate between normal manual text and the text displayed in the program.

Times This is the font used for the normal text in the manual.

Helvetica This is the font used for text that is displayed by the program or must be entered into the program by you.

Special notes 1.1.3

Some special notation is employed in this manual to simplify the descriptions.

< ... > The content between the brackets needs to be substituted with proper entries by the user.

> The right bracket indicates sequential selection of the button entries. For example, <Output Setting> <nnn> > Enter means pressing the Output setting button, followed by entering the desired value, and then pressing Enter.

Warning

You will see a warning box sometimes in the lefthand margin. These are meant to point out critical information. In particular, it warns you about any procedures or operations that may be dangerous to the spectrometer or you.

Electrical Warning

Always read and follow this advice.

Hint box.

In addition, there are also hint boxes in the lefthand margin These are meant to be helpful hints and point out important information.

In between the special notes previously mentioned are important issues of which you should make note. These are presented in take note boxes.

Take note box.

The Stinger® 2

The Stinger® is a completely closed cycle cryogenic cooling engine for the laboratory environment to run multiple types of cryostats. This new cryogenic cooling technology is designed for direct replacement of older liquid transfer cooling systems. Instead of replacing the liquid cryogen cryostat, the Stinger® is designed to be compatible with most of them. The versatile Stinger® can be mated to most existing liquid cryogen cryostats with its flexible point of cooling technology. The Stinger® can cover a variety of cryogenic experiments throughout the lab environment.

Depending on the cryocooler employed, the Stinger® can be of 4K or 10K temperature versions. It has a standard 6 foot flexible point of cooling extension. The Stinger® engine employs a cryocooler running on a closed cycle helium compressor to produce a minimum desired temperature. An auxiliary recirculation circuit is used for the flexible point of cooling and is also fully closed cycle. It employs a separate helium compressor which only requires high purity helium gas to replenish the small amount of gas lost during cryostat changes.

The Stinger® is a perfect fit for the laboratory environment that uses cryogenic cooling. It can fit into any application even if space is tight, or it can be adapted to many liquid cryogen cryostats without any disruption of the sample environment. Additional cryostats are available that interface with the Stinger® and are completely interchangeable at significantly lower cost.

Principles of Operation 2.1

The Stinger® uses Gifford McMahon (GM) cooling technology to cool an auxiliary helium gas circuit to liquid cryogen temperatures. The flexible point of cooling bayonet is designed to be inserted into an existing (or alternatively supplied) cryostat, similar to the commonly used liquid cryogen transfer line. The Stinger® employs a high pressure gas driven cryocooler, a compressor and flexible gas lines between the compressor and the cryocooler. This cryocooler generates a very low temperature a heat exchanger which in turn cools the gas from the auxiliary helium circuit. Helium is circulated through the Stinger® and cooled using innovatively designed internal heat exchangers and Joule-Thomson (JT) technology. Components in the auxiliary helium circuit include a recirculator compressor, a gas manifold to regulate helium flow, connecting flexible gas lines between the recirculator compressor and gas manifold and between the gas manifold and the Stinger® cryocooler. Typical cooling time depends on the type of cold head attachment, temperature to be achieved and heat loads. The Stinger® cools down in about 60-75 minutes to minimum temperature with normal loads.

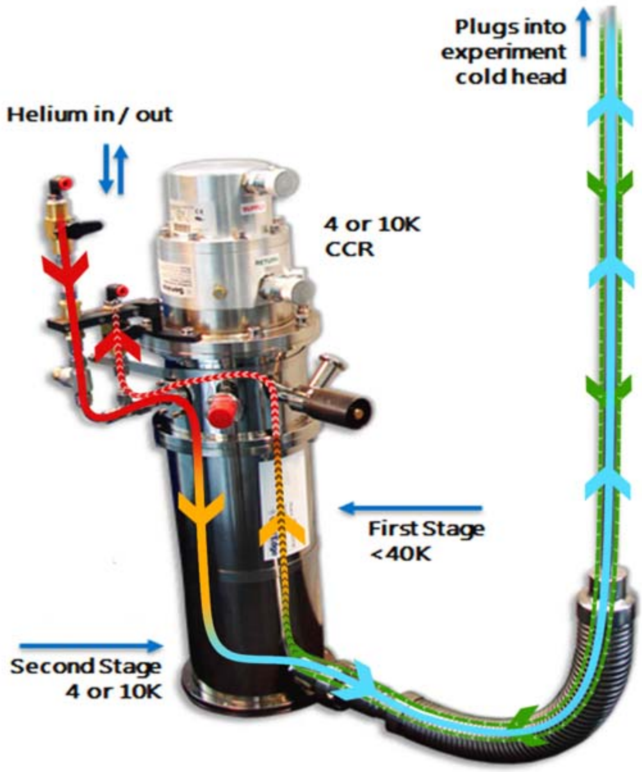

Figure 2-1 Helium recirculated transfer gas pathway.

A gas control manifold is provided to control the recirculated helium while operating. It allows regulation of the supply pressure to optimize the temperature requirements of the experiments. The manifold will also serve in purging and cleaning any contamination introduced into the system during cryostat changes.

A height adjustable carriage or various stands are optionally provided to help maneuver the Stinger® system so the flexible point of cooling and can easily be positioned in the experimental environment

The optional table-top superconducting magnet, cooled by the Stinger, operates at 4.5K while allowing variable temperature to be set in the sample chamber from 4 to 250K.

Additional material from various OEM (Original Equipment Manufacturer) products is included in Chapter 6:

- The 4K or 10K coldhead and description of the functional operation of the Gifford McMahon process.
- The F70L/H Compressor documentation.
- The HC-4E1 Compressor documentation.
- The flexible gas line documentation.
- The Temperature Controller documentation.

Component Description 2.2

Stinger® Cooling Engine 2.2.1

This is a completely closed cycle cryogenic cooling system. It consists of a GM cooler, a compressor to operate the GM cooler, a Recirculator compressor, and industrial flexible hose connections.

- **GM Cooler** – 4K or 10K coldhead used to cool the gas flowing through the heat exchangers and JT technology.
- **Compressor -** Supplies helium gas to operate the GM cooler.
- **Recirculator compressor -** Recirculates gas from the Stinger® to the Cryostat through the flexible point of cooling bayonet, and recovers the gas for complete closed loop operation.

Manifold 2.2.2

A gas manifold is provided to regulate the circulating helium gas as it travels from the Stinger® to the cryostat. It includes a series of valves and ports that isolate the Recirculator compressor during cryostat exchange, allow gas to be added during the purge operation, and allows the cryostat and flexible point of cooling bayonet to be evacuated for the removal of moisture

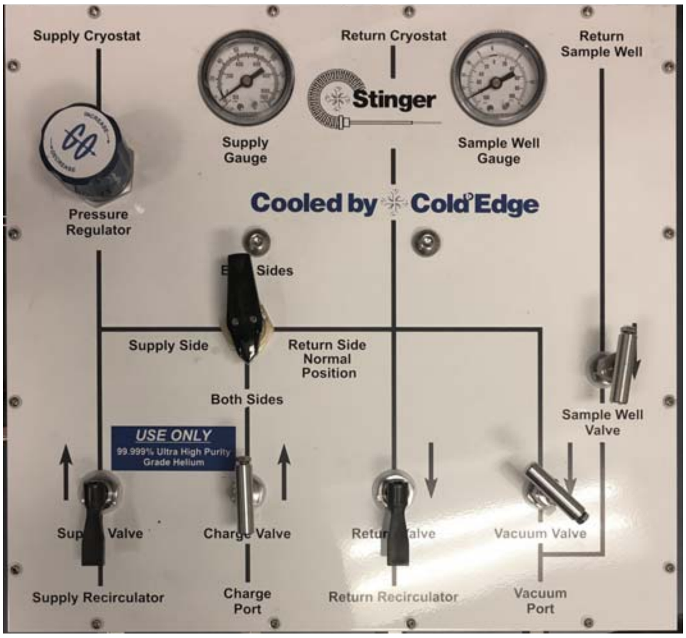

Figure 2-2 Gas Handling Manifold

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Temperature Controller 2.2.3

This electronic unit displays the temperature at various sensors within the Stinger and the attached cryostat and controls the sample temperature. It is necessary to match the controller to the characteristics of the heater contained within the cryostat.

Adjustable Height Carriage 2.2.4

An optional adjustable height carriage is used to transport the Stinger® while making it easy to navigate the flexible point of the cooling bayonet.

Compressor Rack 2.2.5

The optional rack is used to house both the GM cooler compressor and the Recirculator compressor. It provides a common water source between the compressors, and reduces the laboratory footprint.

Heat Exchanger or Chiller 2.2.6

A suitable heat exchanger or chiller is required to provide cooling water to both compressors if suitable cooling water is not available. This can be either a water-to-water heat exchanger or refrigerated chiller.

UHP Helium Gas and Regulator 2.2.7

A cylinder of UHP Helium (99.999% purity, minimum) equipped with a two-stage regulator that regulates 0 - 1,400 kPa (0-200 psi, 0-14 bar) is used to restore helium lost through sample exchange.

Specifications 2.3

Systems

P/N	Product Code	Sample Temperature
		~4 - 300 K (cryostat dependent lower or higher temperatures optional)

Table 2-1 Stinger Specifications

Any orientation of the Stinger is allowed.
The operating pressures for this system are as follows:

- Vacuum pressure: lower than 0.1 Pa (1×10^{-3} mbar, 7.5×10^{-4} torr) starting pressure required.
- Re-circulating pressure: ~690 kPa (~ 100 psi, ~7 bar) starting pressure.The manifold can be regulated for optimization.
- Relief pressure: Manifold has a 1034 kPa (150 psi, 10 bar) relief valve

Installation 3

Unpacking 3.1

The Stinger® components are normally shipped assembled in two heat treated crates when shipped. Below is a table of the packaging size and content for your convenience.

Packaging	Contents
48″ × 48″ × 52″ crate	Includes adjustable height stand and Stinger®
40″ × 24″ × 40″ (inside above crate)	4 K and 10 K Stinger® and temperature controller
28″ × 28″ × 7″ (inside above crate)	¾″ × 10, 20, or 30 ft Helium gas lines, installation wrench kit, CH and compressor power cords, charge/vent adapter
12″ × 12″ × 12″ (inside above crate)	Stinger® accessories and kits
40″ × 48″ × 60″ crate	Compressor rack (F-70 & Re-circulating compressors)
24″ × 24″ × 12″ (inside above crate)	Water lines, re-circulator Helium flex lines (3 & 20 ft)

Table 3-1 Packaging

NOTE: The above packaging is for a standard Stinger® complete system. Please check that all parts are present from factory. Refer to the packing list for an itemized bill of material. If any part is missing, or you are unsure about parts that was sent please contact the service department Techsupport@coldedgetech.com with questions.

Please keep all packaging so that the system can be returned for maintenance

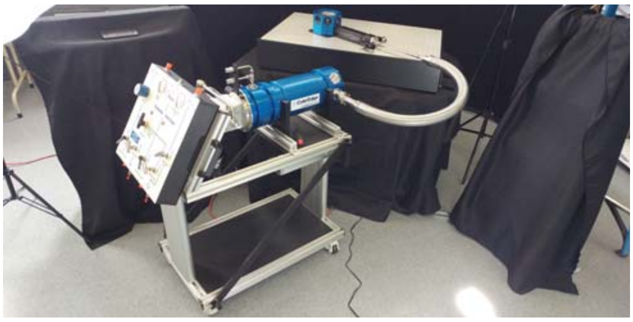

Figure 3-1 Stinger on Adjustable Height Carriage.

or repairs with proper packing requirements. ColdEdge Technology will not be held responsible for damaged shipments if it is not packaged properly.

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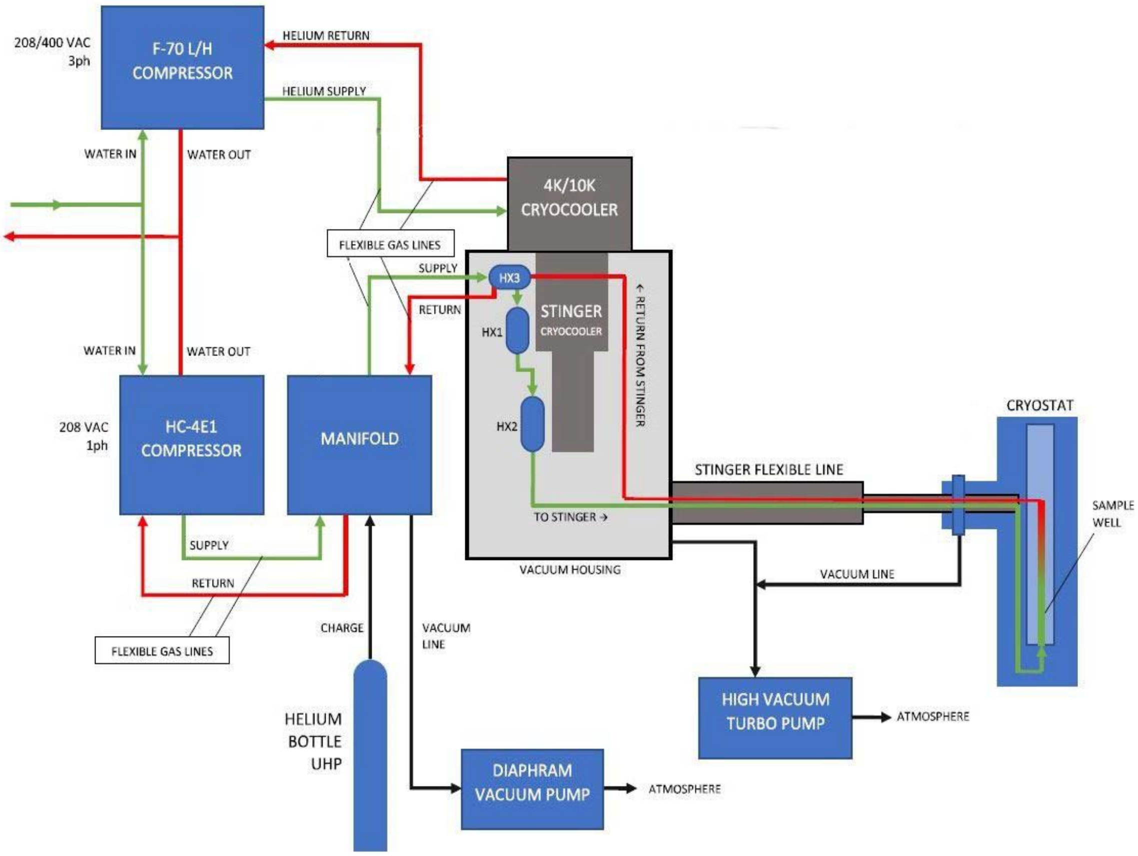

Figure 3-2 Gas Flow Paths in the Stinger

Basic Set-Up 3.2

These are a few very basic steps you need to follow in order to properly set-up the Stinger®

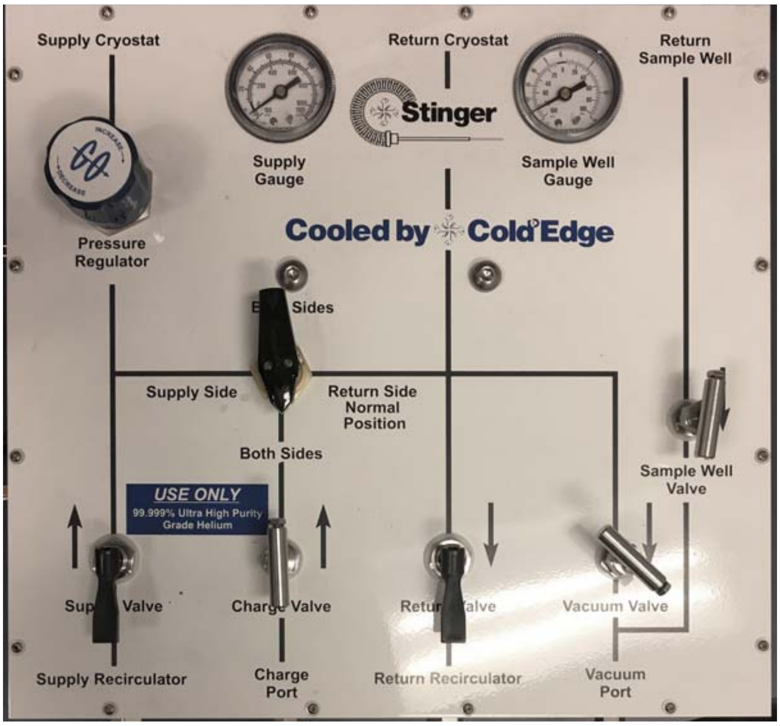

Figure 3-3 Gas Handling Manifold.

1. Mount the gas manifold onto the support stand.
2. Mount the Stinger® to the support stand using the clamps provided with the stand.

   Stinger® gas line connections Supply/Return should be facing towards the back of the gas manifold so that they can easily be mounted to the manifold.
3. Mount the cryostat securely to the table or chamber.
4. Connect helium flex lines to the gas manifold and re-circulating compressor.

- Connect 20 ft (6 m) helium flex line between the re-circulating compressor Supply connection and gas manifold Supply Recirculator connection.
- Connect 20 ft (6 m) helium flex line between the re-circulating compressor Return connection and gas manifold Return Recirculator connection.
- Connect 5 ft (1.5 m) helium flex line between the gas manifold Supply Cryostat connection and Supply connection on the Stinger®.

Supply & Return Valves CLOSED!

- Supply & Return Valves on the manifold should be CLOSED whenever the Stinger® is not operating. This includes during the installation process. Failure to do so can result in loss of helium gas.

Figure 3-4 Supply and Return Valves in CLOSED Position

Electrical Warning

5. Follow the cryocooler's manual for instructions on how to install the cold head, compressor, gas lines, and make all necessary electrical connections.

   Make sure that you are properly following the electrical specifications for the compressor. Also, follow all of your research facility's safety instructions when working with electrical components to avoid electrical shock

   Connect oil-less (GAST) pump to Vacuum Port using 6 mm diameter flexible tubing. This will be used to evacuate the cryostat once the flexible point of cooling bayonet is inserted.

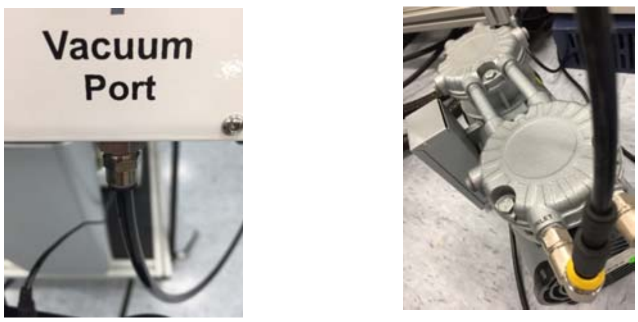

Figure 3-5 Connecting the manifold with GAST pump.

6. Connect helium (99.999% UltraPure) to Charge Port using 6 mm diameter tubing.

This will be used to charge/purge the cryostat once the flexible point of cooling bayonet is inserted. You can also top off the re-circulator if it loses gas.

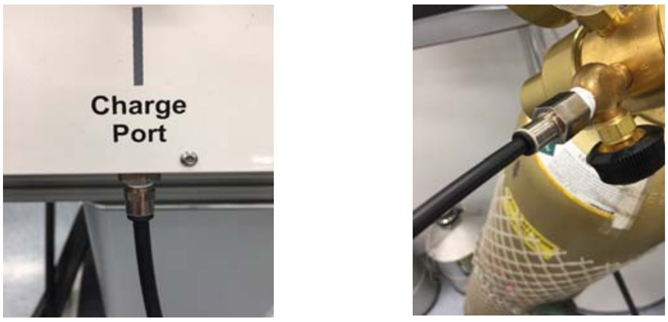

Figure 3-6 Connecting the manifold with helium cylinder.

Turbo-pump
REQUIRED!.

7. Connect the vacuum pump to the NW25 port on the Stinger and cryostat, turn the pump on and begin evacuating the vacuum shroud.

   This system should be run with a turbo molecular pump ONLY

8. Remove the shipping sleeve from the flexible point of cooling bayonet. The system is shipped under vacuum, so you may need to release the vacuum pressure to pull off the sleeve

Figure 3-7 Removing the shipping sleeve.

9. If not already in place, attach the Teflon seal (bushing) to the bayonet before inserting. This will seal off the supply flow from the return flow. The system will notcool optimally without this seal.

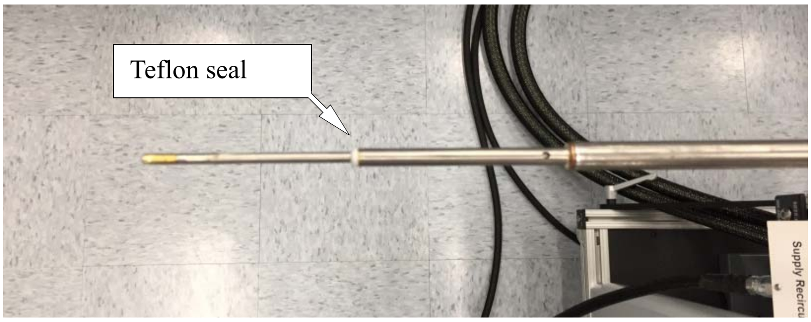

Figure 3-8 Teflon seal on bayonet

Make sure the cryostat clamp is attached to the bayonet before inserting. This clamp will make the leak tight seal between the Stinger® and the cryostat.

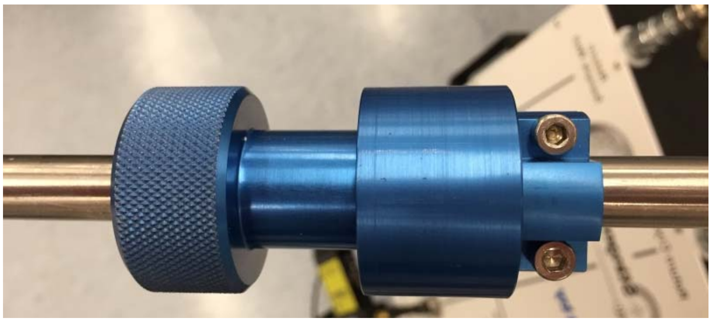

Figure 3-9 Cryostat clamp attached to the bayonet.

10. Insert flexible point of cooling bayonet into the cryostat.

Make sure the Stinger® bayonet is completely inserted. The cryostat determines how far the bayonet will get inserted. Loosen the cap screws and slide the clamp onto the bayonet. Insert the bayonet into the cryostat. Slide the clamp forward and engage the threads on the cryostat so that about half are visible. Tighten the cap screws and then rotate the end to fully tighten the clamp. This will lock the bayonet into position.

Figure 3-10 Bayonet inserted into cryostat

11. Connect 19-Pin Sensor Instrumentation on the Stinger to the temperature display. Configure temperature display. This sensor is a DT-670 Diode.

Figure 3-11 19-pin connector on instrumentation cables.

Consult Section 6 for Temperature Controller Setup.

12. Connect Cryostatt Instrumentation to the temperature controller. . See Section 6.4 for details.

Figure 3-12 Compressor Rack.

NOTE: both 208/480V 3-phase and 208V single phase connections are needed.

13. Connect the F70 main compressor and HC4-E1 Recirculator compressor to the mains supply. Verify that the phase rotation is correct for the 3-phase F70 compressor.

14. Connect the water lines to the optional compressor rack and adjust the flow valve to approximately the 1 o'clock position -- this may require further adjustment to balance the cooling between the two compressors.

Figure 3-13 Water flow balance valve.

Set up Temperature Controller and Display 3.2.1

The Temperature Controller and Temperature Displays should be connected to the magnet sample sensor, heater and additional sensors. Instructions for performing these operations are given in the User's manuals referenced in Section 6.2.

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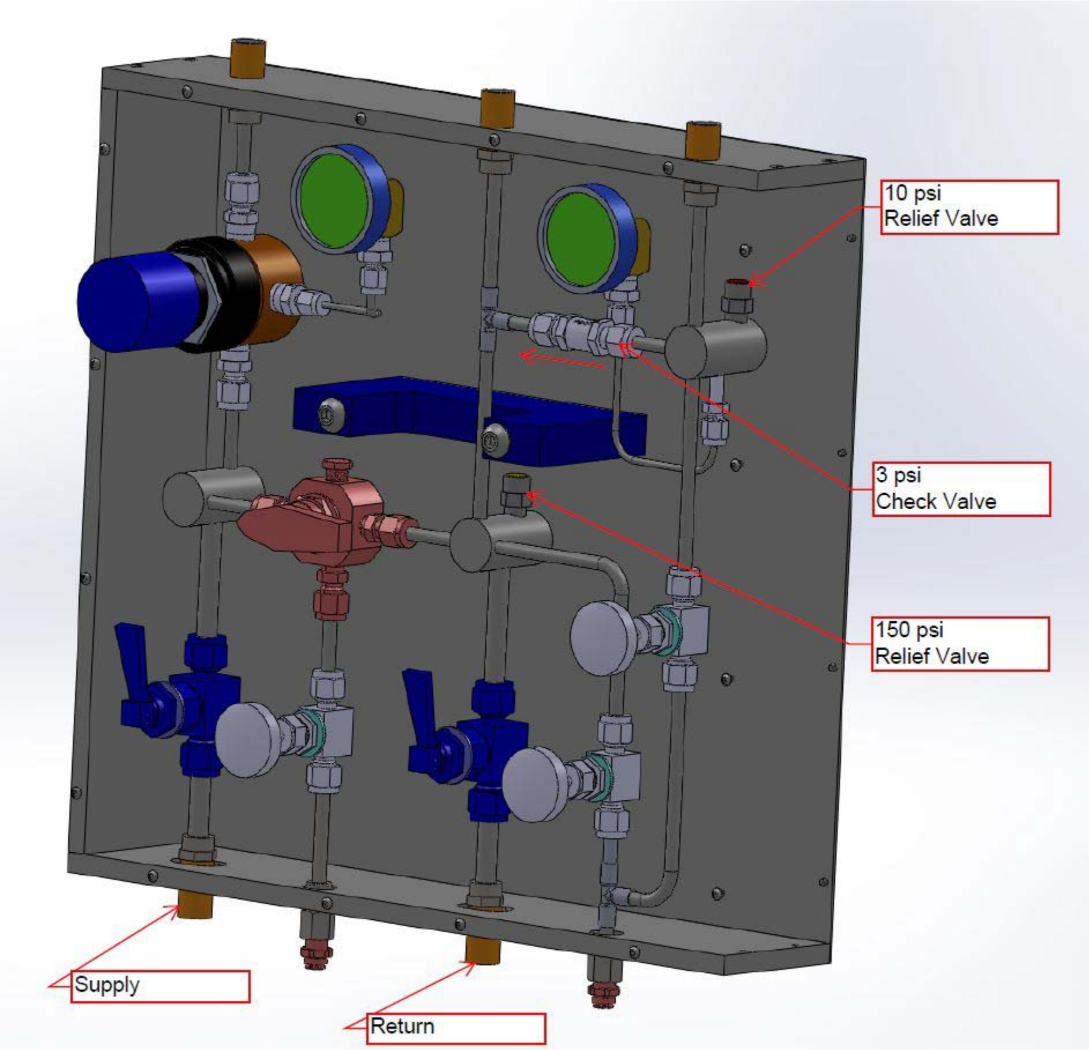


Figure 3-14 Gas Manifold -- Interior

Operation 4

This chapter describes cooling down and warming the system back to room temperature following completion of the experiment

Cooling Down 4.1

With the Stinger® bayonet inserted into the cryostat, make sure that the bayonet is fully inserted such that the Teflon seal (bushing) on the bayonet is firmly engaged inside the cryostat.

1. Turn the vacuum pump ON. Open the valve on the pump, wait for 15 sec, then open the valves on the Stinger and magnet.

   Wait until the pressure reaches ~1 x 10^{-3} Pa (1 x 10^{-5} mbar-, 7.5 x 10^{-6} torr).

2. Do not turn the system on before ~0.1 Pa (1 x 10^{-3} mbar, 7.5 x 10^{-4} torr) of vacuum is achieved. The cool down time will be impacted significantly.

   Checking the system for high vacuum leaks before running the system is also good practice. Spray all joints with iso-Propanol and watch for a spike in vacuum. If spraying iso-Propanol over any joint causes a spike in vacuum you have a small leak. Tighten all bolts around the joint.

3. Turn on the diaphragm pump .
4. Check the transfer gas lines to the Stinger® for leaks.

- Turn the GAST pump ON. Set the Four-way Valve to Both Sides

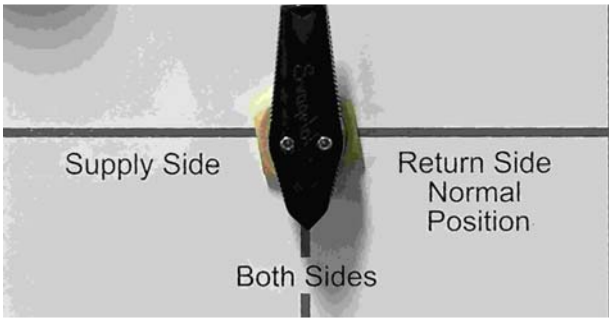


Figure 4-1 Four-way valve set to Both Sides.

Leaks not sealed will cause loss of helium and possible contamination of the transfer helium gas

- Open the the Vacuum Valve.
- Close the Vacuum Valve and observe the Supply Gauge. If the gauge reading is not steady, check for leaks.
- Set the pure helium supply gas regulator to ~50 psi.
- Open the Charge Valve and fill Manifold to ~50 psi.
- Once filled, note pressure on Supply Gauge and close the Charge Valve.
- Wait 30 min. If pressure drops, check for leaks.

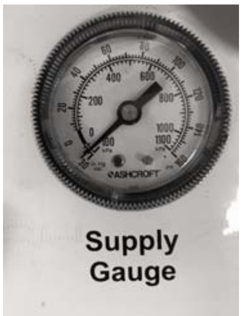


Figure 4-2 Observe the Supply gauge (-85 kPa)

WARNING: Be sure the work area is well ventilated when working with helium or nitrogen. They can cause suffocation.

5. Set the Four Way Valve to Supply.
6. Turn the Regulator fully clockwise.
7. Open the Vacuum Valve . Allow to pump for several hours, preferably overnight, before a run.
8. Purge the system as follows: Open the He tank and set the pressure on the regulator gauge to 70 - 140 kPa (10 - 20 psi, 0.7 - 1.4 bar, ~520 - 1,050 torr).
9. Open the Charge Valve and bring the pressure on the Supply gauge to 10-21 kPa (~100-210 mbar, ~1-3 psi, ~155 Torr)
10. Close the Charge Valve
11. Open the Vacuum Valve
12. Repeat Steps 6-8 several times.
13. Once the purge is done, open the Charge Valve and bring the pressure on the Supply gauge to 10-21kPa (~110-210 mbar, ~1-3 psi, ~155Torr).

Figure 4-3 Setting the pressure on the Supply gauge (10-21 kPa)

14. Switch Four Way Valve to Return Side Normal Position. This is the normal operating position of the Four Way Valve while the system is running.

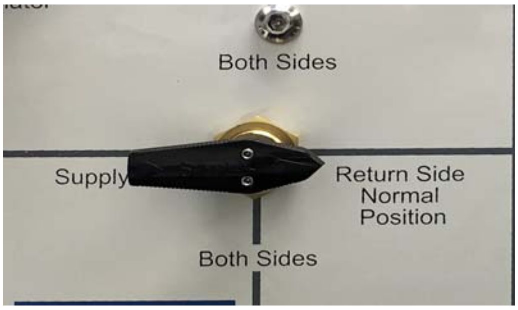


Figure 4-4 Four-Way Valve set to Return Side -- Normal Position.

15. Check the pressure of the re-circulating compressor. It should be ~690 kPa (~ 100 psi, ~ 6.9 bar). If the pressure is low, it will be adjusted in Step 14, below. Turn ON the re-circulating compressor.

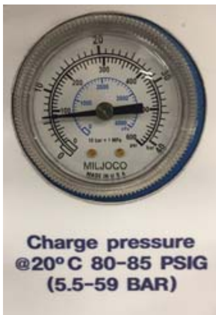


Figure 4-5 Recirculator Charge Pressure.

WARNING:

The Return Valve must always be opened before opening the Supply Valve.

Failure to do so will cause the system to over pressurize and may cause harm to the system.

16. Open the Return Valve.

17. Open the Supply Valve, turn the Pressure Regulator on the manifold and slowly bring the pressure on the Supply Gauge to 690 kPa (100 psi). If necessary, slightly open the Charge Port and allow the pressure to slowly increase to 690 kPa (100 psi)..

Figure 4-6 Supply Gauge 690 kPa (100 psi).

18. Wait for 30 min

19. Turn F-70 compressor ON. The Stinger® will take approximately 60-90 minutes to cool down the Stinger depending on the model (some will take longer, some may require less time).

Temperature Control 4.2

Be sure to read the temperature controller manual and operate accordingly.

Temperature control and sensor type is specific to the cryostat that you are using. Controlling the temperature accurately at the sample will be dependent on the heater power adjustment supplied by the controller, and control of the gas flow.

The temperature monitor does not control the Stinger® temperature; it is provided to display the temperature of the inlet at flexible point of cooling before it enters the cryostat for diagnostic purposes.

Set the Temperature 4.2.1

Set the Temperature Controller to 0 K for start-up, all heaters OFF.

For operation above the base temperature, set the desired temperature using the Control function and enable the auto-PID function if desired. See the LakeShore Operator's Manuals in Section 6.2 for detailed instructions.

Shutting Down Operation 4.3

1. Turn all heaters OFF
2. Open the Regulator by turning fully clockwise
3. Close the Supply toggle valve
4. Wait until gas is pulled back into the HC-4
5. Close the Return toggle valve.
6. Open the Vacuum Valve.
7. Switch the Four-Way Valve to Both Sides.
8. Turn F70 and HC-4 compressors OFF.
9. Turn the supply water and the heat exchanger/water chiller OFF.
10. Leave Cryostat connected and let all warm up (Clean-up mode)

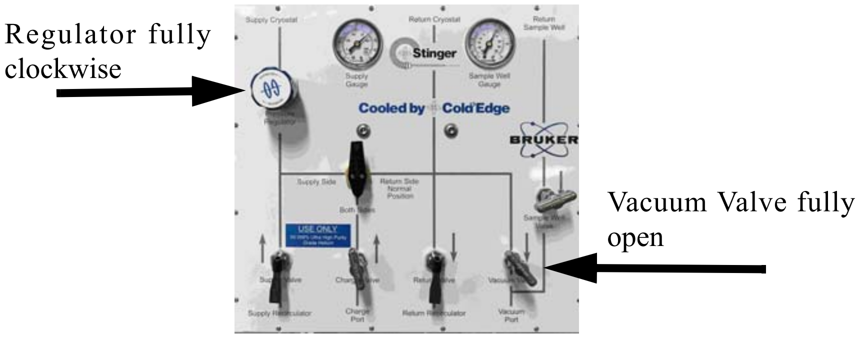


Figure 4-7 Manifold in Shut-Down configuration.

Maintenance 5

Recirculating compressor pressure 5.1

The optimal pressure for the re-circulating compressor should be between ~ 95- 100psi (~ 6.9 bar, ~ 690 kPa). If the pressure falls below these specifications, with the 99.999 % purity helium tank connected to the Charge Port on the manifold, do the following:

1. Set gas cylinder to supply between ~ 70 - 140 kPa (~ 0.7 - 1.4 bar,~ 10 - 20 psi), with all valves initially closed.
2. Switch Four-Way Valve to Return Side Normal Position. This will allow incoming gas from the Charge Port to go through the return side.
3. Turn the regulator on the Manifold to maximum
4. Turn the re-circulating compressor ON.
5. Open Return Valve and wait 30 seconds, open Supply Valve, and then slowly open Charge Valve. This will allow the system to equalize to ~ 580 kPa (~ 5.8 bar, ~ 80 - 85 psi). You can monitor this on the Supply gauge.

Once charge pressure is achieved, close all valves.

Removing blockages 5.2

Capillary blockages may occur if moisture becomes trapped inside the Stinger®. To avoid this, make sure that you are following the purge and evacuation instructions in this manual (Chapter 3). It is also important to understand that the system needs to be kept free of moisture at all times.

If a blockage occurs, allow the system to warm to room temperature. Make sure that the Stinger main body and Oxford cryostat are evacuated properly (vacuum pressure on the pump display is ~ 10E-5 Torr) and purging time is at least 60 min prior cooling down. If clogging persists, please contact your ColdEdge representative

Cold Trap 5.3

Often the only way to prevent blockages due to frozen nitrogen or oxygen is to cold trap the recirculating gas. This is done with a special trap device consisting of a cylinder containing activated charcoal and the appropriate interconnects and a safety overpressure relief valve.

Figure 5-1 Cold Trap

The cold trap is connected to the supply line output from the Recirculator compressor and then through a short gas line to the supply inlet of the manifold. The cold trap cylinder is placed in a dewar of liquid nitrogen and the Recirculator run with the main compressor off for at least one hour (more time may be required depending upon contamination). Then the main compressor can be started and the experimental run proceeding as usual, noting that the operating pressure will be lower as dense gas condenses in the cold trap.

Removing the trap:

1. Shut off Supply on Manifold
2. Wait for supply pressure to reach zero
3. Shut off Return on Manifold
4. Shut off Recriculator compressor
5. Carefully remove Aeroquip fitting from Recirculator supply line to Cold Trap.
6. Carefully remove Aeroquip fitting on small flexlible line from the Manifold.
7. Remove Cold Trap with small flexible line from liquid nitrogen dewar
8. Allow to warm up
9. Before next use, pump out Cold Trap using GAST pump and supplied fitting. Cold Trap may be warmed with heat gun or heating tape during evacuation.

It should not be necessary to use the Cold Trap for each experimental run, if sample changes are done carefully and a positive pressure maintained in the cryostat during sample changes.

Changing a Capillary Tube 5.4

The Stinger system is designed such that difference capillaries can be interchanged to optimize the minimum temperature or capacity of the cold head you are using.

Shown in the picture below, the capillary is removable by unscrewing the brass assembly from the stainless steel rod.

Changing a capillary tube while using the gas manifold 5.4.1

Figure 5-2 Capillary tube replacement.

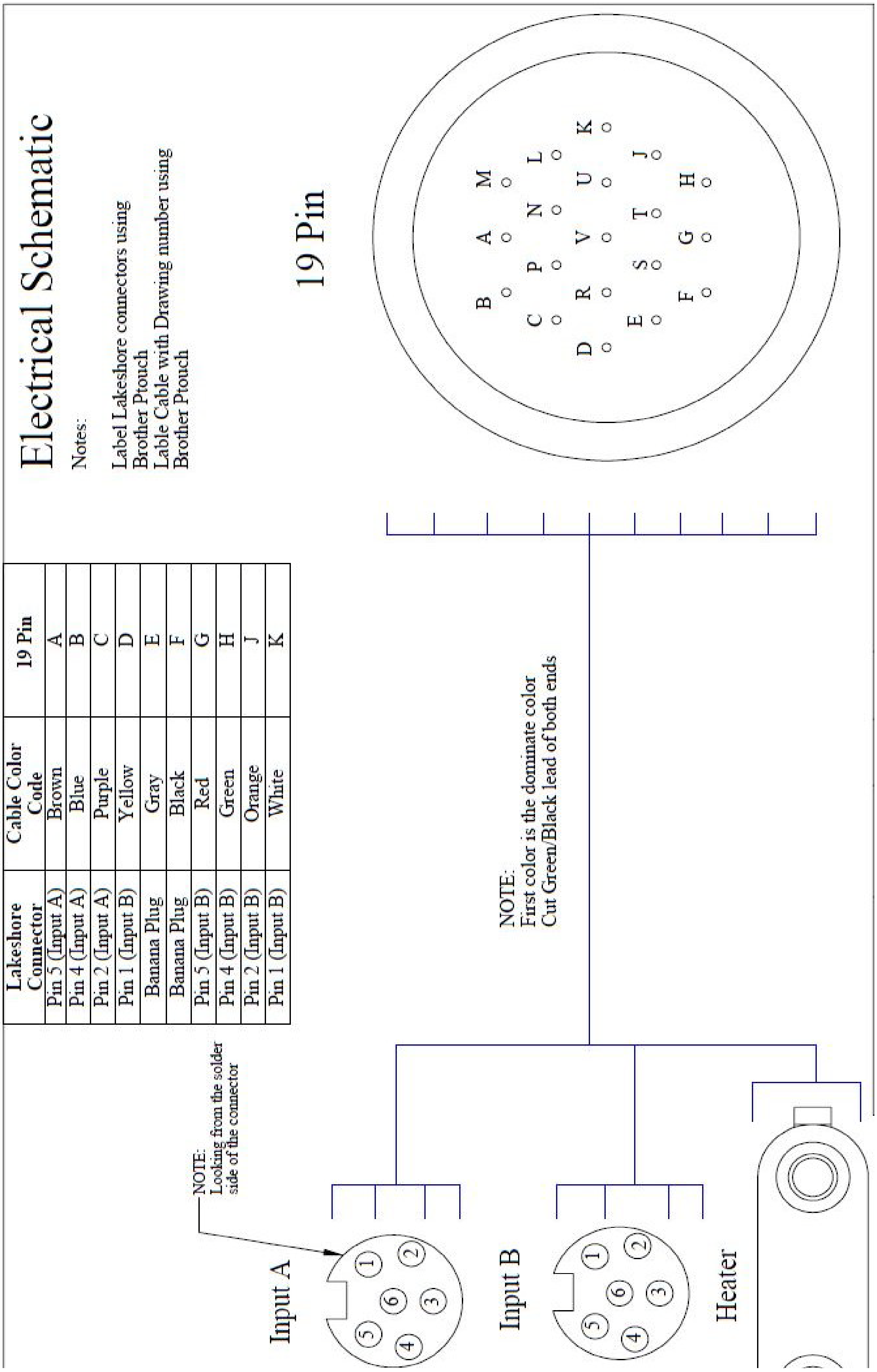
Special wrenches have been provided with the capillary assemblies, and should be used when changing.

The Capillary Housing provides protection for the capillary as the capillary itself is quite small it can easily become bent or broken.

1. Switch Four-Way Valve to Both Sides. This will allow incoming gas from the Charge Port to be pushed through both the supply and return side of the system. When changing the capillary it will ensure that no debris enters the system. Supply and Return Valves on the manifold should be CLOSED.
2. Open Charge Valve slowly and allow a slight purge of helium to flow through the system. The purge should be enough that you can feel it at the capillary assembly, but should not be too much that it blows the capillary out of the system while trying to change it.
3. Use the small piece of indium provided and wrap two times around the bottom base of the threads. The indium should be wrapped in the direction of the thread cuts. This technique is similar to installing pipe tape on threading.
4. Use the wrenches to tighten the brass capillary assembly on the stainless steel rod. The indium should spread out evenly around the joint. You can remove the excess indium with your finger or razor blade.
5. Close Charge Valve and prepare the system for evacuation and purge.

Wiring Diagram 5.5

The wiring diagram for the 19-pin connector is shown below



Lakeshore Connector	Cable Color Code	19 Pin
Pin 5 (Input A)	Brown	A
Pin 4 (Input A)	Blue	B
Pin 2 (Input A)	Purple	C
Pin 1 (Input B)	Yellow	D
Banana Plug	Gray	E
Banana Plug	Black	F
Pin 5 (Input B)	Red	G
Pin 4 (Input B)	Green	H
Pin 2 (Input B)	Orange	J
Pin 1 (Input B)	White	K

Figure 5-3 LakeShore Interface Wiring Diagram

19-Pin Connector Pin Out-Stinger Insert Location

Pins	Connection	Cable Description	Cable Color Code
A	I+	Input A	Blue/Red
B	V+	Sample	Orange/Red
C	V-	Cernox S/N	White
D	I-	____________	Red/Green
E	No Polarity	50 Ohm, 50 W Cartridge Heater	Black
F	No Polarity		Red
G	I+	Input B	White/Red
H	V+	Sample	Blue/White
J	V-	Cernox S/N	Red/White
K	I-	____________	Blue/Black
L	I+	Input C	Orange
M	V+	Sample	Orange/Black
N	V-	Cernox S/N	Black/White
P	I-	____________	Red/Black
R	N/A	Not connected	White/Black
S	N/A	Not connected	Black/Red
T	N/A	Not connected	Blue
U	N/A	Not connected	Green
V	N/A	Not connected	Green/White

Troubleshooting 5.6

Problem	Cause	Corrective Action
Cryostat does not reach minimum temperature	Helium flow is insufficient	690 kPa (100 psi) is required. Verify flow of >= 5 lpm
	Insufficient vacuum	Minimum isolation vacuum of 0.7 Pa (6×10^{-3} mbar, 5×10^{-3} torr) before starting system
	Instrumentation not connected properly	Check connections per manuals. Verify sensor curves and sensor types.

Problem	Cause	Corrective Action
	Sensor not in correct position	Ensure that the sensor is directly placed over the siphon nozzle in the ER 4112HV
	Helium bypassing cryostat capillary	Ensure bayonet is completely inserted into cryostat and Cryostat clamp tightened sufficiently
	Helium bypassing cryostat capillary	Bayonet missing TFE bushing
System not cooling within ~ 1 1/2 hours	Helium purge is insufficient	690 kPa (6.9 bar, 100 psi) required
Shroud icing or sweating	Isolation Vacuum leak	Check centering rings and clamps for tightness. Leak check with isopropanol.
Sensors not reading	Sensors grounded or cables disconnected	Verify that sensor wiring correct

Supplementary Material 6

SHI Cryogenics Manuals 6.1

The following documents from Sumitomo (SHI) Cryogenics are included for reference:

266404A RDK408 RDK415 Cold Head Technical Manual 6.1.1

This manual is attached to the documentation memory device.

267472A F70H-L- Operating Manual Rev02 6.1.2

This manual is attached to the documentation memory device.

267318A HC-4E1 Technical Manual Rev02 6.1.3

This manual is attached to the documentation memory device.

261320A Gas Lines Technical Manual 6.1.4

This manual is attached to the documentation memory device.

LakeShore Manuals 6.2

The following documents from LakeShore are referenced below:

LakeShore 335 Temperature Controller Manual 6.2.1

The complete LakeShore 335 Temperature Controller Manual can be found at:

https://www.lakeshore.com/docs/default-source/product-downloads/335_manual.pdf?sfvrsn=9f5c5b7f_7

LakeShore 336 Temperature Controller Manual 6.2.2

The complete LakeShore 336 Temperature Controller Manual can be found at:

https://www.lakeshore.com/docs/default-source/product-downloads/336_manual.pdf?sfvrsn=fa4e3a80_5.

GAST Pump Manual 6.3

This manual is attached to the documentation memory device.

Sensor Calibrations 6.4

Calibration files for the various temperature sensors are attached to the documentation memory device.

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Stinger 19-Pin Connector 6.4.1

Cable Connector	Location	Calibration
• A	Stinger	DT670