OPERATING INSTRUCTIONS
FOR THE LAKE SHORE
MODEL RGC4 CRYOGEN FREE
CLOSED CYCLE REFRIGERATED SYSTEM
FOR COOLING CONTINUOUS
FLOW CRYOSTATS

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CONTENTS

1. GENERAL SAFETY PRECAUTIONS

1.1 SAFETY LABELS

The **WARNING!** label indicates a hazard. It calls attention to a procedure, practice, or condition that, if not observed or adhered to, could result in serious injury or even death.

The **NOTICE!** label indicates a hazard. It calls attention to a procedure, practice, or condition that, if not observed or adhered to, could result in damage to the equipment.

1.2 SUMMARY

All safety pressure relief valves are installed to provide protection to the equipment and operating personnel. Do not tamper with any pressure relief valve.

High voltage is present within the system components and can cause serious injury from electric shock. Follow these instructions to ensure operator safety:

1. Disconnect all components from the electrical power source before making component interconnections.
2. Shut off the compressor power switch before connecting it to a power source.
3. Do not connect the cold head power cable to the cold head while the compressor is running.

High gas pressure is present within the system and can cause serious injury if suddenly vented. Follow specified procedures when assembling and disassembling the self-sealing gas couplings on the flexible gas lines. Use caution to avoid puncturing the flexible gas lines.

2. INTRODUCTION

The Lake Shore Company's Model RGC4 Cryogen Free Closed Cycle Refrigerated System provides continues flow of cold helium liquid/gas to cool down Lake Shore SuperTran Continuous Flow Cryostats.
This manual will detail the operation of the basic cryostat and includes information about any special features that may have been incorporated into the specific unit.

3. UNPACKING AND SET-UP

Before removing the dewar from the shipping crates, it is advisable visibly inspect the outside and the inside of the crates for any obvious damage or excessive shock incurred during shipment. Any shipping damage should be immediately noted and communicated to Lake Shore and to the shipping company. Most dewars are supplied with lifting lugs, and these can be used to lift the dewar vertically out of the crate. If this is not possible, the remainder of the shipping crate must first be dismantled. As a temporary expedient, the front side of the dewar crate may be removed, and the dewar left in the inner frame.

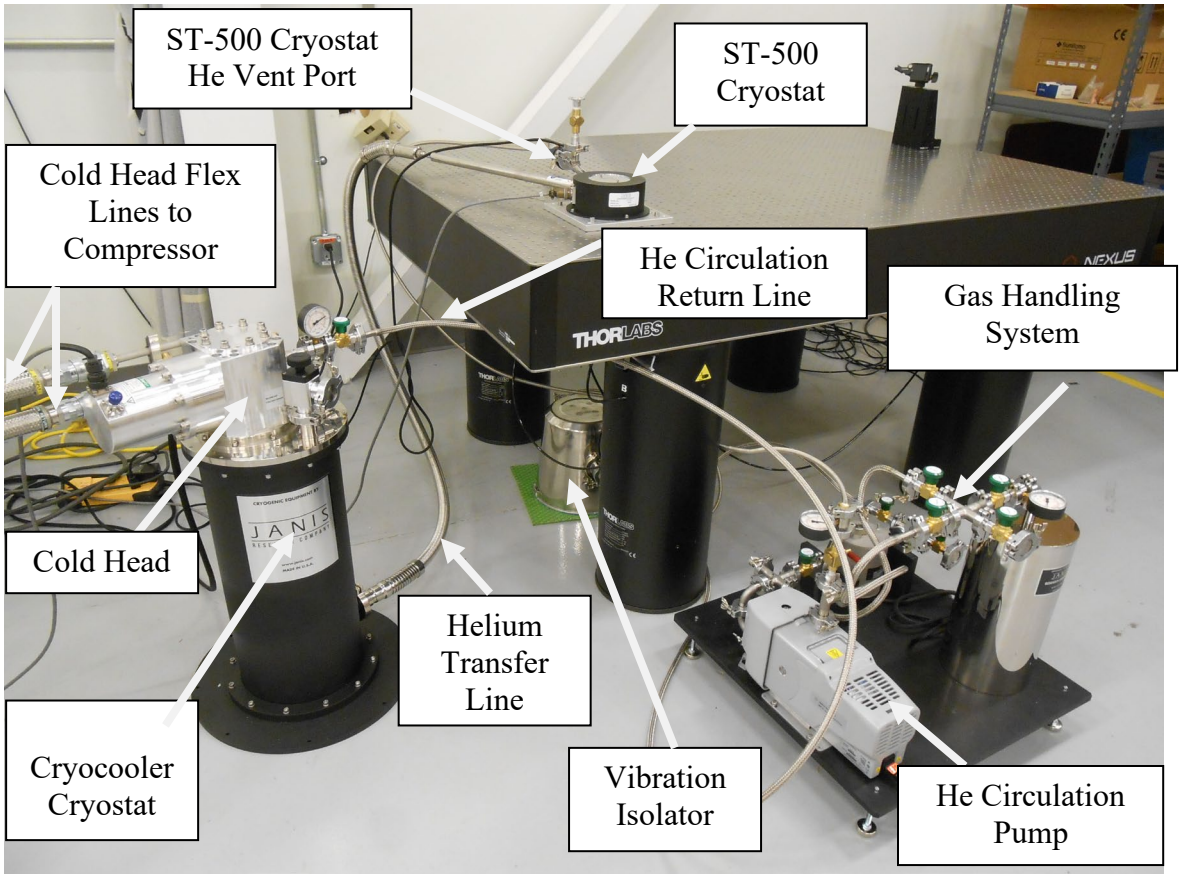


Figure 1 System layout with ST-500 SuperTran cryostat

4. SYSTEM DESCRIPTION

Figure 1 shows the main following components of a complete Cryogen Free Closed Cycle Refrigerated System.

- Crycooler Cryostat with helium transfer line for cooling Lake Shore SuperTran Continuous Flow Cryostat Systems
- Compressor for Cold Head
- High Pressure Helium Lines between the cold head and compressor
- Gas handling system (GHS)
- Vibration isolator
- NW-25 (or NW-16) flexible pumping line between the SuperTran cryostat and vibration isolator
- NW-25 (or NW-16) flexible pumping line between the vibration isolator and circulation pump
- NW-16 flexible helium gas return line between gas handling system and cryocooler cryostat

⚠ WARNING The above components contain high-pressure helium gas. Refer to the accompanying SHI manual for instructions on proper handling and operation.

Figures 2 and 3 show the main following components of the Gas Handling System.

- Helium gas storage tank (25 liters nominal volume)
- Sealed circulation scroll pump
- Zeolite TrapNW
- **V1** - circulation pump inlet valve
- **V2** – valve to add more helium gas from the storage tank to circulation line
- **V3** – helium storage tank valve
- **V4** – helium storage tank pump and fill valve
- **V5** – helium circulation and collecting valve
- **V6** – helium circulation line return valve
- **V7** – zeolite trap outlet valve
- **V8** – zeolite trap and gas handling system pumping and leak checking valve
- **V9** –zeolite trap inlet valve
- **G1** – circulation pump inlet compound vacuum gauge
- **G2** – helium storage tank compound vacuum gauge
- **G3** – cryostat return port compound vacuum gauge

Internal wiring

The top flange of the cryostat includes a hermetically sealed electrical feedthrough wired as indicated in the accompanying wiring schematic. Two diagnostic Si diode thermometers are provided on the two cold plates that are linked to the two stages of the cooler. Each cold plate also has 25 Ohm heater for warming up the system if necessary.

Please refer to the accompanying wiring diagram.

5. SYSTEM ASSEMBLY AND INSTALLATION

⚠ WARNING BEFORE BEGINNING THE SYSTEM INSTALLATION, REVIEW THE SHI COMPRESSOR AND COLD HEAD INSTRUCTIONS FOUND IN THE REFRIGERATOR MANUAL.

The gas handling system is shipped with ~ 30 liters of helium gas in the 25 liters nominal volume helium gas storage tank. This helium amount corresponds to ~ 3 psi pressure on the G2 compound gauge.

Take the following steps for the system assembly and installation (refer to **Figures 1-4)**

5.1 Arrange all system components the way shown in **Figures 1-4.**

5.2 At the SuperTran Cryostat NW-16 (or NW-25) vent port, install the provided extension nipple with the heater (see **Figure 4** where SuperTran ST-500 shown).

5.3 Connect the SuperTran cryostat extension nipple with the vibration isolator using provided NW-25 (or NW-16 for ST-100 cryostat) flex pumping line (see **Figures 4, 1 and 2**).

5.4 Connect the vibration isolator second port with circulation pump V1 valve using provided NW-25 (or NW-16 for ST-100 Cryostat) pumping flex line (see **Figures 2 and 1**).

5.5 Connect the RGC cryocooler cryostat V6 valve inlet port with the GHS V7 valve using provided NW-16 flex return line (see **Figures 3 and 2**).

5.6 Insert the cryocooler cryostat Helium transfer line all way into the ST cryostat inlet port and carefully tighten the O-ring seal (see **Figures 1 and 2** where the system shown with SuperTran ST-500 cryostat).

NOTES:

- *Make sure that the proper transfer line tip is used for your continuous flow ST cryostat.*
- *Use vacuum grease to lubricate the O-ring.*
- *Make sure the transfer line is inserted all way into the ST cryostat.*

5.7 Connect a high vacuum turbo pump station to the gas handling system V8 pump out valve.

NOTE: *The system and GHS shipped with all valves closed, including the needle valve.*

5.8 Open V1, V6, V7, V8 and V9. **Keep V2, V3, V4, and V5 closed.**

5.9 Completely open the needle valve by turning anti-clockwise the control knob 5 complete turns.

5.10 Turn on the turbo pump station to evacuate the gas handling system (**except the helium storage tank**) and other parts of the circulation system.

5.11 In a few minutes turn on the scroll circulation pump and keep it running during the whole procedure below.

5.12 Continue turbo-pumping at least for 8 hours (preferably overnight) to purge the system from the residual helium gas.

5.13 Close V8 valve and stop the turbo-pump.

5.14 Replace the turbo-pump with a helium leak detector.

5.15 Start the leak detector and open V8 valve.

5.16 Leak check the entire systems including all connections made during the system assembly at the leak detector sensitivity scale at least of 10^-7 mbar.l/sec.

NOTES:

A. If the background is still higher repeat or partially repeat steps 5.7-5.15 above.

B. The gas handling system lines are long, and it could take a while until helium from a possible leak reaches the leak detector. Be patient and wait for ~ 30 seconds after spraying helium at a specific place while looking at the leak detector signal.

C. Pay your special attention to the SuperTran cryostat inlet – helium transfer line connection by spraying a lot of helium gas around the connection.

5.17 If there are no leaks close valve V8 and disconnect the leak detector from the gas handling system.

5.18 Close V1, V6, V7 and V9 valves. Now all valves of the gas handling and circulation system should be closed except the needle valve.

5.19 Proceed with the cryostat preparation for cooldown and cooling (see Sections 7 and 8 below).

6. <u>ZEOLITE TRAP REGENERATING</u> (Recommended every 12 – 18 months)

6.1 Make sure that the zeolite trap valves V7, V8 and V9 are closed.
6.2 Connect a scroll or mechanical pump to the Zeolite trap pumping valve V8.
6.3 Turn on the pump and wait for a few minutes to pump the connection line.
6.4 Slowly open valve V8.
6.5 Plug in the zeolite trap cartridge heater into a power source.
6.6 Continue pumping on the trap with the heater on for at least 3 hours.
6.7 Turn off the heater and continue pumping on the trap for another 4 hours.
6.8 Close V8 valve and disconnect the pump.

<u>NOTE</u>: ***The Zeolite trap should be regenerated every 12 -18 months.***

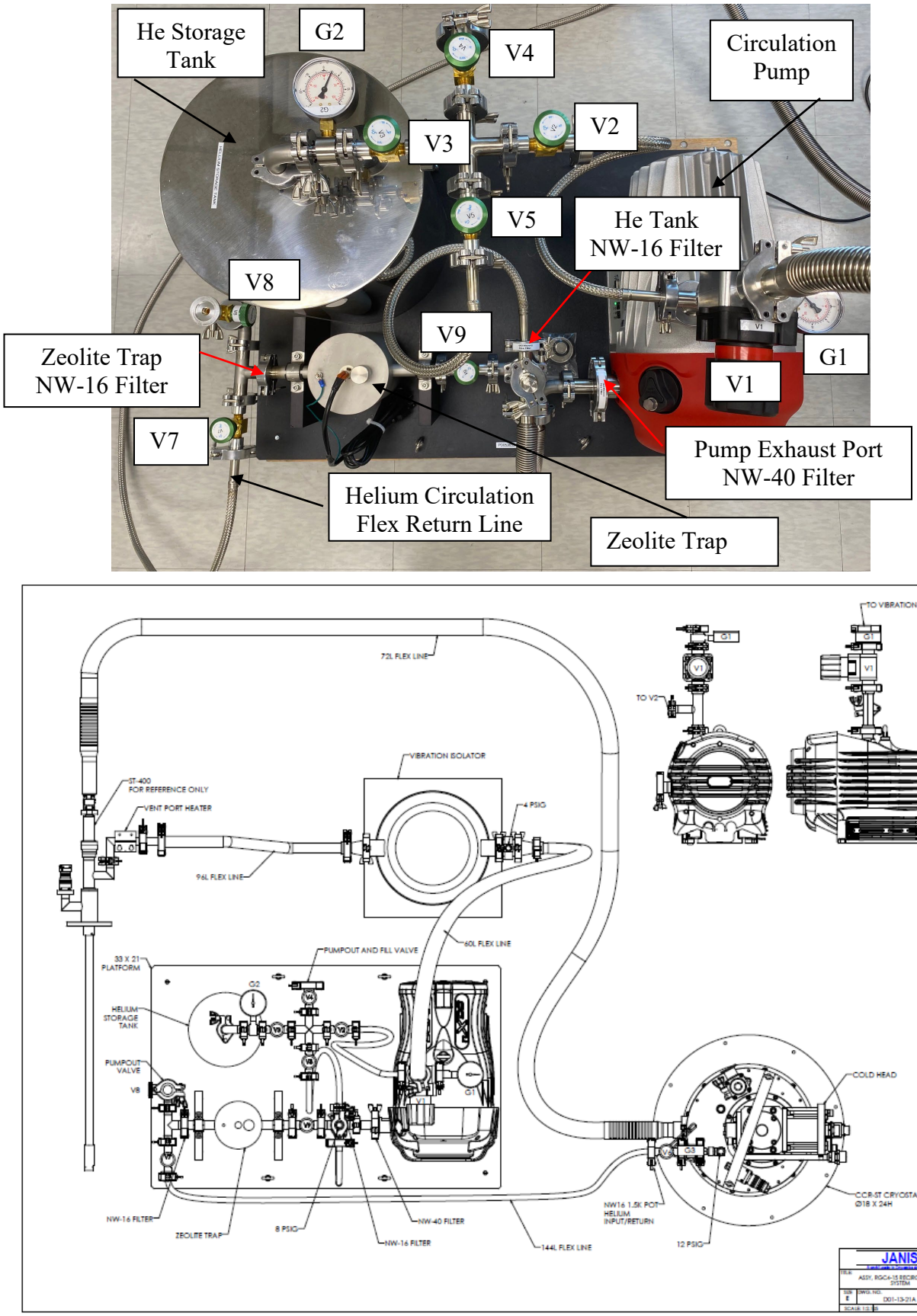


Figure 2 Gas handling and circulation system picture and layout with ST-400 Cryostat

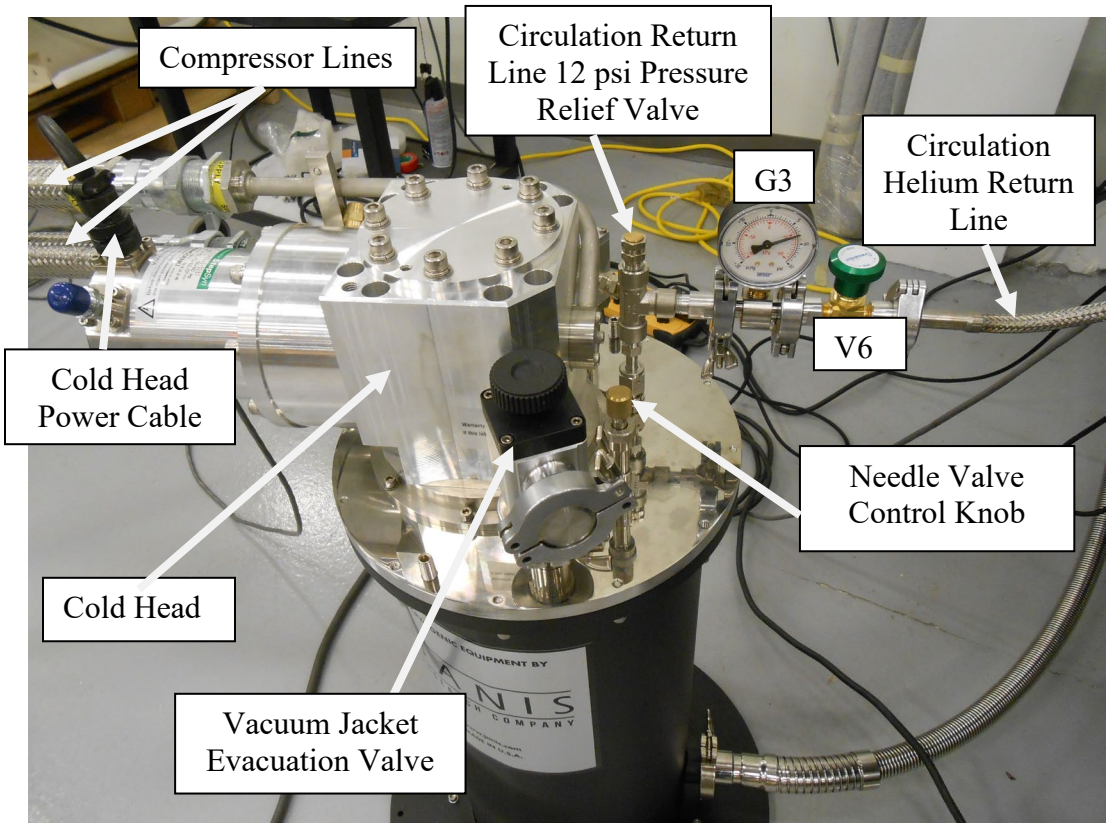


Figure 3 Cryocooler cryostat top flange

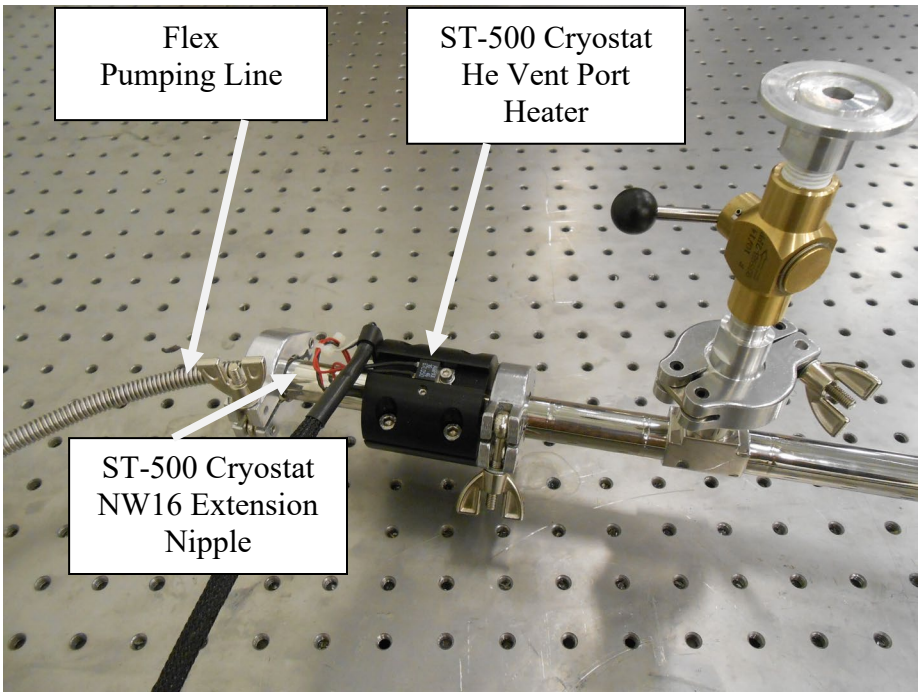


Figure 4 ST-500 Cryostat He Vent Port

7. PREPARATION FOR COOLDOWN

7.1 Cold head cryostat evacuation.

The cold head cryostat is shipped evacuated, but it must be re-evacuated prior to use. This is best done with a good pumping station (e.g., a turbo-molecular or cold-trapped rotary/diffusion pumping station) capable of bringing the ultimate pressure down to 10^{-5} Torr or less. An engineering drawing showing the details of your system, including the evacuation valve, is enclosed for your reference (see also **Figures 3 and 1**). A mass spectrometer helium leak detector may optionally be used to ensure that there are no leaks from the outside of the dewar, or from either reservoir into the vacuum space.

The dewar vacuum jacket is protected against cold leaks with a safety pressure relief which will vent any pressure that exceeds 4 psi.

When evacuation of the jacket is initiated, always be sure that the pressure on the pump side of the evacuation valve is lower than the jacket pressure. This is done to avoid drawing oil vapor from the pump into the vacuum jacket. Thus, one should not pump the vacuum jacket when the cooler is on and the internal stages cold since the cold surfaces will usually cryopump to a lower pressure (10^{-6} Torr less) than the pumping station in use.

NOTICE *The cryostat vacuum jacket must be continuously pumped during system cooling and can be only stopped after the cryocooler second stage reaches ~ 20 K.*

After evacuating the jacket, the valve should be firmly closed, but care should be exercised to avoid damaging the seat with too much pressure.

7.2 SuperTran cryostat evacuation.

Make sure that the SuperTran cryostat vacuum jacket is evacuated before you start cooling it.

7.3 Cold Head preparations

- **Must read the accompanying SHI Cold Head and Compressor Manuals before starting.**
- Connect cooling water supply lines to the compressor if it is water cooled.
- Connect the cold head high pressure lines to the compressor and cold head (see **Figure 3**).

NOTICE Gas Lines - Interconnecting helium supply and return gas lines should be installed in the sequence described in the compressor manual. **Use two wrenches when tightening the fittings and support the gas lines to prevent gas leakage during assembly.**

- Connect three phase power supply cable to compressor.

⚠ WARNING **Be sure the compressor power is off when making this connection.**

- Connect the supplied electrical cable from the compressor “cold head power” outlet to the matching connector on the cold head motor (see **Figure 3)**.

⚠ WARNING **Be sure the compressor power is off when making this connection**

8 ROOM TEMPERATURE HELIUM CIRCULATION

NOTES:

- ***If the system is cooled down the first time after receiving it from Lake Shore and the whole system mounting procedure has been done (see Section 5 above) then skip steps 8.1 – 8.8 and proceed with step 8.9.***
- ***The zeolite trap should be regenerated every 12-18 months (see Section 6 above).***

8.1 Make sure that all valves except the needle valve are closed.
8.2 Connect a high vacuum turbo pump station to the gas handling system pump out valve V8.
8.3 Make sure that the cryostat is at room temperature.
8.4 Open valves V6, V7 and V8.
8.5 **Immediately** turn on the pumping station to start evacuation of the zeolite trap and internal parts of the circulation system.
8.6 Continue pumping the system for at least three hours (the turbo-pump vacuum gauge pressure should go below 10^{-4} mbar).
8.7 Close valve V8 and stop the turbo pump.
8.8 Close valves V6 and V7.
8.9 Make sure that valves V1, V2, V3, V4, V5, V6, V7, V8 and V9 are closed and needle valve is open.
8.10 Turn on the circulation pump.
8.11 Open valves V1, V9, V7 and V6 to start helium circulation.
8.12 Open valve V3. Add helium to the circulation line by slowly opening and closing valve V5 while watching the cryostat inlet pressure (gauge G3). Stop adding helium and close V5 after G3 pressure reaches between – 2" and 1 bar ("0" reading on the compound gauge G3).
8.13 Continue helium circulation at room temperature at least 3 hours to remove any water vapor from the circulation system.
8.14 Start system cooling (see **Section 9** below).

9 COOL DOWN

NOTICE The cryostat vacuum jacket must be continuously pumped during system cooling and can be only stopped after the cryocooler second stage reaches ~ 20 K.

9.1 Make sure the cold head high pressure lines are connected to the compressor and cold head.
9.2 Make sure the electrical cable is connected between the compressor and cold head.
9.3 Make sure cooling water supply lines are connected to the water cooled compressor.
9.4 Make sure three phase power supply cable is connected to the compressor.
9.5 Plug in the SuperTran cryostat helium vent port electrical heater to automatically keep the vent port at ~ 50 C degrees during cooling to avoid the ice formation (see **Figure 4** where the heater with ST-500 cryostat is shown).
9.6 Make sure that valves V1, V3, V6, V7 and V9 are open and valves V2, V4, V5 and V8 are closed.
9.7 Make sure that the GHS circulation scroll pump is running.
9.8 For water cooled compressors, start running cooling water through the compressor.
9.9 **Turn the compressor on to start the system cool down.**
9.10 Continue helium circulation (see 8.12) during system cooling.
9.11 Make sure that the needle valve is fully open (see procedure 5.9 above).
9.12 During the cooling process the cryostat inlet pressure (G3) will slowly go down. To reduce the system cooling time it is recommended to keep the G3 pressure between – 2" and 1 bar

("0" reading on the compound gauge G3) during initial cooling. To do it more helium should be added into the circulation line by slowly opening and closing V5 while watching the helium return pressure at G3.

9.13 After the ST cryostat reaches ~ 10K - 15 K (in approximately 2.5 to 3.5 hours depending on the ST cryostat) proceed to step 9.14 below.

9.14 To condense helium in the second stage heat exchanger, close the cryostat needle valve and wait a few minutes until the G3 return pressure goes down between - 8" and -10".

9.15 Open needle valve to approximately **3/8** turn.

9.16 After approximately 20 minutes the ST cryostat temperature should reach ~ 5K – 8K.

NOTES:

- *Initially the temperature of the ST cryostat will go up and then will start going down. That is normal.*
- ***If the higher cooling power at higher temperatures is more important than the low base temperature, then follow the operation procedure described in the Amendment 2.***

9.17 Very gently (rotate just by +/- a few degrees) adjust the needle valve position around to get the lowest ST cryostat temperature. **The typical optimum needle valve position is between ¼ and ½ turn.**

NOTE: ***It is possible that the farther ST cryostat temperature can be slightly decreased by following the Section 9.18 below.***

9.18 To increase the liquid helium circulation amount to reduce the ST base temperature or increase its cooling power, follow the steps below.

- Close valve V5.
- Add more helium from the helium storage tank into the circulation line by very slowly opening **and immediately closing** V2 valve while watching the circulation helium return pressure (G3). Do it until the G3 pressure reaches ~ 1 bar ("0" reading on the compound gauge G3). Make sure V2 valve is closed.

  NOTE: To farther reduce the ST-500 cryostat temperature, more helium gas can be added up to 3 psi on G3 pressure gauge via V2 valve, however we do not recommend working at this high return pressure mode more than a few hours because it reduces the scroll pump tip-seal life.
- After adding more helium into the circulating line, the ST Cryostat base temperature could go further down.
- When running this 9.18 step, keep V2 and V5 valves closed.

NOTE: ***Before taking any ST continuous flow cryostat set points above the base temperature (see Section 10 below) slowly open V5 valve if it was closed during the procedure 9.18.***

10 TEMPERATURE CONTROL

IMPORTANT:

- **Before taking any ST continuous flow cryostat set points above the base temperature very slowly open V5 valve if it was closed during the procedure 9.18 above.**
- **If the RGC4 is used to cool down an ST-400 flow cryostat designed to operate above 300K, the RGC needle valve must be completely closed when operating above 300K. To cool down the ST-400 cryostat after taking the set point above 300 K, completely open the needle valve (5 turns), and after the ST-400 cryostat reaches ~ 10K - 15 K follow steps 9.14 – 9.17 above.**

Refer to the ST cryostat manual for the cryostat temperature control above the base temperature.

NOTE:

If the ST cryostat heater power is not enough to reach the ST cryostat highest temperature the cryocooler cryostat needle valve can be slightly closed to reduce amount of helium provided to the ST cryostat.

In this case, after these high temperature points are taken, the needle valve either could be reopened back to ~3/8 turn or could be completely opened (see the Note above) to speed up the cooling of the ST cryostat.

11 SUPERTRAN CRYOSTAT WARMING UP FOR SAMPLE CHANGING

The SuperTran Cryostat warming up to the room temperature can be done without warming up the RGC4 cold head cryostat by following the procedure below.

11.1 Collect the helium circulation gas back into the storage tank by following the steps below

- Make sure that V3 valve is open.
- Open V5 valve if it is closed.
- Close V9 valve.
- Completely open the needle valve (5 turns).
- Continue to pump helium into the storage tank during the whole sample changing procedure.

NOTE:

To speed up warming of the SuperTran cryostat, the SuperTran heater and a PID temperature controller can be used.

11.2 When all parts of the SuperTran cryostat reach room temperature the cryostat can be opened to change the sample.

NOTE: ***Make sure that all parts of the SuperTran cryostat are at room temperature before opening it.***

11.3 After changing the sample, the cryostat should be closed, and its vacuum jacket must be re-evacuated prior to use. This is best done with a good pumping station (e.g., a turbo-molecular or cold-trapped rotary/diffusion pumping station) capable of bringing the ultimate pressure down to 10^{-4} Torr or less.

11.4 To cool down the SuperTran cryostat after the sample changing follow the procedure described in Section 12 below.

12 SUPERTRAN CRYOSTAT COOL DOWN AFTER SAMPLE CHANGING

12.1 Make sure that the RGC cold head cryostat is running normally meaning that the first stage temperature is below 40 K and the second stage temperature is about 4 K or below.

12.2 Make sure that V1, V6, and V7 valves are open and needle valve is completely open (5 turns).

12.3 Start helium circulation by **VERY SLOWLY** opening V9 valve while watching G3 pressure that should go up very slowly. Completely open V9.
NOTE: *If V9 is opened too fast then big helium flow could overheat the trap located on the cold head first stage and the circulation system could be blocked.*

12.4 After the temperature of the SuperTran cryostat reaches ~ 10K – 15K, follow steps 9.13 - 9.17 above.

13 SYSTEM ROOM TEMPERATURE WARMING UP

⚠ WARNING Make sure the cold head temperature never exceeds 300 K to avoid the cold head damaging.

⚠ WARNING The vacuum jackets of **both cryostats** should never be vented to atmospheric pressure and opened before all parts of the cryostat warmed up to room temperature.

⚠ WARNING Never remove the RGC transfer line from an ST cryostat before both cryostats are at room temperature.

13.1 Make sure that V3 valve is open and V2 is closed.

13.2 Start collecting the helium circulation gas back into the storage tank by opening V5 valve (if it is closed) and immediately closing V9 valve.

13.3 **Open fully the needle valve by 5 complete turns.**

13.4 Continue to pump helium gas into the storage tank for at least 30 minutes.

13.5 After approximately 30 minutes, pressure in the storage tank (G2) should be about 2.5 psi.
NOTE: *If in 30 minutes the G2 pressure is still below 2 psi then in order to collect all helium gas into the storage tank the liquid helium condensed in the second stage heat exchanger should be evaporated.*
To do it make the following steps:

- *Warm up the second stage of the cold head cryostat to 8 K using the heater and temperature sensor of the second stage.*
- *Wait until G2 pressure goes up to approximately 2.5 psi and stabilized (it could take another 15-20 minutes) and then turn off the second stage heater.*

13.6 Close V1, V3, V5, V6 and V7 valves. At this point all valves of the circulation system should be closed. Keep the needle valve completely open.

13.7 Turn off the circulation pump.

13.8 Warm up the cold head cryostat. The cold head cryostat can be warmed up to room temperature by simply turning the compressor off, while monitoring the temperature of the various thermometers until they reach room temperature.

NOTE:

- Two independent 25 Ohm heaters (each 25 Ohm heater consist of two 50 Ohm cartridge heaters connected in parallel) located on the 1st and 2nd stage cold plates could be used to warm up the cryostat to the room temperature.

Warnings: ***Always use a PID temperature controller and make sure the cryostat temperature never exceeds 300 K to avoid the cold head damaging. It is important that the first stage heater is ALWAYS used with the first stage sensor and the 2nd stage heater is ALWAYS used with the 2nd stage sensor. Damage may result to the cold head if the sensors are mixed up.***

13.9 Every 12 -18 months regenerate Zeolite trap after warming up the cryostat. To do it, follow the procedure described in Section 6.

14 TROUBLESHOOTING

Problem	Suggestions
The base temperature is too high	- Try to adjust the position of the needle valve to optimize the circulation flow (see procedure 9.17 above). OR - Scroll pump exhaust port NW-40 filter is clogged. Proceed with the filter replacement or cleaning as described in MAINTENANCE below OR - Scroll pump tip-seal is worn and must be replaced (refer to accompanying scroll pump manual).
The base temperature slowly increasing and the circulation line cryostat inlet pressure (gauge G3) slowly rising.	The circulation line could be partially contaminated. Try the following actions: - Open the needle valve to ~ 5 turns and let the system run with this high flow for one hour. Then adjust the position of the needle valve to its optimum opening of ~ 3/8 turn (see procedure 9.14 – 9.17 above) - If it does not work then the system should be warmed up to rom temperature (see Section 13 above) and then purged, per procedures described in Section 8.
Condensation on the outside of the vacuum jacket and inability of the second stage cooled cold plate to reach below 4.5 K may be indications of a vacuum problem.	If these symptoms appear, re-evacuate the vacuum shroud as described in the cryostat evacuation Section 7.1 above. If the symptoms disappear, no further action may be required. If the symptoms remain, or reappear quickly, a vacuum leak may be present. Contact Lake Shore to obtain further directions in this case.
Instrumentation Problem	Occasionally a heater or thermometer wire may be broken during sample removal or installation. If this occurs, reconnect the broken wire using 60/40 rosin core solder. Be sure to insulate the joint with shrinkable PVC tubing or Teflon insulation. Occasionally a heater may burn out. Replacement heater kits are available from Lake Shore, and include all materials and instructions necessary for replacement. Refer to the accompanying Wiring Diagram.
Any other problems	Should any difficulty arise with the cryostat, it is recommended that you contact Lake Shore before any repair work is undertaken. In addition to the description of the difficulty, it is always helpful to obtain the model and serial number of the system in question. This will enable our scientists to uniquely identify this system and help in resolving any difficulty that may arise.

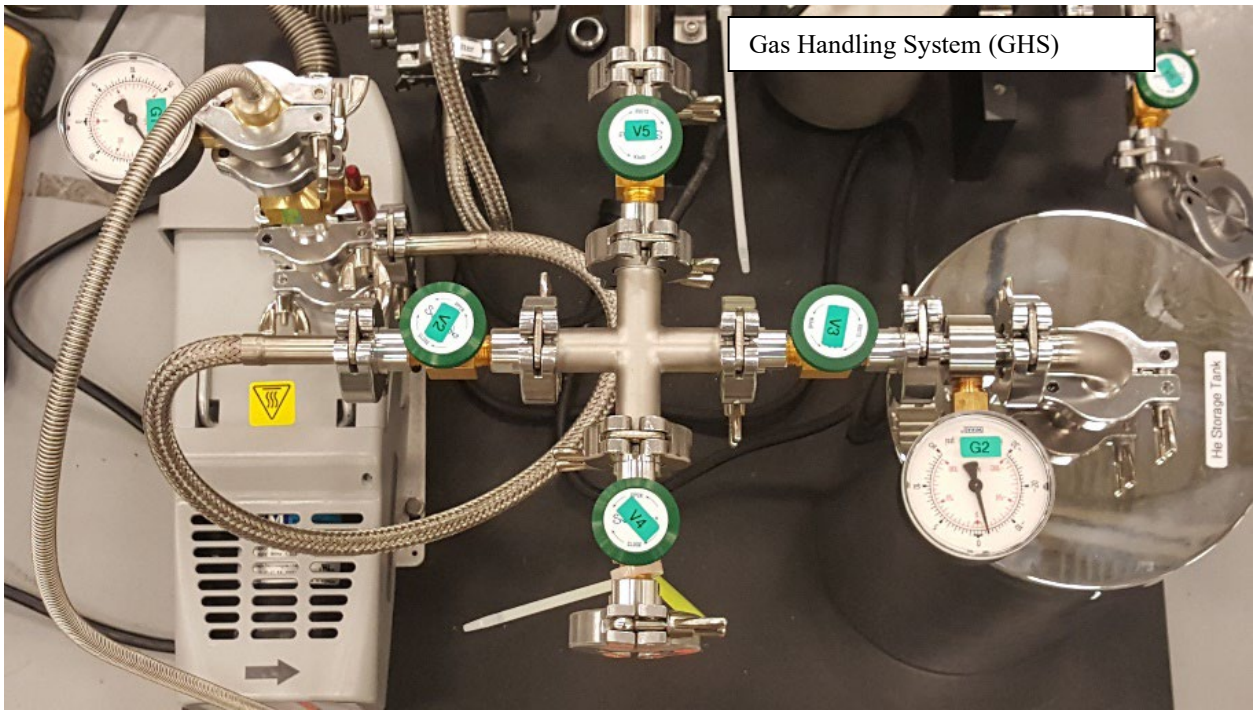
15 MAINTENANCE

System Item	Task	Service Interval
Recirculating Scroll Pump Exhaust Port Filter Replacement (see Figure 2)	Replacement of exhaust port filter.	**Every three months of system operation** NOTE: As a temporary measure, a clogged filter can be cleaned with a Q-tip soaked in IPA or ethanol. If you have an ultrasound machine, you can sonicate the filter for 15 minutes in IPA or ethanol.
Compressor	Replacement of charcoal adsorber.	Please refer to accompanying compressor manual
Cold Head	Maintenance	Please refer to accompanying cold head manual
Zeolite Trap	Zeolite trap regeneration (see Section 6 above)	Every 12 -18 months
Zeolite Trap	13X synthetic zeolite replacement	Every 15,000 hours of operation
GHS Scroll Pump	Please refer to accompanying pump manual	Please refer to accompanying pump manual

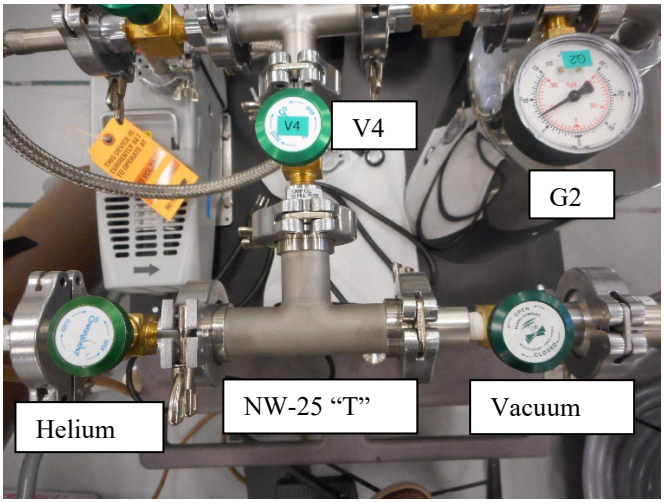
Amendment 1

ADDING HELIUM GAS INTO RECIRCULATING SYSTEM

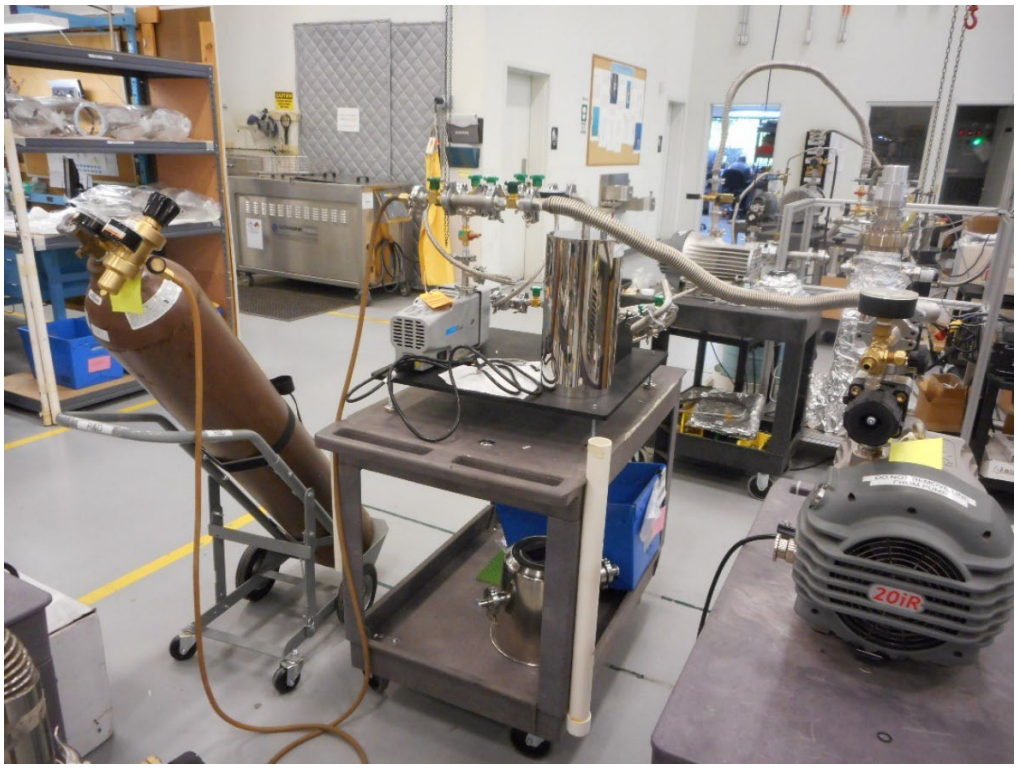
A quick note before beginning: You do not need high purity helium gas. Common industrial grade helium will be fine. If you only have higher grades of helium, then they can be used as well, but there is no special requirement for them.
Make sure that all 4 valves on the Gas Handling System (GHS) manifold V2, V3, V4 and V5 are closed.



Prepare the charging manifold consisting of an NW-25 "T" with two valves (similar to the manifold shown in the picture below). Remove the NW-25 blank flange from the valve V4 NW-25 flange on the GHS manifold. Connect the charging manifold to the NW-25 flange on V4. Make sure both valves on the charging manifold are closed.



Connect one port of the charging manifold to your vacuum pump (Vacuum Port) and the second port to the regulator mounted to a helium gas cylinder (Helium Port)



Start the vacuum pump. If there are any valves between the pump and the manifold, then make sure that they are open so that there is vacuum in the pumping line all the way to the closed valve VACUUM.

Your helium pressure regulator on the gas cylinder should have a delivery pressure rating of 5 psi or hire. Make sure the pressure adjusting screw on the regulator is backed out. Open the gas cylinder valve and verify that the pressure shown on the inlet pressure gauge of the regulator goes up accordingly. Use the pressure adjusting screw on the regulator to set the outlet pressure of the regulator to ~ 5 psi. If there are any valves between the regulator and the manifold, then make sure that they are open so that there is pressurized helium in the charging line all the way to the closed valve HELIUM.

Remove the helium charging line from HELIUM Valve NW-25 Port and allow helium to pass through the charging line for 30 seconds. This is to purge the charging line. After 30 seconds, while helium is still passing through the charging line, reconnect the helium charging line to the HELIUM Valve NW-25 Port.

*Open the valve VACUUM slowly, taking 4 to 5 seconds from closed to fully open, to prevent dumping the gas in the manifold into the pump all at once. Evacuate the manifold for 2 to 4 minutes. Close the valve VACUUM.

*Open the valve HELIUM and fill the charging manifold until it equalizes with the regulator output, then close the valve HELIUM.

Repeat these last two steps marked * 2 more times, for a total of 3 evacuation and fill cycles. This should finish with both valves HELIUM, and VACUUM closed and ~ 5 psi of helium in the charging manifold. Valves V2, V3, V4 and V5 have remained closed.

Open valve V4.

** Open the valve VACUUM slowly, taking 4 to 5 seconds from closed to fully open, to prevent dumping the helium in both now connected manifolds into the pump all at once. Evacuate the manifold for 2 to 4 minutes. Close the valve VACUUM.

** Open the valve HELIUM and fill the manifolds until they equalize with the regulator output, then close the valve HELIUM.

Repeat these last two steps marked ** 2 more times, for a total of 3 evacuation and fill cycles. This should finish with both valves HELIUM and VACUUM closed, with V4 open, ~ 5 psi of helium in both manifolds, and valves V2, V3 and V5 closed.

Open valve V3. The helium storage tank pressure gauges G2 and CHARGING PRESSURE will equalize.

Open valve HELIUM very slowly until the pressure shown on gauges G2 starts to increase. Allow helium to flow into the storage tank until the pressure on gauge G2 reaches required pressure of ~ 3 psi (see Section 5 above) and then close valve HELIUM.

Close valve V3.
Close valve V4.
Back out the regulator adjusting screw and close the cylinder valve.
Shut off the vacuum pump.
Disconnect the charging line from the regulator and the charging manifold.
Disconnect the pumping line from the pump and the charging manifold.
Remove the charging manifold.
Replace the NW-25 blank flange on the NW-25 flange on valve V4.

This concludes the charging procedure.

Amendment 2

NEEDLE VALVE OPEN MODE OF OPERATION

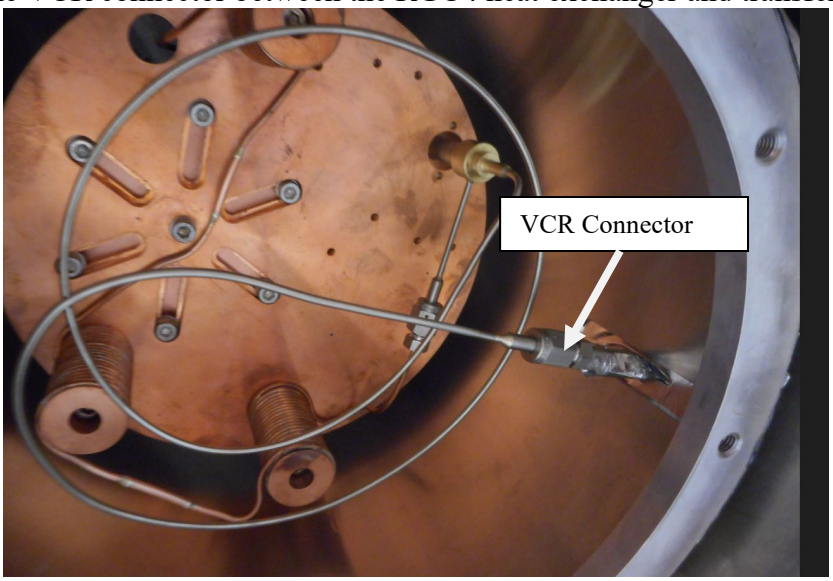
If the higher cooling power of an ST cryostat at higher temperatures is more important than the ST cryostat base temperature, then after step 9.13 keep the needle valve completely open (5 turns) and start your measurements.

Amendment 3

RGC4 CRYOSTAT TRANSFER LINE REPLACEMENT

If the transfer line of the RGC4 cryostat is to be replaced for use with another continuous flow ST cryostat, follow the procedure below.

- Make sure that all parts of the RGC4 cryostat are at room temperature before opening it.
- Fill vacuum jacket of the RGC4 cryostat with dry nitrogen gas.
- Remove the RGC vacuum shroud bottom flange.
- Remove the RGC radiation shield bottom flange.
- Disconnect the VCR connector between the RGC4 heat exchanger and transfer line.



- Unbolt the RGC4 cryostat transfer line flange from the vacuum jacket.

- Carefully remove the transfer line by pulling it from the cryostat.
- Install the new transfer line internal capillary with a VCR connector into RGC4 cryostat.
- Reinstall the RGC4 cryostat transfer line flange on the RGC vacuum jacket.
- Install a new gasket and connect the transfer line VCR connector with RGC heat exchanger VCR connector.
- Install 20 layers of superinsulation around the transfer line inner capillary.
- Make sure that the transfer line inner capillary does not touch the RGC radiation shield and vacuum jacket.
- If a helium leak detector is available, leak check the VCR connection.
- Reinstall the RGC radiation shield bottom flange.
- Reinstall the RGC vacuum shroud bottom flange.