UHV Flow Cryostat for Manipulation

The ARS manufactured LT3M Helitran is a True UHV cold head (10-11 Torr) where all of the rubber o-ring seals have been replaced with welded joints and metal seals. Like all of our LT3 helium flow cryostats, the LT3M is an advanced liquid helium flow cryostat utilizing many unique features, such as the matrix heat exchanged and the coaxial shield flow transfer line to achieve unparalleled efficiency and ultra low vibration levels. The combination of True UHV and angstrom level vibrations makes the LT3M ideal for low temperature application. The extended length and addition of a rigid support tube allow for cleaving and manipulation.

The above picture shows LT3M Helitran® with a radiation shield.

Applications

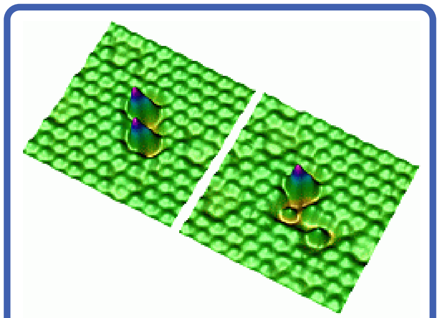
- UHV
- STM
- Surface Science

Features

- True UHV (10-11 Torr)
- Bakeable to 200C
- Open Sample Space
- Optional Cold Tip Extensions
- Liquid Helium Flow (or Liquid Nitrogen(
- Matrix Heat Exchanged for High Cooling Efficiency
- Coaxial Shield Flow Transfer Line
- 4.2K Liquid Helium Operation (1.7K with Pumping)
- 0.7 LL/hr Liquid Helium Consumption at 4.2K (tip flow)
- Angstrom Level Vibrations
- Precision Flow Control
- Exhause Heater
- Operation in ANY Orientation
- Fully Customizable

Typical Configuration

- Cold head (LT3M)
- Coaxial Shield Flow Transfer Line
- True UHV welded stainless steel instrumentation skirt with 4.5 in non rotatable CF flange
- Dewar Adapter
- Flow Meter Panel for Helium Flow Control and Optimization
- Nickel Plated OFHC Copper Radiation Shield terminating 0.125 inch short of the cold tip
- Instrumentation for temperature measurement and control:
  - 10 pin UHV feed through
  - 36 ohm thermofoil heater (wire wrapped)
  - Silicon diode sensor curve matched to (±0.5K) for control
  - Calibrated silicon diode sensor (±12 mk) with 4 in. free length for accurate sample measurement.
- Wiring for electrical experiments:
  - 10 pin hermetic feed through
  - 4 copper wires
- Sample holder for optical and electrical experiments
- Temperature Controller



The above picture shows results using an LT3B UHV Flow Cryostat.

Options and Upgrades

- High Flow Transfer Line
- 6 and 8 inch non rotatable CF flanges available
- 450K High Temperature Interface
- 800K High Temperature Interface
- Custom temperature sensor configuration (please contact our sales staff
- Custom wiring configurations (please contact our sales staff)
- Sample holder upgrades (custom sample holders available)

DS-LT3M-R1

UHV Flow Cryostat for Manipulation

Cooling Technology-

LT3	Open Cycle Cryocooler, Helitran
Refrigeration Type	Liquid Helium Flow
Liquid Cryogen Usage	Helium, Nitrogen Compatible

Temperature*-

LT3B	< 4.2K - 350K (<2K with pumping)
With 800K Interface	(Base Temp + 2K) - 700K
With 450K Interface	Base Temp - 450K
Stability	0.002 K
*Based on bare cold head with a closed radiation shield, and no additional sources of experimental or parasitic heat load	

Sample Space -

Diameter	Large Open Radiation Shield
Height	Large Open Radiation Shield
Sample Holder Attachment	1/4-28 screw
Sample Holder	www.arscryo.com/Products/ SampleHolders.html

Temperature Instrumentation and Control - (Standard) -

Heater	36 ohm wire wrapped Thermofoil Heater anchored to the coldtip
Control Sensor	Curve Matched Silicon Diode installed on the coldtip
Sample Sensor	Calibrated Silicon Diode with free length wires
Contact ARS for other options	

Instrumentation Access-

Instrumentation Skirt	Welded Stainless Steel
Pump out Port	1 - NW 25
Instrumentation Ports	5 (1.33 Mini Conflat Flanges)
Instrumentation Wiring	Contact sales staff for options

Radiation Shield -

Material	Nickel Plated OFHC Copper
Attachment	Threaded
Optical Access	Open End Radiation Shield terminated 0.125” short of cold tip (Customer Specified)

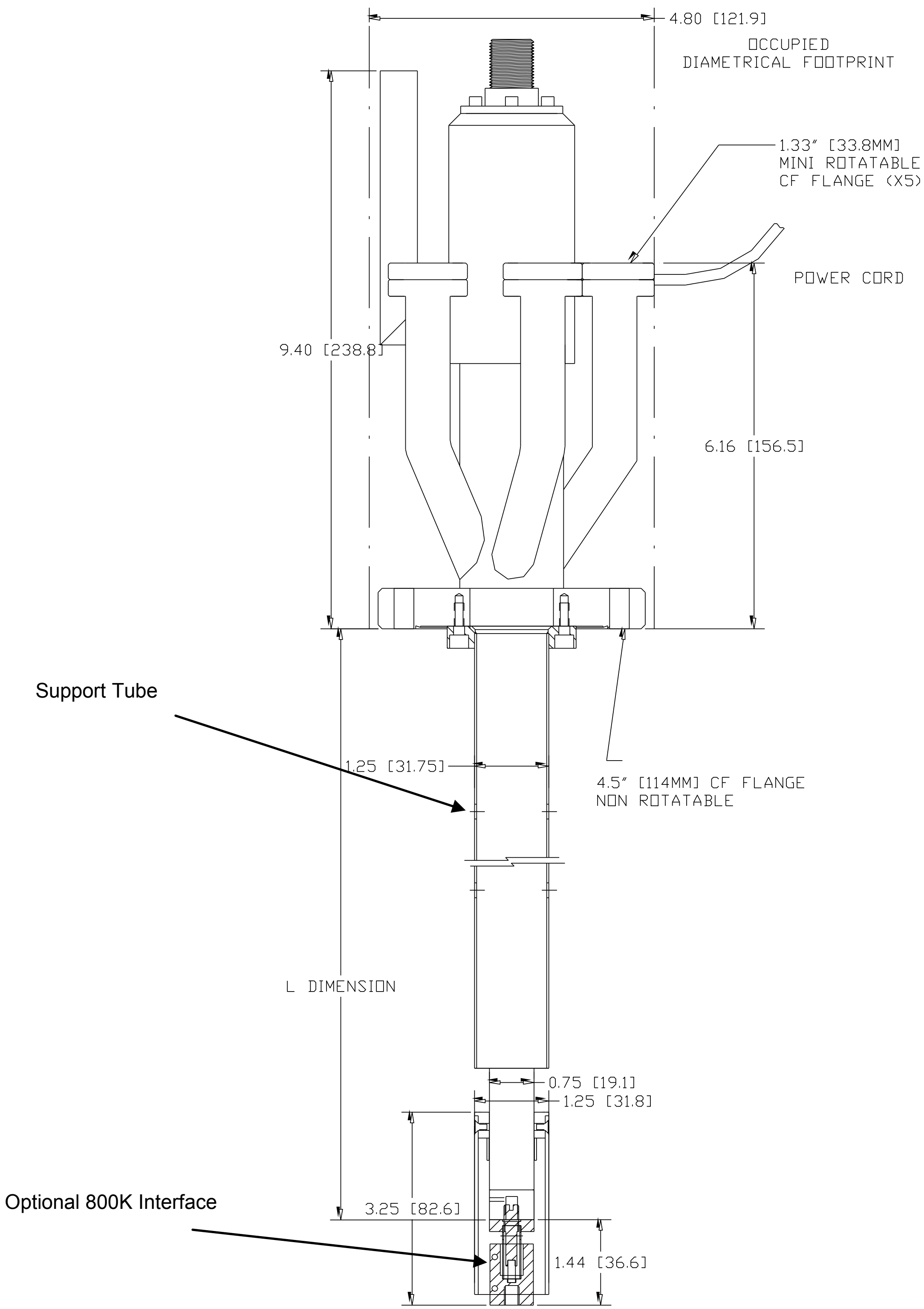
Cryostat Footprint -

Overall Length	Varies - Customer Specified
Motor Housing Diameter	N/A
Rotational Clearance	121 mm (4.8 in) with “G” Configuration

Cryostat Model		**LT3**		
Cryogen		Liquid Helium		Liquid Nitrogen
Base Temperature		4.2K	<2K with Pumping	77K
Nominal Helium Consumption at 4.2K		0.7 LL/hr	-	
Cooling Capacity		0.7 LL/hr	2 LL/hr	
	4.2K	0.5W	1.5W	
	20K	3.0W	8.0W	
	50K	7W	20W	
Maximum Temperature		450K with cold gas through transfer line		
Cooldown Time		20 min		
Weight		0.9 kg (2 lbs)		

UHV Flow Cryostat for Manipulation

LT3M Outline Drawing



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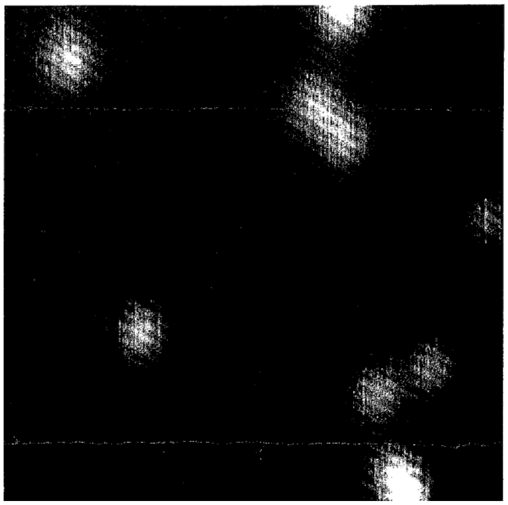
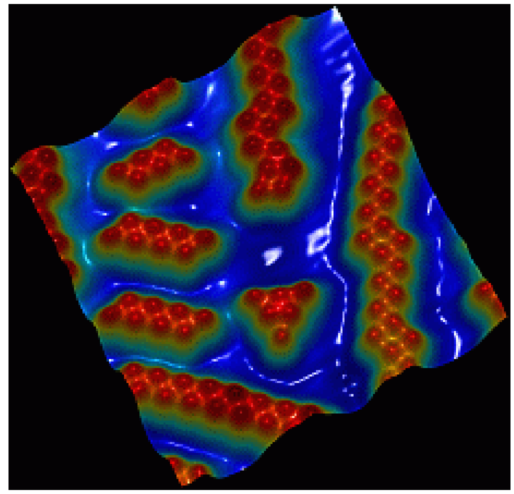
UHV Flow Cryostat for Manipulation

LT3B Vibration Image	STM Image
	

Courtesy of:
Hyojune Lee
University of California Los Angeles
Electrical Engineering Department
Helitran® LT3B
Connected Directly to STM Scanner.
Scan Size Approx: 62Å x 62Å
Noise in the image is < 3 Å

Courtesy of:
Prof. Michael F. Crommie,
University of California at Berkeley
Physics Department
Helitran® LT3B
120 x 120 Angstrom image of azobenzene molecules on Au(111)
taken at T = 15K

UHV - STM– SURFACE SCIENCE

Helitran® LT-3B FOR UHV and STM:

This is the UHV model. It is manufactured from UHV grade materials and instrumentation. The LT-3B has the following features:
Sample in UHV. (10E-11 Torr)
Interface is Conflat Flange, 2.75 Inch Conflat. (DN-35CF)
Temperature Range; 4.2-500K Standard. (1.7K with Pumping). 4.2K to 900K with HiTemp™ Interface.
Matrix Heat Exchanger integrated with sample mount.
Co-axial Transfer Line for reduced flow of single phase Helium.
Applications:
Scanning Tunneling Microscope. STM: the Helitran® is uniquely designed for the STM application. With the Coaxial flow transfer line and the Matrix Heat Exchanger combination the vibrations at the STM are less than 1Å. Scientists have used the Helitran to cool STM samples to less than 8K with drift less than 0.001 Å per minute.

Helitran® LT-3M for Surface Science and UHV Manipulator:

This is the UHV cryostat is designed with an extended length for surface science experiments. It is typically mounted on a UHV manipulator. The LT-3M has the following features:
Sample in UHV. (10E-11 Torr)
Interface is Conflat Flange, 4.5 Inch Conflat. (DN-63CF)
Temperature Range; 4.2-500K Standard. (1.7K with Pumping).
Matrix Heat Exchanger integrated with sample mount. This is important because of the typical larger size of the sample holders (Due to tilt and rotation requirements)
Co-axial Transfer Line for reduced flow of single phase Helium.
Applications:
Surface Science/UHV Manipulators: the Helitran® is uniquely designed for the UHV mainpulator. With the Matrix Heat Exchanger the helium consumption is dramatically reduced.

UHV Flow Cryostat for Manipulation

Advanced Features of LT3B Helitran®

The Helitran® has been designed for high performance with advanced features not normally found in traditional open cycle cryostats. A detailed description of the **Matrix Heat Exchanger**, the **Adjustable Impedance Valve** and the **Coaxial Transfer Line** is presented in this paper

Helium Consumption:

Conventional Helium Flow Cryostats do not incorporate extended surface Heat Exchangers (at the sample mount) for cost reasons. The liquid helium is contained in a reservoir similar to a copper cup over the sample mount. As the helium boils and evaporates only the latent heat of vaporization is used to cool the sample mount, there is no provision to capture the enthalpy of the gas as it escapes from the cryostat at 4.2K regardless of the sample temperature. The cooling power of the gas is wasted. Enthalpy of Helium gas from 4.2 to 300K is substantial at 1542 Joules/gm.

The Helitran® incorporates an extended surface tip heat exchanger **(Matrix Heat Exchanger)** which provides efficient heat transfer between the helium and the sample mount. The Liquid helium flows through this heat exchanger and as the latent heat of vaporization cools the sample mount, the liquid evaporates, the gas continues to flow through the exchanger providing additional cooling (capturing the enthalpy of the gas) to the sample mount. If the flow is optimized the helium gas will exit the Matrix Heat Exchanger at a temperature equal to the sample temperature.

Helium usage is dramatically reduced as reported by J. B. Jacobs in Advances in Cryogenic Engineering, Volume 8, 1963, Page 529 as follows:

Amount of Cryogenic fluid required to cool metals (Liters/Kg.) to 4.2K.

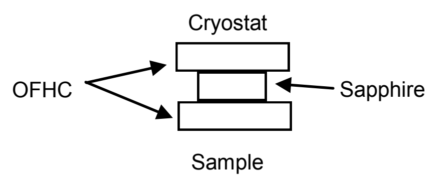
Cryogen	^{4}He	^{4}He
Initial Temperature of 1 Kg of Copper.	300K	77K
Final Temperature of 1 Kg of Copper,	4.2K	4.2K
Using the latent heat of vaporization only. **(Inefficient Heat Transfer)**	**31.1** Liters of Helium	2.16 Liters of Helium
Using the Enthalpy of Gas. (**Efficient Heat Transfer**)	**0.79** Liters of Helium	0.15 Liters of Helium

From this it is clear that for any sample size the consumption of He during initial cooldown is 40 times higher without an extended surface cryostat tip heat exchanger from 300K (room temperature) to 4.2K and 14 times higher when cooling from 77K to 4.2K.

Temperature Range:

Sub 4.2K Operation: The temperature of helium drops to 1.8K when the pressure is reduced across an **Adjustable Impedance Valve**. Pumping on a reservoir, as in a traditional system is not practical as all the helium will evaporate rather quickly. In the Helitran® the suction is applied against the Impedance Valve by attaching a vacuum pump, this reduces the pressure of the helium as it flows through the Matrix Heat Exchanger , The matrix heat exchanger and the conductively coupled sample mount are cooled to below 1.8K.

800K Operation: The high temperature can be achieved by incorporating a thermal switch, composed of a sapphire and OFHC copper arrangement as shown below. The unique property of sapphire is utilized, where its thermal conductivity is equal to that of copper from 4-300K but it becomes a thermal insulator above 300K. The high cooling power of the Matrix Heat exchanger protects the cryostat.



Temperature Stability:

Conventional helium flow cryostats utilize a capillary tube in a vacuum jacket with superinsulation to reduce the radiant heat load. However as the helium absorbs radiant heat the liquid is vaporized and forms bubbles of gas which have a larger volume than the liquid thus forming a temporary block to the flow of the liquid called “vapor binding”. At the delivery end of the transfer line this results in the liquid/gas mixture being delivered in spurts with accompanying pressure and temperature cycling.

The coaxial flow transfer line incorporates a shield flow (See figure) surrounding the tip flow for the entire length of the transfer line. The entrance to the coaxial shield flow tube is provided with a nozzle which results in a pressure and corresponding temperature drop in the shield flow which subcools the tip flow in the center tube. This subcooling prevents boiling and gas bubble formation in the helium, even at very low flow rates. The Helium is delivered at the sample end with the desired temperature stability and low vibrations.

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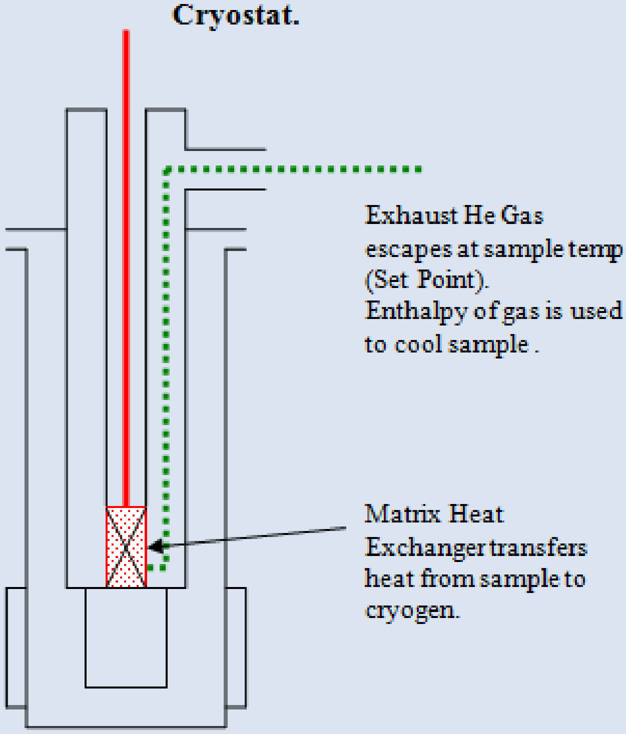
Cryostat Design Features

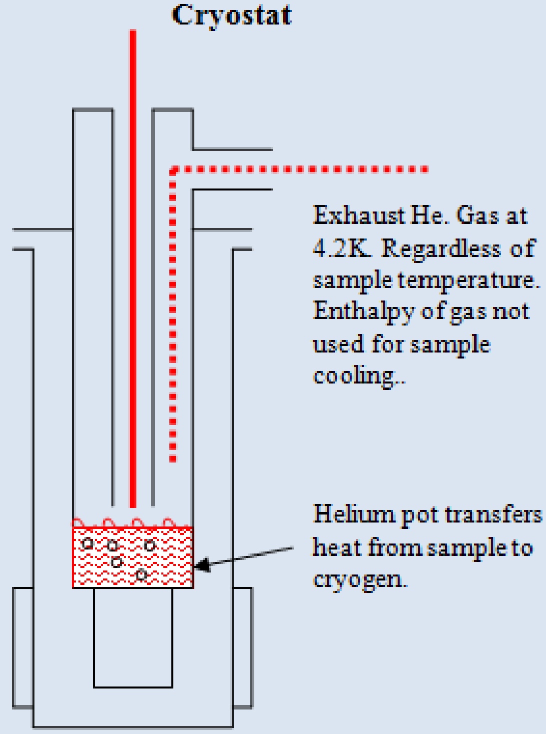
Helitran® Continuous Flow Cryostat.



Helitran® Features:

- Matrix Heat Exchanger for efficient heat transfer between sample mount and cryogen.
- Orientation independent.

Conventional Continuous Flow Cryostat

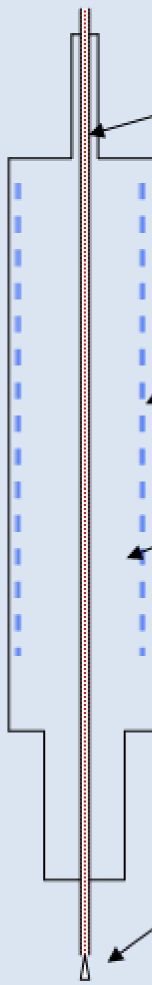


Conventional Helium Flow Cryostat Features:

- Helium reservoir exchanger results in helium boiling with resulting vibrations from the bubbling.
- Orientation dependent as helium is gravity contained.
- Gas escapes at 4.2K. No provision for heat transfer between sample mount and Helium gas from 4.2K to the sample temperature.

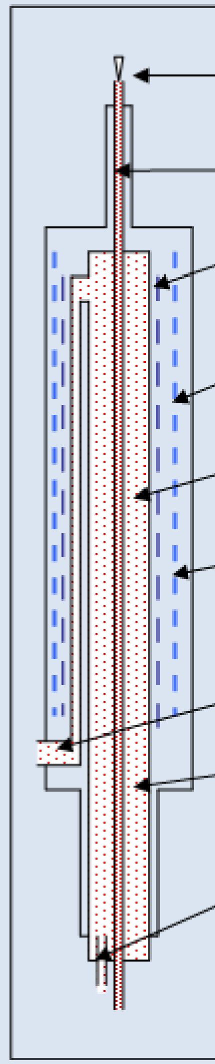
UHV Flow Cryostat for Manipulation

Helium Flow Transfer Line Features



Conventional – Superinsulated, vacuum-jacket Helium Transfer line, Features:

1. Simple inexpensive construction.
2. Flow control at dewar end.
3. Vacuum Jacket.
4. Superinsulation, Aluminized mylar. Provides insulation.
5. Percentage of liquid / gas mixture depends on helium flow rate.



High performance – Coaxial flow, Helium Transfer line, Features:

1. Flow control at cryostat end allows precise flow control (cooling power) at sample. Also permits lower temperature during sub 4.2K operation.
2. Shield flow enters the outer tube through an expansion nozzle, the resulting pressure and temperature drop sub cools the tip flow.
3. Shield flow is surrounded by copper foil radiation shield plus superinsulation in vacuum jacket.
4. Sub cooled tip flow is delivered as 100% liquid at very precise and low flow rate. No “Vapor Binding”.