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QUANTUM HELIUM LIQUEFIER

P650 – UVA

MODEL – QLHe100

100 L/Day

MANUAL

February 2023

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1. SAFETY

GENERAL NOTES

Quantum Technology Corp. systems are designed according to the national safety standards. The installation, operation and service are to be performed in accordance with the technical manual. Contact Quantum Technology with any questions.

SPECIAL NOTICES

Three types of special notices - WARNINGS, CAUTIONS and NOTES are used in this technical manual.

WARNINGS

WARNINGS pay attention to actions or conditions that can result in serious injury or death.

CAUTIONS

CAUTIONS pay attention to actions or conditions that can result in damage to the equipment or the abnormal performance.

NOTES

NOTES provide important, additional information to explain or suggest related problems or operations.

WARNINGS RELATED TO CRYOGENICS

AVOID INJURY.

Extreme cold may cause frostbite. Do not touch any parts with frost while handling system components. Do not splash cryogenic liquids on any areas of clothing or exposed skin; otherwise, skin tissue will get damaged. Always wear eye protection and gloves.

AVOID ASPHYXIATION.

Keep the operation environment properly ventilated.

GENERAL WARNINGS

AVOID ELECTRIC SHOCK.

All electrical supply equipment must meet applicable codes and be installed by qualified personnel.

AVOID INJURY.

Never use compressed gas in the system without a proper regulator. Overpressure can cause serious injury if the system equipment ruptures. Never surpass the maximum allowable working pressure of the dewar.

The M.A.W.P. = 0.5 BAR.

Always wear eye protection when handling pressurized gas lines and other pressurized equipment. Never heat up the pressurized gas line or other pressurized components.

Disconnect gas lines only when the liquefier and compressors are stopped. For special service, only ever disconnect the cold head when the gas returns to room temperature. Material failure and uncontrolled pressure release might cause serious injury. When disconnecting or connecting a gas line coupling avoid loosening the cold head or compressor coupling according to the QPHeC compressor operating manual. Gas pressure can push the coupling with enough force to cause serious injury.

CAUTIONS

PRESERVE YOUR WARRANTY.

Modification to equipment without the consent of the manufacturer will void the warranty. Helium gas with a minimum purity of 99.99+% is required. Unqualified helium gas can damage the system and the warranty is invalid in this condition. It is extremely important to ensure that only high purity helium is used in the liquefier.

PREVENT EQUIPMENT DAMAGE.

Only trained persons are permitted to install and remove the cold head.

Damage to gas lines can result from crimping by repeated bending and repositioning.

AVOID GAS LEAKS.

Check the gasket seal on the male half of each Aeroquip coupling. Be sure that the gasket seal is in place and the sealing surfaces both on the male and female halves are clean before connecting. Replace the gasket seal if it is damaged or missing. Keep the gas line couplings aligned when making or breaking a coupling connection. Leaks might occur due to the weight of the gas line or due to a sharp bend near the connection.

AVOID A MALFUNCTION.

Do not allow air to get into the helium gas cryogenic system. Moisture from the atmosphere can seriously degrade the performance of cold heads. Moisture in the cryogenic system can produce an abnormal noise

2. INTRODUCTION

The LIQUEFIER can produce liquid helium from gas at 6 psig. The feed source of helium gas can be either from high purity bottled helium, or directly from the outlet of the Q16.1 Quantum Pure.

The diagram below shows the complete system with all the major components.



Figure 1: Liquefier Major Components

2.1. Liquefier Major Components

1. **QCH4KH Cold Head:** Used to cool the process helium gas. For more information see section 7 “Cold Head” of this manual.
2. **Cold Box Liquefier:** The cold head and cold box are used to liquefy the helium gas before it enters the dewar. The cold box contains proprietary components used to improve the liquefaction efficiency.
3. **Liquefier Control Box:** The control panel includes a Siemens PLC, touch screen (HMI), data acquisition equipment, and power supplies. The data acquisition equipment can acquire the temperature, pressure, liquid level and monitor the status of the helium liquefier and helium compressor.
4. **Liquefier Manifold:** The manifold includes the inlet ports for bottled and recovered helium. It also contains the shut off valves, pressure regulators and pressure gauges.
5. **Production Dewar:** The production dewar is used to collect liquid helium from the cold box.
6. **Q9.1-CH-10-250 Helium Compressor:** the helium compressors deliver higher pressure, oil free helium gas to the cold heads.

3. INSTALLATION & SETUP

3.1. Electrical Connections

WARNING: Only a licensed professional electrician should perform the electrical connection.

Liquefier Control Cabinet

The Control Cabinet is powered by a standard 3-prong 120VAC connection.

Q9.1-CH-10-250 Helium Compressor

The Helium Compressor is to be powered by a 3-phase, 480VAC, 60Hz connection. The power cable is supplied with a pigtail connection on the Compressor end and Power Source ends. Connect the remote function cable from the PLC to the compressor and the power cable from the compressor to the coldhead. Once the connection is made, turn the Power Switch located on the front of the panel to the ON position. The small screen on the Compressor should start to display values and will wait for Start Instructions from the PLC.

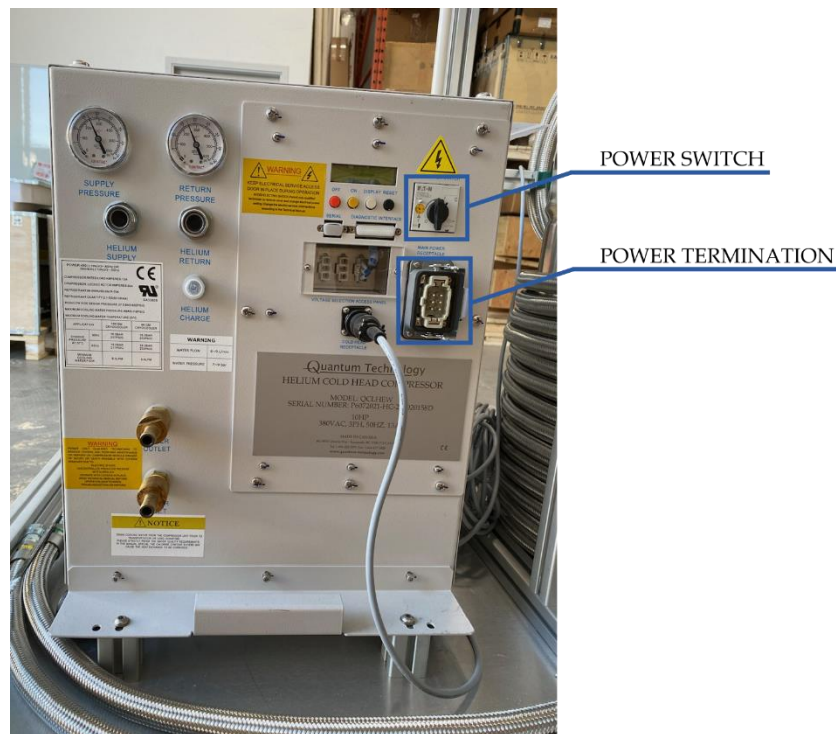


Figure 2: Helium Compressor Connections

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3.2. Cooling Water for Each Helium Compressor

Connect the cooling water supply and return to their respective ports, as shown in Figure 2. Please refer to the Helium Compressor Manual model Q9.1-CH-10-250 for cooling water requirements, additionally see information in the Design Document for cooling water requirements and equipment connections.

CAUTION: *Never run the liquefier without the cooling water turned on. This will overheat the helium compressor and will shut down and/or damage the system.*

3.2.1. Cooling Requirements

Application	Cooling water flow rate
4K GM and 10K GM Cold Head	6 to 9 L/min
Cooling water inlet temperature	5°C to 25°C
Cooling water outlet temperature	46°C maximum
Cooling water supply pressure	8 bar (116 psig) maximum
Pressure drop at 9L/min	<1 bar (<14.5 psig)
Alternative coolant	50% ethylene glycol + 50% water
Ethylene glycol/water (50/50) flow rate	7.8 to 11.7 L/min

For an installation using a water chiller or other circulating cooling system:

Use pure ethylene glycol with water for the coolant antifreeze solution. Do not use commercial ethylene glycol sold for automotive cooling systems, which usually contains a fine grit material that can damage the cooling system.

3.2.2. Water Quality Requirements

Water supplied for cooling the compressor should be filtered through a 300-micron screen.

CAUTION: *Some water sources contain significant amounts of organic contaminants. This contamination can build up in the passageways of the compressor, eventually leading to a blockage. This can cause a shut down and/or damage to the internal components.*

Cooling water must meet certain quality requirements, please review the requirements listed in the P607 Helium Compressor Manual.

3.3. Pump Down & Helium Purge

WARNING: Never exceed the maximum working pressure of the system, which is 10 psig. Always wear protective eyewear when operating the equipment.

WARNING: Follow the step by step procedure to protect the equipment not rated for vacuum service pressures.

The purpose of this step is to remove the contamination (air) from the liquefier dewar and piping and backfill with helium.

Initial Setup and Assumptions:

- If there is any liquid in the dewar, make sure to transfer as much of it out as possible before starting this procedure.
- Ensure the liquefier is in the “OFF” mode, indicated at the top of the screen.
- On the HMI, navigate to main menu by tapping the “Quantum Technology” logo in the top left of the screen. Navigate the “System Enable” screen and ensure the system is enabled.
- Connect vacuum pump to the KF-25 port located on the manifold of the liquefier (IC513).
- On the HMI, go to the Liquefier Alarms tab and change Dewar Low Pressure setpoint to -15 PSI.
- Solenoid Valves (XY) can be controlled on the HMI. They can fail open or closed so for the purpose of this procedure they will be referred to as “ON” (green) or “OFF” (red) on the HMI.

Sub Step A - Check status of each valve:

- A1) Open BV509 (to FC501) and BV510 (FC501 bypass)
- A2) Open BV501, BV502, BV503, BV504, and BV505 (Supply valves to each Cold Head)
- A3) Open BV515 (to FC502) and BV516 (FC502 bypass)
- A4) Close BV520, BV521, BV522, BV523, BV524 (Cold head purge lines)
- A5) Close BV525 (Purity meter supply valve)
- A6) Close BV529 (Helium Gas Feed)
- A7) Open NV503
- A8) Close BV526 (Recovery gas valve)

Sub Step B – Setup system to purge from IC253

- B1) Ensure an ultra-high purity (UHP) helium bottle (>99.999% He) is connected to IC523.
- B2) Ensure there is UHP helium flowing to the liquefier manifolds through IC523.
- B3) Ensure BV527 is open and BV531 is closed.
- B4) Turn on vacuum pump with vacuum gauge. Ensure vacuum pump can reach <100 microns.

Sub Step C – Pump and purge cycle

- C1) Drain any residual pressure in the system by opening BV530 and ensure FE502 is fully open.
- C2) Close BV530.
- C3) Open BV531. Monitor PI502 and PT502.
- C4) Pump down to <100 microns (100mTorr)
- C5) Close BV531. Confirm vacuum inside the liquefier is stable (if it climbs, there is a leak in the system).
- C6) Confirm UHP supply pressure is set to 6 PSI
- C7) Open BV527 slowly.
- C8) Monitor PI501 and ensure it rises to 1 PSI. If the system is being commissioned, bleed the differential pressure sensors on the liquefier dewar.
- C9) Close BV527.

Repeat this pump & purge cycle (steps C1 to C9) a total of three times. Ensure purity remains above 99.995%.

Sub Step D – Preparation for liquefaction

- D1) Open BV529 and bring the liquefier (PT502) up to operating pressure (8 psig).
- D2) Close BV510 and BV516
- D3) Close NV503

4. LIQUEFACTION

Now that the liquefier has been filled with high purity helium and the cooling water is turned on it is safe to start cooling down the dewar. This step should take 12-24 hours to bring the dewar temperature down to 70K and another 12-24 hours to get to <6K. The liquefier will start producing liquid helium once the dewar temperature is below ~6K.

CAUTION: Only use high purity (99.995+) helium to feed the liquefier

This can be achieved by using high purity bottled helium or from the QuantumPure purifier.

The following is a quick start guide to operating the liquefier. It also explains the basic function of some of the key components. A detailed explanation of the controls can be found in the controls section of the manual.

4.1. Cool Down

- The objective is to cool the hot dewar with maximum flow, then gradually reduce the flow until the dewar reaches liquefaction temperature. Then increase flow to produce liquid.
- Navigate to the Liquefier Settings tab and confirm that all settings are congruent with user specifications
- Navigate to the Liquefier He Compressor tab and ensure CH501, CH502, CH503, CH504 and CH505 by pressing the “Enable All” button.
- Navigate to the Liquefier Overview tab and set the system to “Auto.” Toggle the system to “ON.”
 - Verify cold the heads start. There will be a green circle on HMI to indicate they are on. You should hear an audible “chirping” sound from the compressors at about ~1 Hz frequency.
 - Verify the flow controllers (FC501 and FC502) are allowing flow to the liquefier.
- The liquefier will automatically switch to liquefy mode when any of the following Mode End conditions occur:
 - Low Coldhead Temp: the coldhead temperatures drop below the setpoint.
 - Inlet-Outlet Flow Diff: the differential flow between flow controllers is higher than the flow differential set point for the outlet flow differential time,
 - Dewar Level: Dewar level increases above set point.
- During initial cool down leave NV503 closed until the production dewar reaches 100K. At this point or close to it, open to 2 rotations from close.

**** During cool down ALWAYS ensure that there is an adequate supply of helium. ****

4.2. Liquefy

- Key component:
 - FC501 regulates the inlet pressure.
 - FC502 controls flow out of the liquefier to help maintain pressure and control boiloff
- System will continue maintaining set pressure and producing liquid until the operator intervenes or the dewar level sensor trips.

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4.3. Transfer

Transfer mode can be accessed using the toggle button on each liquefiers' overview page. Pressing the button will put the system into a pre-transfer state where pressure is dropped to allow for smooth transfers and minimize boil off. For specific information regarding the controls of the system, please see the Controls section of the manual.

4.4. Regenerate

The Regeneration process is Manual. Regeneration is required when the liquefaction rate had dropped lower than normal performance.

- The main indicator for a contaminated coldhead is the temperature. Frozen contaminants will drop the temperature of a coldhead. When the temperature falls below 3.0K, the system is designed to provide a warning to the operator that a cold head may have become contaminated.
- To begin a manual regeneration, place the liquefier in to manual mode.
 - Go to the coldhead compressor screen and place the compressor in to manual. Manual run and pause should be off
 - Turn on manual Heaters for all 5 cold heads. The heaters will automatically shut off at 300K.
 - Ensure P501 is off
 - Close BV501, BV502, BV503, BV504, BV505
 - Open BV520, BV521, BV522, BV523, BV524
 - Ensure the rotameter FE503 for the cold box being regenerated are open and allowing contaminants to vent out of the check valves. Set the flow rate to between 4-6 SLPM.
- When the cold box has reached 300K, Close FE503 and return ball valves to liquefaction position.
- Place system back in to auto mode, the compressors will also require being placed in auto mode.

4.5. Idle Mode

- This mode gets used when
 - there is no supply gas available
 - or supply purity is too low to run
 - or user enters idle mode on HMI
- The inlet valves close, and the system maintains pressure set points and re-liquefies boil-off

Full description of HMI controls may be found within Control Manual

5. SPECIFICATIONS

Guaranteed Specifications	100L/day @ 6 psig
Typical liquefaction rate	\geq 100L/day @ 6.0 psig
System Electrical (compressor power input)	3 phase, 480V (60Hz), 13A (per compressor)
System Electrical (control cabinet power input)	1 phase, 120V (60Hz), 5A
Helium purity requirement	> 99.995%
Cool down time (to full load liquefaction)	< 24 hours
Dewar Capacity	250L
Liquefier System Dimensions (in)	56x56x86
Liquefier System Weight (lb)	1200
Cooling Water	9 L/min per compressor (for more details see compressor manual)
Ambient Temperature Range	4 to 40°C

Table 1. Specifications and Parameters

6. LABELS

Quantum Technology

HELIUM LIQUEFIER

MODEL Q1.1LHe100-CB-250

SERIAL NUMBER: P6502023-LHE100-CB-250

LIQUEFACTION RATE: 100 L/DAY AT 5 PSIG

MADE IN CANADA

#4-38936 Queens Way, Squamish, BC, V8B 0V2 CANADA

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CONTROL BOX

MODEL Q5.1-CON-LIQ-100

SERIAL NUMBER: P6502023-CON-LIQ-100

120 VAC / 1 PH / 60 HZ / 5 A

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