CRYOMECH

Automatic Purifier

INSTALLATION, OPERATION and ROUTINE MAINTENANCE MANUAL

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Section A: Introduction

The Cryomech Automatic Purifier is designed to automatically purify helium. It utilizes a cryogenic trap to purify helium to 99.999% purity. The system has a fully integrated control system that controls the automatic operation of the purifier, including regeneration.

The cryogenic trap is attached to a GM pulse-tube cryorefrigerator that supplies the cryorefrigeration necessary to cool the trap. The cryorefrigerator is the most complicated component in the complete system. Following this manual is the Cryogenic Refrigerator Manual.

It is imperative that you read the Cryogenic Refrigerator Manual before unpacking and installing your system. It is necessary to read the Cryogenic Refrigerator Manual to be informed about safety regulations, certification, and compliance issues.

A.1 Description of the Automatic Purifier

The Automatic Purifier is a self-contained, automatic system that purifies impure helium gas to 99.999% or higher purity. It is fully assembled and self-contained on a cart. The system utilizes a touchscreen PLC panel to control and monitor the operation of the purifier.

The impure helium that enters the system's inlet is passed through a room-temperature adsorber that traps any moisture in the gas. It then goes through a pressure regulator and enters the cryogenic trap. As the helium passes through the trap it is purified and exits the trap at 99.999% or higher purity. The gas continues on to the system's outlet, with some flow passing through a sensor that checks the purity of the gas.

The purifier continues to operate in this function until it detects a change in conditions, such as the cryogenic trap becoming saturated or a low inlet pressure caused by the upstream gas supply running low. The control system automatically changes the mode of the purifier in response to these changing conditions. Most temporary conditions, such as low inlet pressure, cause the system to enter a temporary standby mode until the condition returns to normal.

When the cryogenic trap becomes saturated the system will enter a regeneration cycle that automatically regenerates the trap. The system does this by warming the trap to room temperature, venting the contaminants from the trap, and pumping the trap with the integrated vacuum pump. After this process is complete the system begins cooling down again with the cryogenic refrigerator. When the system reaches a low temperature it returns to normal purification.

Figure A-1: Automatic Purifier

Section B: Installation

WARNING

Be sure read Cryogenic Refrigerator before unpacking your system and follow this manual for the installation requirements of the cryocooler.

The Automatic Purifier will be shipped to you complete and ready for you to install into your Helium Recovery System.

B.1 Installing the Automatic Purifier

The compressor that is integrated into the Automatic Purifier requires cooling water and electrical power. Please refer to the Cryogenic Refrigerator manual for these installation requirements and instructions.

The Automatic Purifier has three 1/4" Male Aeroquip gas connections: In, Out, and Sensor Vent. These three connections must be connected to the correct locations for the system to operate. These connections should be made as follows:

Figure B-1: Purifier helium gas connections

1. The **In** port supplies impure helium gas to the purifier from the pressurized storage cylinders. This port connects to the 1/4" Male Aeroquip to 1/4" Male Aeroquip flex line. The other end of this line connects to the pressure regulator at the storage cylinders.

Figure B-2: Pressure regulator at storage cylinders

2. The **Out** port supplies 99.999% or greater purity helium gas, typically to a Cryomech Liquid Helium Plant (LHeP). This port connects to the 1/4" Male Aeroquip to Quick Connect flex line. The other end of this line connects to the inlet of the LHeP.

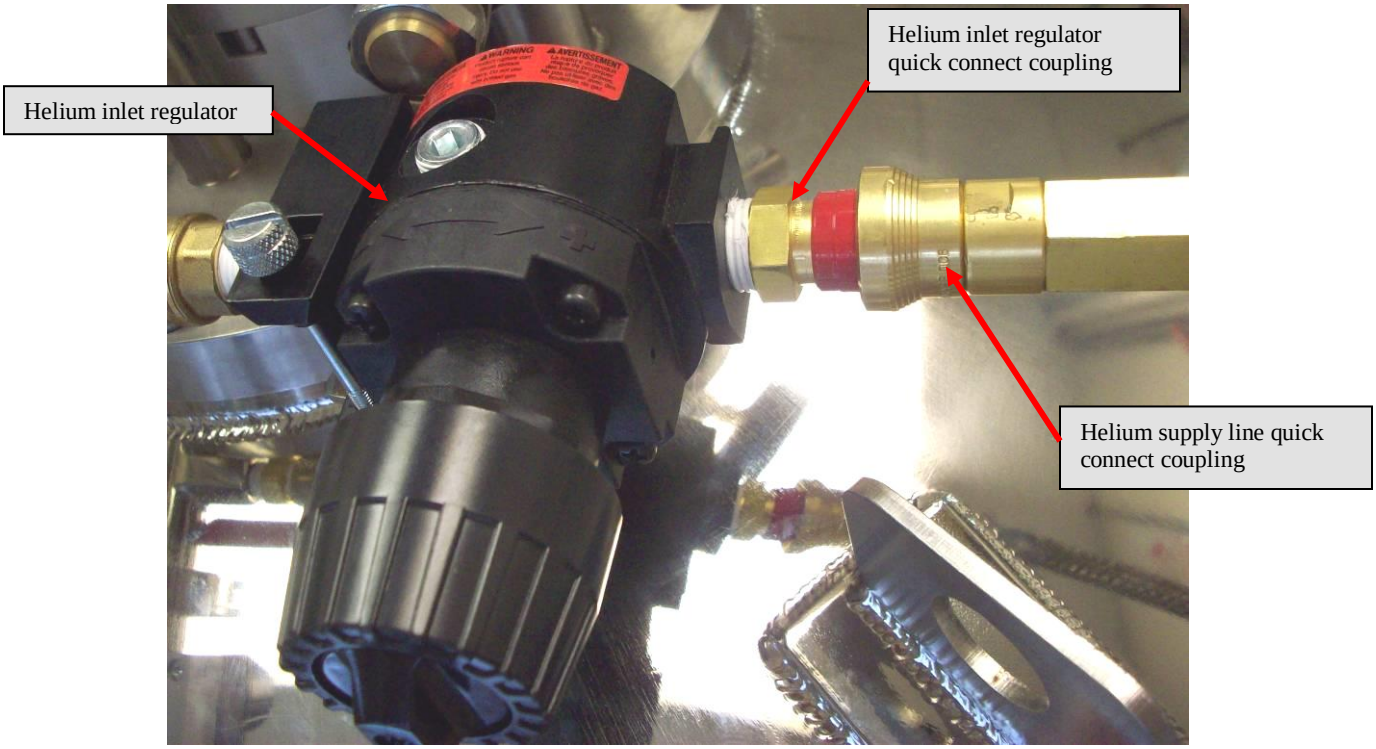


Figure B-3: Connecting the helium supply line quick connect to the LHeP

3. The **Sensor Vent** port directs the gas that purges the purifier and sensor back into the recovery system. This port connects to the 1/4" Male Aeroquip to 1/4" Male Aeroquip flex line. The other end of this flex line connects to the 1/4" Male Aeroquip on the Low Pressure Manifold.

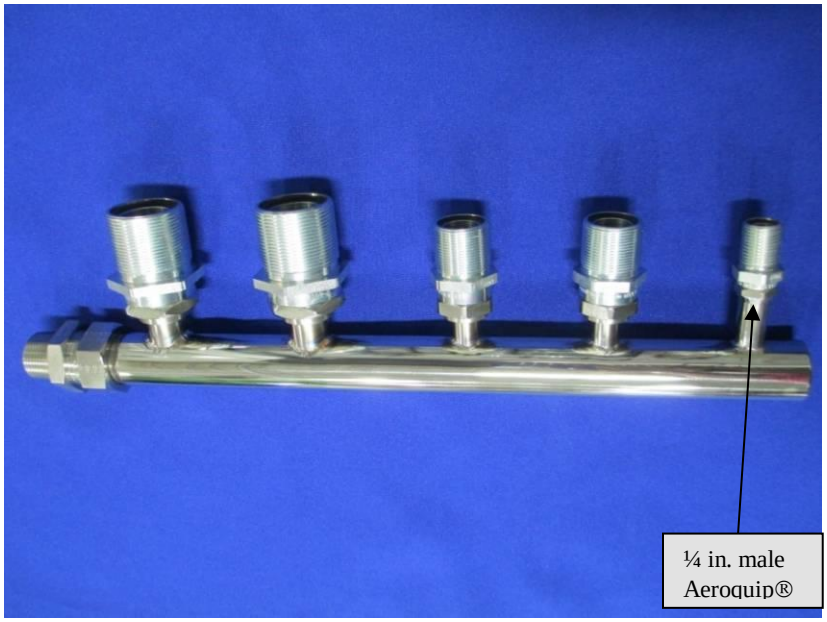


Figure B-4: Low pressure manifold

Section C: Operation

C.1 Checks Before Operating

1) Check the helium pressure in the Compressor Package - the gauges should read the pressure specified in Appendix A of the cryorefrigerator manual.
   - If the pressure is too high, vent some of the helium following the instructions in Section 6 in the cryorefrigerator manual.
   - If the pressure is too low, add helium following the instructions in Section 8 in the cryorefrigerator manual.
2) Make sure the input power meets the specifications on the identification label.

> **CAUTION**
>
> A voltage deviation of more than 10% above or below the voltage rating can cause compressor motor overheating and possible failure. *Indications of voltage operation outside that range will void the compressor warranty*.

3) Make sure the flow rate and temperature range of the cooling water meet the requirements specified in Section 5 in the cryorefrigerator manual.
4) Check that the dedicated circuit breaker is on.

C.3 Startup Procedure

1) Switch on the Compressor Package power at the compressor circuit breaker.
2) Switch on the power to the purifier controls by switching on the circuit breaker to the right of the PLC. The PLC touchscreen will begin to start up.
3) Press the **ON** button on the PLC touchscreen to start automatic operation of the Automatic Purifier.

C.4 Normal Operation Behavior

C.4.1 Normal Compressor Pressures

On start up a pressure differential should be noticed immediately between the high and low pressure gauges. This differential will decrease as the cold head cools down.

The typical pressure differential is approximately 220 to 250 PSI (15.2 to 17.2 bar) with a 5 to 10 PSI (.34 to .7 bar) bounce on the pressure gauge needles.

C.4.2 Normal Sounds

When operating properly, the cryorefrigerator will emit a rhythmic squeak or chirp. This noise is an indication of the proper flow of helium gas within the system.

C.5 Shutdown Procedure

Press the **OFF** button on the PLC Touchscreen. This will switch off the control system and compressor. Switch off the panel mounted circuit breakers to shut down the control system, switch off the circuit breaker on the compressor to shut down the compressor package.

C.6 PLC Touchscreen Operation

The PLC touchscreen controls the operation of the Automatic Purifier. It does this by reading the status of the system's pressures, temperatures, and the purity sensor, and by controlling valves, heaters, the cryorefrigerator, and the vacuum pump.

C.6.1 Home Screen

The PLC Home screen displays the current control mode of the system as well as the status of all valves and sensors. The Home screen is shown below.

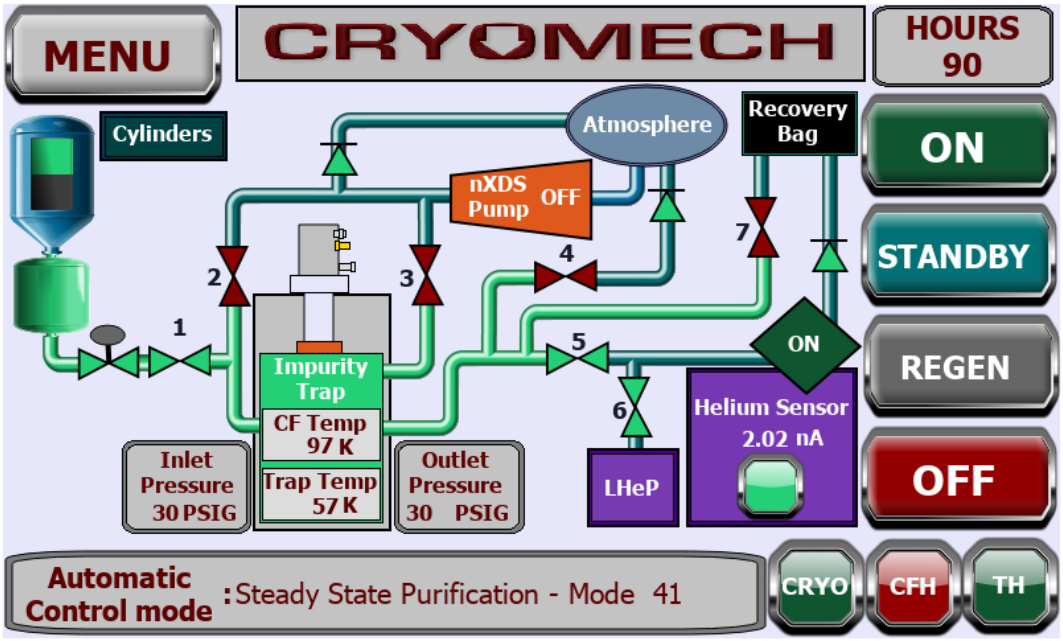


Figure C-1: Home screen

The Home screen has the following buttons and indicators:

- **Menu**: Pressing this button displays the Menu screen.
- **On:** Pressing this button turns the system on. The system will begin automatic operation in the correct operating mode based on the system's conditions.
- **Standby:** Pressing this button puts the system into a standby mode. The standby mode closes the inlet and outlet valves and uses the heaters on the cryogenic trap to maintain the system at a stable temperature.
- **Regen:** Pressing this button manually puts the system into the regeneration mode. The system will automatically resume normal operation and begin cooling down after the regeneration mode is completed.

- **Off:** Pressing this button turns the system Off, putting the system in mode 00, closing all valves, and turning the Cryorefrigerator and all heaters off.
- **Cryo:** This indicator shows the status of the Cryorefrigerator. Green is on, red is off.
- **CFH:** This indicator shows the status of the Counterflow Heater. Green is on, red is off.
- **TH:** This indicator shows the status of the Trap Heater. Green is on, red is off.

C.6.2 Operating Modes

During automatic operation the system goes through a variety of modes. A list of the system's modes and a brief description of each mode is below. The modes ending in 1 are normal operating modes, and the system will step through each mode ending in 1 from 11 to 71 during a normal operation cycle. Modes ending in 2 are low inlet pressure modes and keep the system in a standby mode while waiting for inlet pressure to rise to normal levels. Modes ending in 3 are de-plug modes that attempt to clear a frozen blockage in the cryogenic trap by slightly raising the temperature.

- Mode 00: System off
- Mode 11: System cool down from room temperature to “purity purge temp”
- Mode 12: Low inlet pressure on cool down between room temperature and “purity purge temp”
- Mode 21: System cool down from “purity purge temp” to “purification start temp”
- Mode 22: Low inlet pressure on cool down between “purity purge temp” and “purification start temp”
- Mode 31: Transition to steady-state purification (purge & sensor startup)
- Mode 32: Low inlet pressure during transition to steady-state purification
- Mode 33: High pressure differential during transition to steady-state purification
- Mode 35: Transition to steady-state purification (purge only)
- Mode 41: Steady-state purification
- Mode 42: Low inlet pressure during steady-state purification
- Mode 43: High pressure differential during steady-state purification
- Mode 44: Steady-state purification temperature regulation
- Mode 51: Trap warm-up for regeneration
- Mode 61: Vent trap charge
- Mode 71: Pump trap
- Mode 81: System standby

C.6.3 Menu

Pressing the **Menu** button on the Home screen displays the Menu screen. The Menu screen has 4 main options: **Home**, **Control**, **Data**, and **Settings.** The **Home** button displays the main Home screen. The other 3 buttons display submenus. A description of these submenus is given in the following sections.

C.6.4 Control Menu

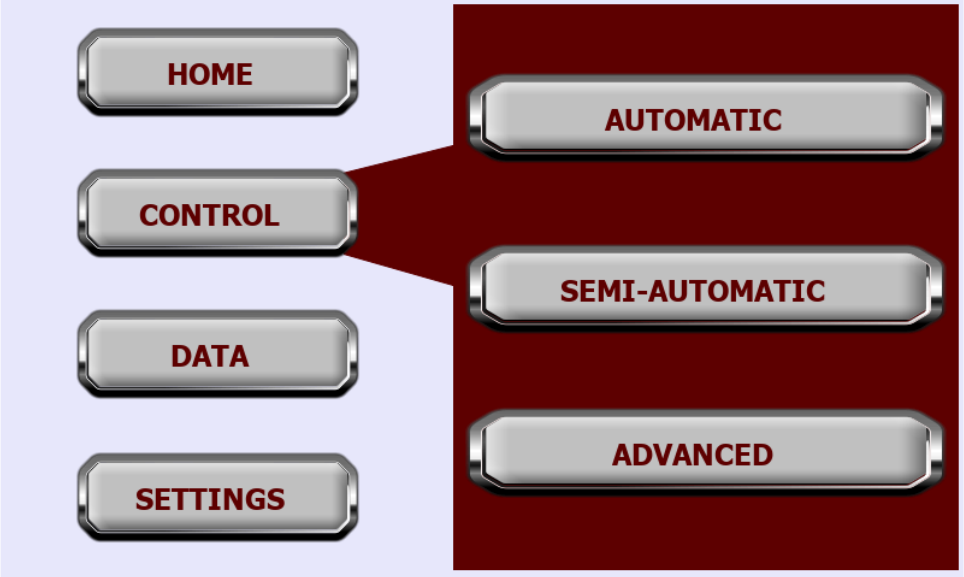


Figure C-2: Control menu

The **Control** menu allows the user to change the control mode. It has 3 options:

- **Automatic:** This button will place the system in its automatic operating mode and return the display to the Home screen.
- **Semi-Automatic:** This button displays options for the Semi-Automatic operating mode.
- **Advanced:** This button displays the Advanced options.

The **Semi-Automatic** operating mode allows the user to select which mode the system should operate in. The system will switch to that mode, but continue to operate in automatic mode once the conditions for entering another mode are met. It is semi-automatic because the system has some control over which mode the system actually enters. When a mode is chosen in the Semi-Automatic operating mode the system checks whether it is possible to enter that mode. If it is not possible then the system will enter the closest possible mode.

For example, for Mode 41, Steady-state operation, the system must be cold enough to allow proper purification. If the user selects Mode 41 in Semi-Automatic mode then the system will check the temperature. If it is not cold enough then the system will enter the

proper cool down mode. Semi-Automatic mode exists to add additional functionality but is not needed for normal operation.

ST1 = Mode 11-12, ST2 = Mode 21-22, ST3 = Mode 31-35, ST4 = Mode 41-44, ST5 = Mode 51, ST6 = Mode 61, ST7 = Mode 71

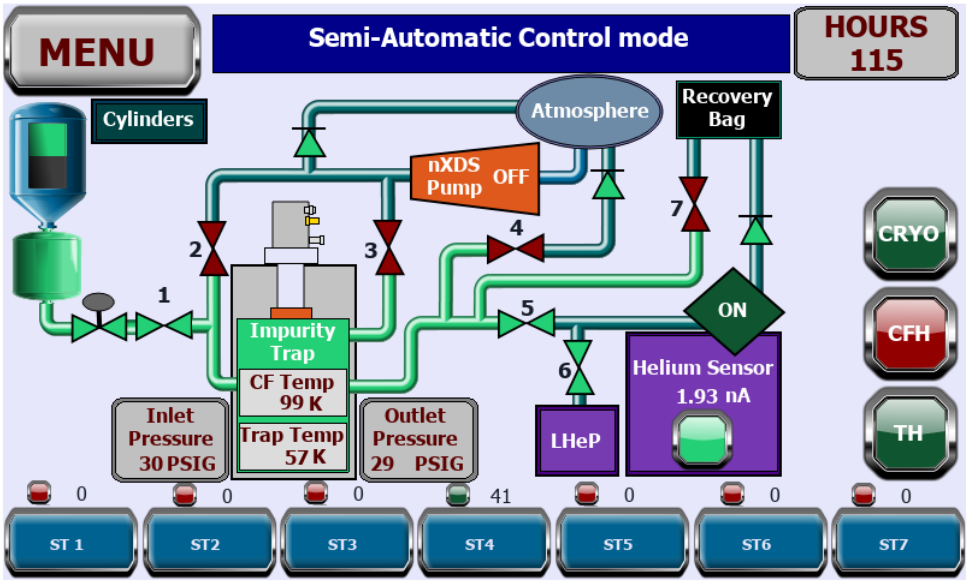


Figure C-3: Semi-Automatic mode

The **Advanced** menu has an option to change the pump duration. The default duration is 30 minutes, but the system can be switched to an extended pump cycle when required. Pressing the **Extended Pump On** button changes the pumping time to 24 hours. Pressing the **Extended Pump Off** button changes the pumping time to 30 minutes. The pumping time set on this screen will be used every time the system regenerates until it is changed on this screen. This mode is only used in in extreme scenarios where contamination is an issue.

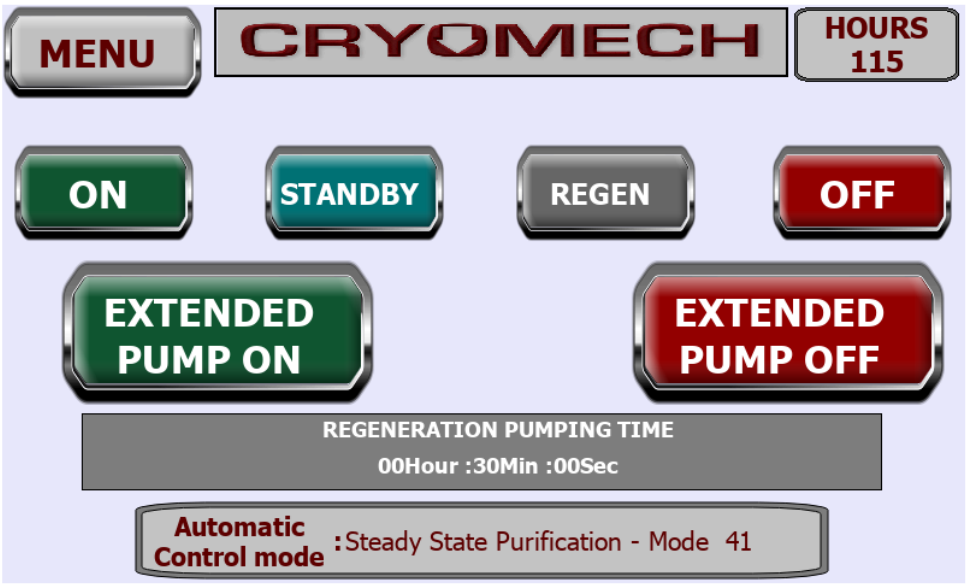


Figure C-4: Advanced mode

C.6.5 Data

The Data menu gives the option of viewing the **Operation Graph, Temperature Graph,** and **Pressure Graph,** with their respective buttons, or using the **Download** button to open the Download menu and download data to a USB drive.

The **Graph** screens are all similar and display a basic graph of their respective data.

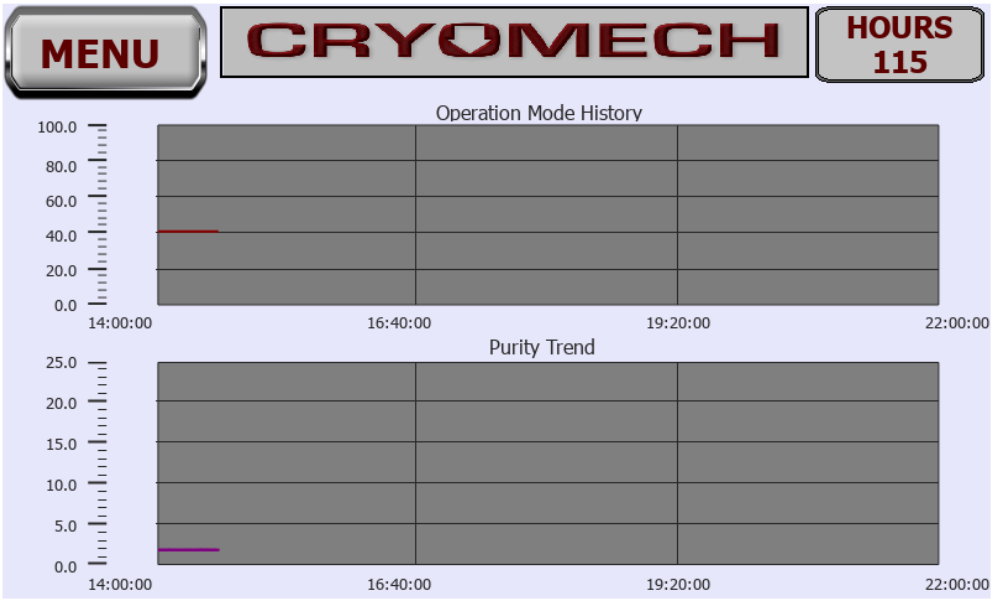


Figure C-5: Graph display

The **Download** screen allows the user to download the purifier's stored logs of Operation Mode, Helium Purity, Trap Temperature, Counterflow Temperature, Inlet Pressure, and Outlet Pressure. These files must each be downloaded individually.

To download the files, insert a USB drive into the USB slot to the right of the PLC touchscreen. Press the Download button corresponding to the data that you want to download. The data will be saved in a .csv (comma-separated values) file format on the USB drive. Before removing the USB drive, press the Eject button with the upward facing arrow to safely eject the USB drive.

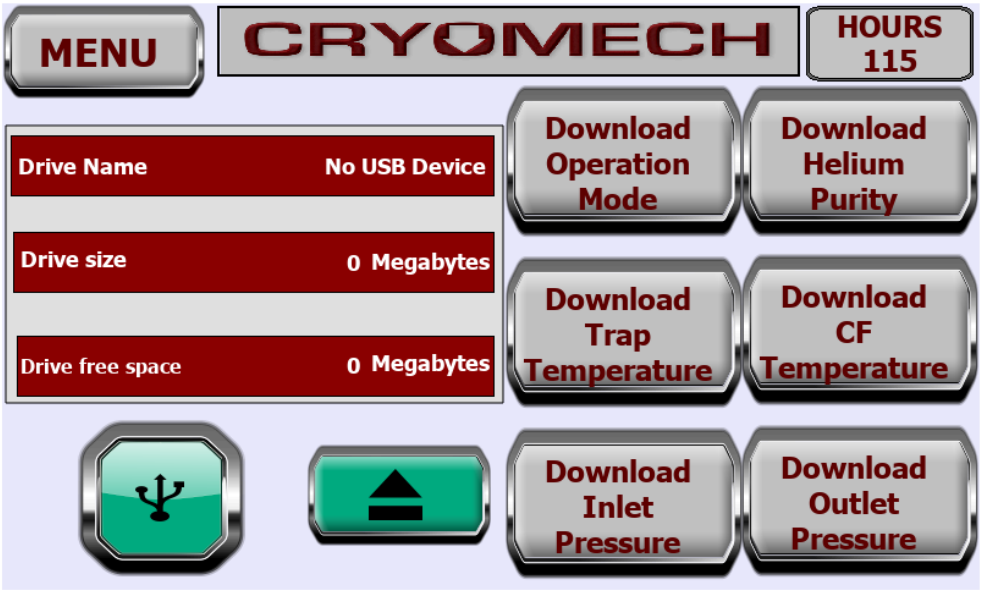


Figure C-6: Download display

C.6.6 Settings

Pressing the **Settings** button on the Home screen displays the Settings menu. The settings in this section should not be changed without first contacting Cryomech as they can have a significant impact on the system's performance.

The **Trap Temperature Control** screen allows the user to change the temperature set point of the cryogenic trap.

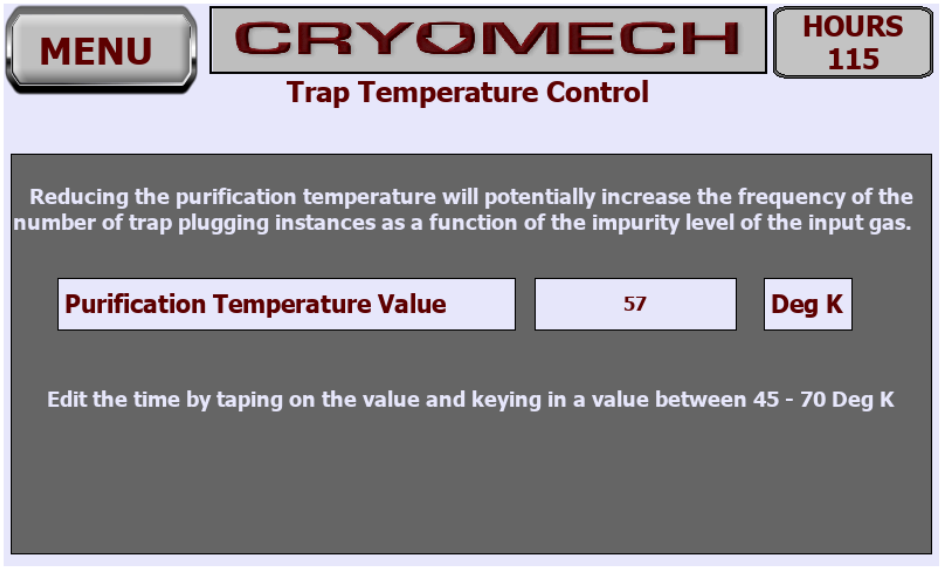


Figure C-7: Trap Temperature Control display

The **Heater Circuits** screen allows the user to turn the separate heater circuits on or off.

This feature provides some duel redundancy but is only necessary if the one or more of the heaters fail due to an internal heater short circuit failure. Running the purifier in this configuration will reduce the auto purifiers performance. Please contact Cryomech in the event of a heater failure.

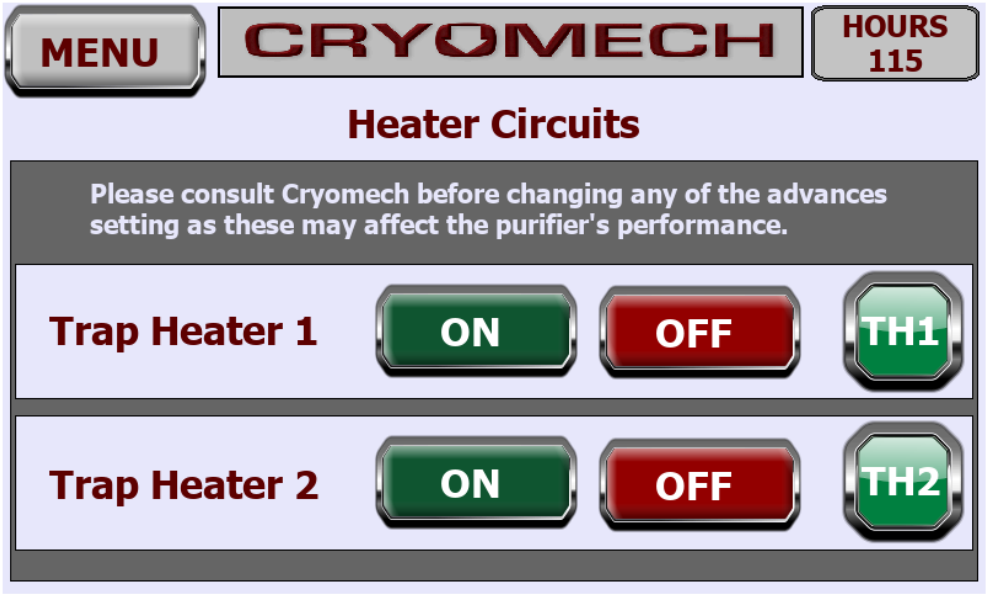


Figure C-8: Heater Circuits display

The **About** screen displays information about the system and its software.

Section D: Maintenance

D.1 Cryorefrigerator Maintenance

The cryorefrigerator that is part of the Automatic Purifier requires periodic maintenance. Please consult **Section 8: Routine Maintenance** in the cryorefrigerator manual following this section for a maintenance schedule and instructions.

D.2 Automatic Purifier Maintenance

The Automatic Purifier may require periodic manual regeneration of the water adsorber at the inlet of the purifier, depending on the moisture content of the impure inlet gas. **Note that this water adsorber is not to be confused with the adsorber inside the compressor that is part of the cryorefrigerator. See figure D-1.**

Figure D-1: Location of the Sight Glass and Water Adsorber

The sight glass on the left side of the Automatic Purifier should be checked weekly to monitor the status of the water adsorber. The dot in the center of the sight glass will change color to indicate the amount of water present in the adsorber. The beads surrounding the dot will also change color, but the dot should always be monitored, not the beads.

- If the dot is blue, the adsorber does not need to be regenerated.
- If the silica gel is blue, but the dot is pink, the adsorber is saturated and needs to be regenerated.
- If the silica gel is pink and the dot is pink, the adsorber is very saturated and needs to be regenerated.

Figure D-2: Blue dot signifies a dry condition.

Figure D-3: Pink dot signifies a saturated adsorber. **Regenerate adsorber.**

Figure D-4: Pink dot and pink beads signify an oversaturated adsorber. **Regenerate adsorber.**

D.2.2 Vacuum/Charging Station

Construct a vacuum/charging station similar to **Figure D-5**, by following these guidelines*****:

A. The vacuum pump can reach approximately **25 microns**, or better, pressure.
   - Due to the significant amount of water in the adsorber, a dry scroll pump is recommended for this application.

B. The **vacuum gauge** can read **25 microns**, or less.

C. The compressed helium cylinder contains **99.999% pure helium**, or greater.

D. A **high pressure regulator** is securely attached to the helium tank, leak tight.

E. The **vacuum manifold** is connected to the pump, leak tight.

F. The **charging flex lines** are connected to the manifold fittings, leak tight.

G. The **helium flex line** is connected to the manifold and regulator, leak tight.

H. The **service Aeroquips®** are functional; inspect gaskets, remove debris, etc.

* ***A.—D****. are user-acquired materials;* ***E.—H****. are provided by Cryomech.*

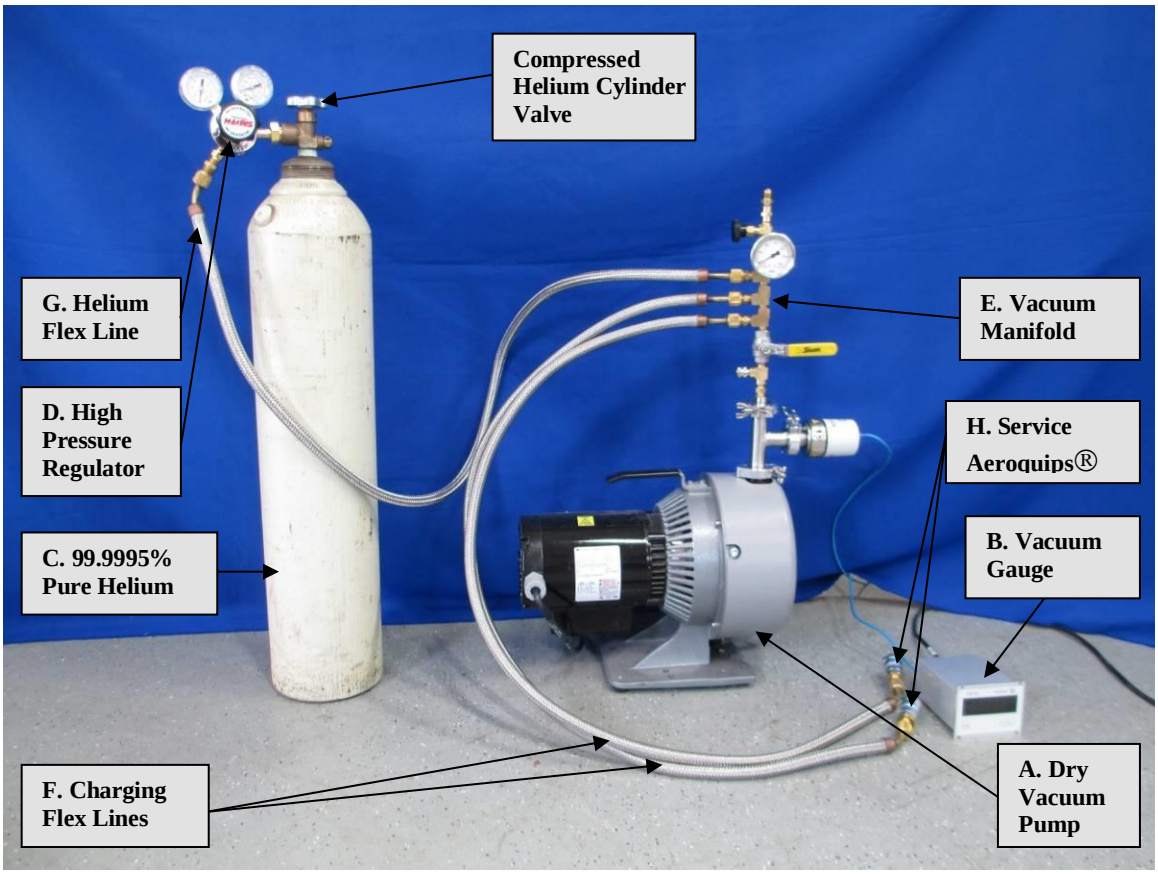


Figure D-5: Typical Vacuum/charging system

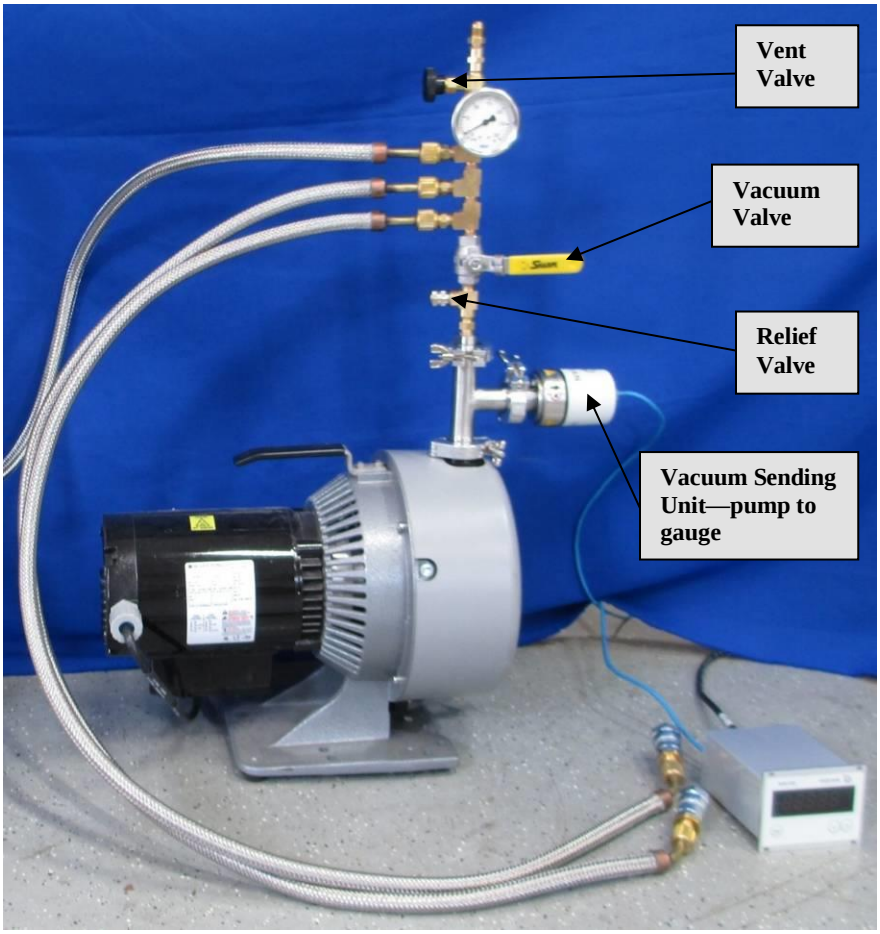


Figure D-6: Close up of vacuum/charging manifold and dry pump

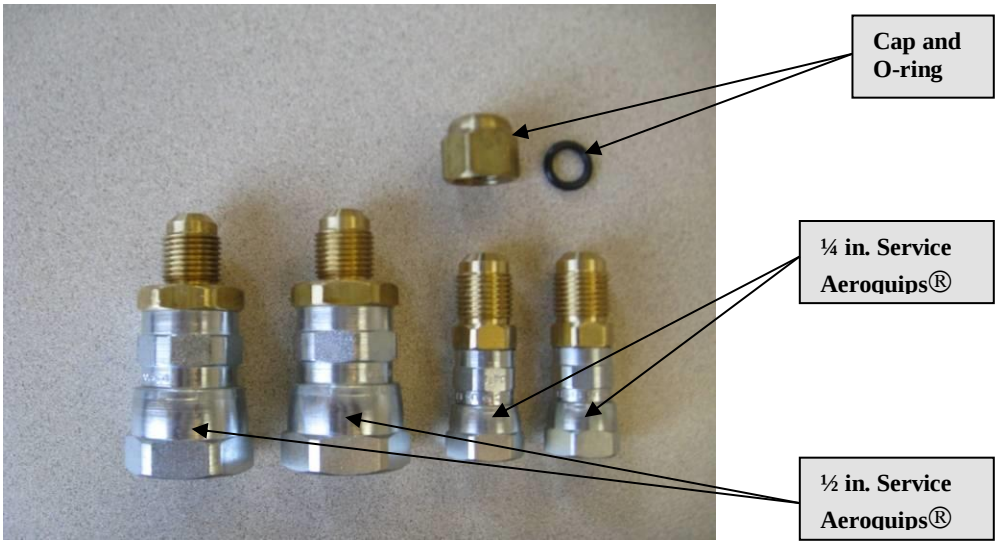


Figure D-7: Service Aeroquips®

D.2.3 Regenerating the Purifier Water Adsorber

1. Remove the left side panel from the Automatic Purifier by removing all button head cap screws on the left side panel.

> **CAUTION**
>
> At no time should the Aeroquip® couplings be removed from purifier when adding or removing the ¼ in. helium flex line and adsorber. The purifier connections are equipped with Aeroquip® couplings for sealed removal.

2. Disconnect the two **¼ in. Aeroquip® couplings** on the adsorber**. See Figure D-8**.
   - Use two ¾ in wrenches: Hold the male Aeroquip®, turn the female Aeroquip®.

Figure D-8: Adsorber

3. Remove the **adsorber clamp** using a screwdriver to loosen the screw.
4. Remove the adsorber.
5. Proceed to **Section D.2.4**

D.2.4 Regenerating purifier adsorber

1. Close the **compressed helium cylinder valve**. **See Figure D-5.**
2. Close the **vacuum valve** on the vacuum/charging station. **See Figure D-6.**

3. Connect the proper size service Aeroquips® to the end of the flex lines on the vacuum/charging station.
4. Connect the service Aeroquips® to the adsorber.
5. Vent the helium charge to atmosphere with the helium vent valve. **See Figure D-6.**
6. Close the helium vent valve.
7. Open the vacuum valve. **See Figure D-6.**
8. Wrap the **heating jacket**, provided with the recovery system, around the adsorber after it has been removed from the purifier assembly front panel.
    - The Aeroquip® connector on the bottom of the adsorber should be outside of the heating jacket. **See Figure D-9.**

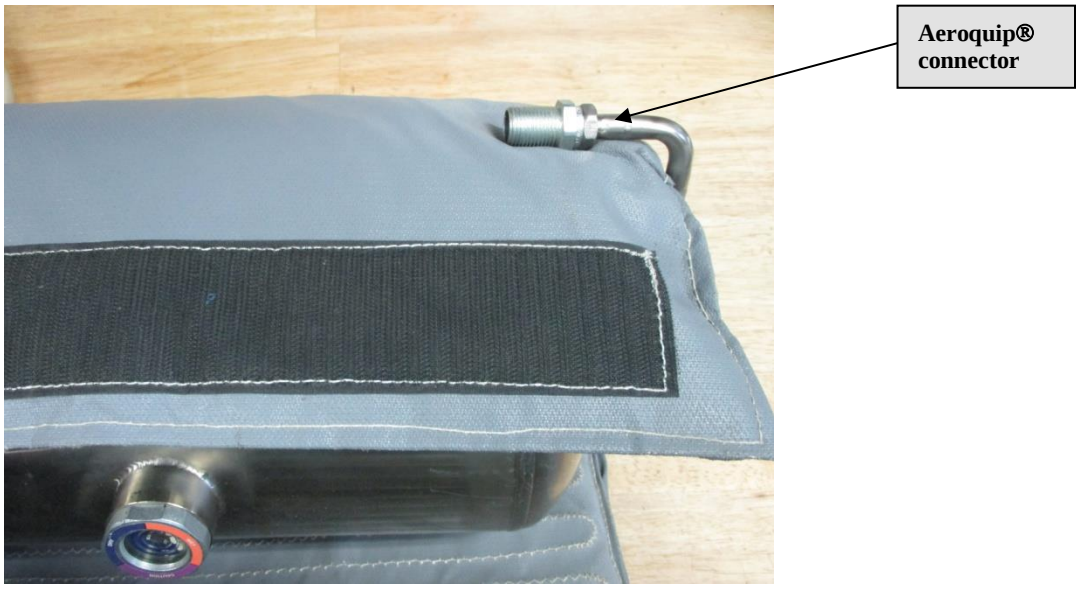


Figure D-9: Heating jacket, containing adsorber

- The heating jacket should not cover the adsorber sight glass. Position the sight glass at the opening of the heating jacket and tuck the flaps around it. The jacket should be as tight as possible around the adsorber whilst keeping the sight glass uncovered. **See Figure D-10**.

Figure D-10: Heating jacket with uncovered sight glass

9. Plug the heating jacket power cord into an electrical socket.
    - The heating jacket will automatically turn on, maintain a temperature of **225ºF** (107ºC), and begin to bake the adsorber.

> **CAUTION**
>
> The heating jacket temperature is set to **225ºF** (107ºC). The outside of the jacket will be hot; do not touch without personal protective equipment.

    - Power on the vacuum pump and evacuate the adsorber for **at least 24 hours**,
        - The vacuum pump valve should be open.
        - Allow vacuum to reach its lowest pump value; if it does not reach 25 microns or less, the pump may be bad or there may be a leak.
        - The dot in the center of the sight glass will turn blue. **See Figure D-2.**
10. Unplug the heater jacket.
11. Close the vacuum pump valve on the charging manifold.
12. Pressurize the compressor and/or purifier adsorber to **50 PSIG** of **99.999%** or greater purity helium from the cylinder. **See Figure D-5.**
    - Allow the adsorber to cool down to room temperature.
13. Remove the adsorber from the heating jacket and reinstall.

D.2.5 Maintaining adequate vacuum

1. The helium purifier operates at cryogenic temperatures and the necessary thermal insulation is provided by two vacuum spaces surrounding the purifier. The vacuum in the insulation space may deteriorate over time. If the cool down time **exceeds nine hours**, a soft vacuum may be the cause.
2. To restore a deep vacuum, a vacuum valve operator and vacuum pump capable of reaching $1x10^{-6}$ torr are needed. The valve operator is needed to remove the plug from the valve while surrounding the valve and plug in a vacuum environment to prevent air from entering the system. The vacuum valve operator is provided in the tool kit that ships with the helium purifier system.

Figure D-11: Valve Operator

3. Remove the top cover of the purifier cabinet. Locate the first vacuum port on the top of the purifier. Remove the protective cap. A brass threaded plug should be visible inside of the fitting and is covered with a layer of vacuum grease. Do not remove the grease or allow debris to stick to it.

Figure D-12: Vacuum port with threaded plug

4. Place the operator over this port and tighten the nut in the **counterclockwise** direction. A wrench is recommended to create a tight seal. **Do not over tighten**.

Figure D-13: Sealing operator around port

5. Connect the vacuum pump to the KF16 on the open end of the valve operator.

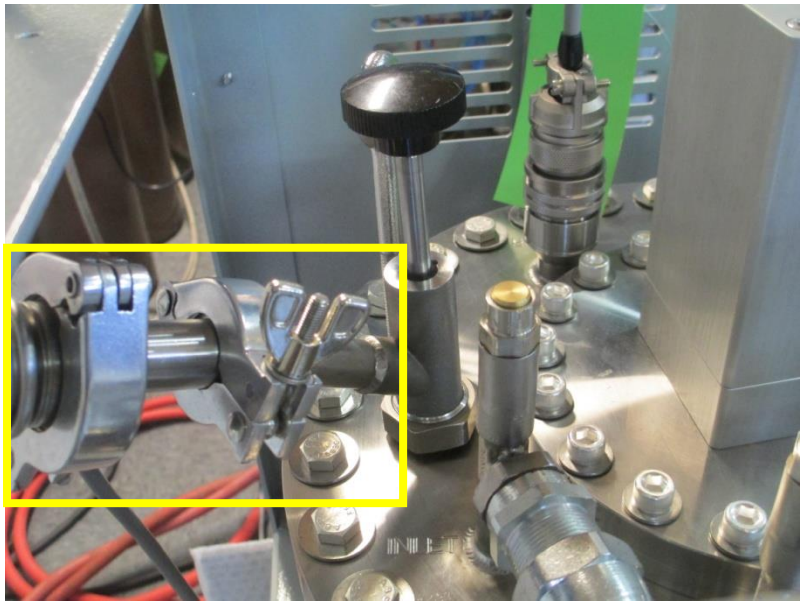


Figure D-14: Connection to vacuum pump

6. Run the vacuum pump to pull an initial vacuum on the flexible line connecting the vacuum pump to the valve operator. Doing so will minimize the pressure difference between the line and the vacuum space and prevent any air in the line from being drawn in.
7. Push the round handle on the operator down until the threaded tip contacts the vacuum plug. Proceed to turn the handle **clockwise** to thread the operator handle into the plug. The operator doesn't have to be fully threaded into the plug, three or four turns will suffice.

8. Once threaded in, slowly pull on the handle to pull the plug out of the vacuum valve. This will open the valve port to the vacuum pump. Be sure the handle is pulled back as far as it will go. The valve plug will remain inside the body of the operator and is not visible.
9. Continue pumping on the vacuum can. A vacuum depth of $1x10^{-6}$ Torr is recommended but $1x10^{-5}$ Torr is acceptable. Please note that the time required to reach an adequate vacuum can range from a few hours to several days depending on the vacuum pump used.
10. Once the best vacuum is reached, reinsert the plug back into the port by pushing the handle on the operator downwards until the plug feels firmly seated.
11. Once the plug is seated, turn the round handle **counterclockwise** to unthread the operator from the plug. It is imperative that the plug is fully unthreaded from the tip of the handle before attempting to remove the valve operator from the port.
12. To verify that the plug is fully unthreaded, apply a slight downward force on the operator handle (pushing towards the purifier) and twist the handle **counterclockwise** until a slight "click" is felt in the handle. This "click" signifies that the threaded tip of the handle has passed over the last thread on the plug and it is now fully disengaged. The operator handle can be pulled back.
13. The vacuum pump can be turned off and disconnected from the KF16 on the operator.
14. Remove the operator from the vacuum valve by turning the hex nut **clockwise** until loosened. The valve operator can now be pulled off. Replace the protective cap over the vacuum valve.
15. Repeat the process for the second vacuum valve located on the side of the purifier assembly, just above the mounting flange. This vacuum valve is accessed by removing the rear panel on the purifier cabinet. **See Figure D-14.**

Figure D-14: Location of second vacuum valve port

Appendix A

Specifications
Cold Head Drawing
Electrical Schematic

Specifications: PT60 with CP103

Cold head
Total weight……16.0 lb. (7.3 kg)
Dimensions…… See cold head drawing
Cool down time…….. 20 minutes to 80K
Lowest temperature……. <30K with no load

Helium static pressure – all components @ 77°F (25°C)
60 Hz System…….... 220 ± 5 PSIG (15.2 ± .34 bar)
50 Hz System……..... 15.2 ± .34 bar (220 ± 5 PSIG)

Maximum sound level
Water cooled system…… 70 dBA at 1 meter

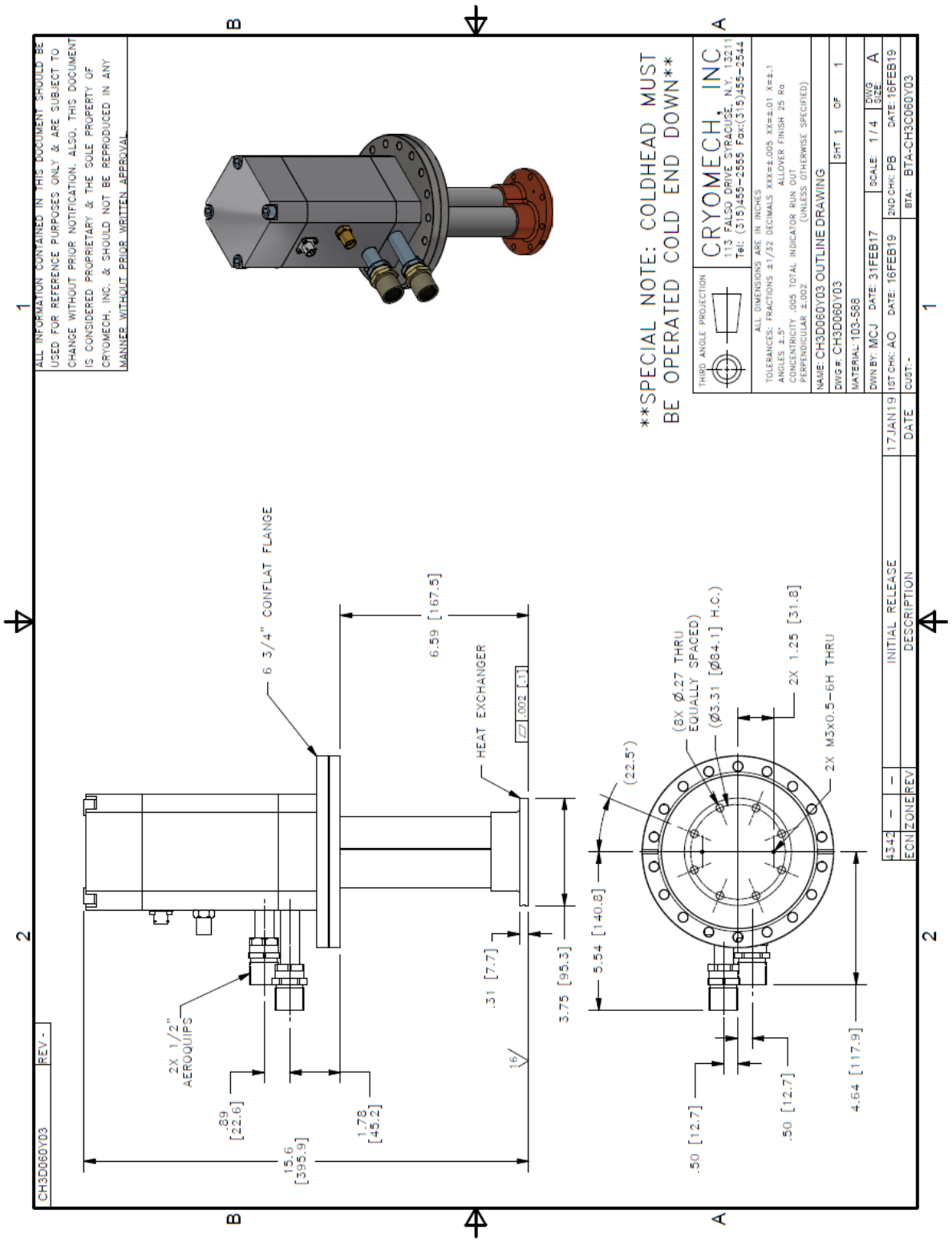
Flexible lines
Standard length…....10 ft (3 m)
Weight (pair)……7.2 lb. (3.3 kg)

Electrical specifications

Electrical Rating	Water Cooled Systems			Dedicated Circuit Breaker (A)
	Input Power (kW)		Maximum Current (A)	
	Maximum	Steady State		
208/230 VAC 60 Hz	4.2	3.1	20	30
200 VAC 50 Hz	3.5	2.7	18	30

Appendix A

Figure A-1: Cold Head Drawing



A-2

Appendix A

Figure A-2: Electrical Schematic