HC-80

Helium Controller

for Particle Therapy Nozzle Systems

User Manual

Pyramid Technical Consultants, Inc.

1050 Waltham Street Suite 200, Lexington, MA 02421 USA

US: TEL: (781) 402-1700 ♦ FAX: (781) 402-1750 ♦ EMAIL: SUPPORT@PTCUSA.COM

Europe: TEL: +44 1273 492001

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3 Safety Information

3.1 Standards

This unit is designed for compliance with harmonized electrical safety standard EN61010-1:2000. It must be used in accordance with its specifications and operating instructions. Operators of the unit are expected to be qualified personnel who are aware of electrical safety issues. The customer's Responsible Body, as defined in the standard, must ensure that operators are provided with the appropriate equipment and training.

3.2 Power and Grounding

The unit is designed to operate from +24 VDC power, with a typical current requirement of 1200 mA to 2000 mA and a peak requirement or 2500 mA. A suitably rated power supply module is supplied as standard and is strongly recommended. Customers who make their own 24 V power provision should ensure that the supply cannot source more than 4200 mA, that it has the correct connector type, that it is rated for use in the environment, that it provides overcurrent and short circuit shutdown and that it has all necessary regulatory approvals.

A safety ground must be securely connected to the ground lug on the case.

3.3 Safety considerations for the intended application

The HC-80 is a component of an overall safety system for a proton therapy system. By itself, it cannot ensure safe delivery of dose. It must be connected to relevant signals and interlock systems, the configuration must be subjected to risk analysis, and the connections must be checked and tested. The following are safety features of the HC-80 that must be functional and used correctly. If there is any reason to suspect the features are not working as described, the proton therapy system must not be used for medical treatments until the problem is identified and resolved.

3.3.1 **Gas**

The HC-80 is intended to deliver helium. The built-in mass flow controllers are calibrated for this gas. However, the unit does not detect helium directly, but rather the absence of oxygen. The user must ensure that the feed gas is helium.

3.3.2 **Exhaust**

Helium leaving the helium chamber is vented to atmosphere through the HC-80 main unit. The intended application will require the HC-80 to be located near a proton therapy treatment nozzle, and such areas are typically large rooms with good ventilation. However, the user must ensure that there is sufficient air circulation to prevent an asphyxiation hazard even in the event that a failure causes a the supply cylinder to be consumed quickly.

3.3.3 **Interlock relays**

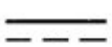
The unit is equipped with a safety rated relays that can be used to interlock the beam in the event of inadequate Helium concentration or failure of the HC-80 unit.

3.3.4 **Watchdog**

The unit is equipped with a watchdog timer, maintained by the ARM/Linux + PRU programs. The watchdog triggers within 2ms if the program is compromised, opening both safety relays and resetting the processor.

3.4 Symbols

Some of the following symbols may be displayed on the unit and have the indicated meanings.


Direct current


Earth (ground) terminal


Protective conductor terminal


Frame or chassis terminal


Equipotentiality

Supply ON


Supply OFF


CAUTION – RISK OF ELECTRIC SHOCK


CAUTION – RISK OF DANGER – REFER TO MANUAL

4 Models

HC-80	Helium controller including remote sensor unit and interconnecting cable and hoses.

5 Scope of Supply

HC-80 electronic unit.

Remote sensor and electronic cable to HC-80 unit.

Mating connector 284511-4 for interlock output.

Tubing and adaptors between the remote sensor and the helium chamber.

Tubing and adaptors between the remote sensor and the HC-80 electronic unit.

PSU24-100-1R 24 VDC 100-watt power supply with Redel PXG two pin locking connector, rated for medical use.

USB memory stick containing:

- HC-80 User manual
- HC-80 datasheet
- Test data

OEM customers will receive only components relevant to their application.

6 Optional items and related products

6.1 Power Supplies

PSU24-100-1R +24 VDC 100W medical rated PSU (universal voltage input, 50-60 Hz plug receptacle for standard IEC C14 three-pin socket) with output lead terminated in two-pin Redel PAG.M0 connector.

6.2 Tubing and Fittings

3/8” polyethylene, color coded, length specified at purchase time.

The base unit gas inlets and outlets are female ¼” NPT pipe fittings. These are supplied fitted with 3/8” push-to connect tubing adaptors. However, other fitting types can be specified, including Swagelok. In some installations, a special fitting may be required to adapt the chamber fittings to the sensor block.

6.3 Data Cables

CAB-RJ45-xxx-RJ45 Ethernet CAT5.

7 Intended Use and Key Features

7.1 Intended Use

The HC-80 Helium controller is used in combination with a helium enclosure or chamber. This enclosure provides a low-scattering beam path through the treatment nozzle in a proton therapy system. The particle beam energy and lateral size reaching the patient is affected by the helium concentration in the beam path, especially at low energy. Therefore it is important to have continuous verification that the helium-filled section is in its correct state. The HC-80 controls the flow of helium through the chamber, maintaining a safe internal pressure and verifying that the most of the air is displaced from the helium enclosure.

7.2 Key Features

Controls and monitors helium concentration, pressure and flow to maintain a known and stable helium-filled beamline segment.

Mass flow control of flow and purge.

Fully automated startup, purge and flow sequences.

Front panel control or remote control via Ethernet with browser interface.

Integrates with Pyramid proton therapy nozzle systems.

Detection of residual oxygen.

Logging of helium consumption.

Detection of fault conditions including over and under-pressure.

Interlock relay allowing fault state to disable beam.

Parameters adjustable under software control to suit different system configurations.

Pressure servo alternative operating mode.

8 Specification

Features		
	Sustain flow control	Helium regulated by 0 to 30 sccm mass flow controller.
	Purge control	Helium regulated by 0 to 5000 sccm mass flow controller.
	Helium supply	N2.0 grade (99%) helium gas at 15 psi. Typical sustain flow rate 10 sccm (depending on chamber size and integrity). L size cylinder (9 m^3) duration approx. one year including purge cycles.
	Inlet pressure sensing	Pressure switches set at 10 psi (low pressure limit) and 30 psi (high pressure limit).
	Helium chamber pressure sensing	+/- 1 psi pressure relative to atmosphere sensed by differential sensor in remote sensor head, resolution better than 0.1 psi.
	Residual air detection	Oxygen sensor (optical fluorescence quenching) located in remote sensor head, measuring exhaust gas.
	Chamber orientation sensing	Dual axis accelerometer located in remote sensor head detects gantry rotation.
	Temperature measurement	IC temperature sensor device in remote sensor head.
Internal Features		
	Pipework	Stainless steel pipes and fittings in helium supply path.
	Overflow	Safety-rated relay (Tyco SR4) with mechanically-guided contacts and sensing of welded contacts. Normally open contacts. Closed if oxygen concentration is below pre-set value, otherwise open.
Gas Connectors		
	Helium connections to HC-80 unit	Three 1/4” NPT female threaded ports for helium supply in, chamber flow out, chamber flow return. Unit is supplied with push-fit adaptors to for 3/8” od plastic tubing.
	Helium connections to remote sensor unit	Two 1/4” NPT female threaded ports for gas in and gas out. Fitted with brass push-fit adaptors for 3/8” plastic hose as standard.
Electrical Connections		

	Remote connection to sensor unit	HD15 male (HC-80), HD15 female (remote sensor).
	Interlock	Four pin 3.81 mm header TE Connectivity 284541-4. Mating connector 284511-4 is included.
	Diagnostics port	Six-pin 2.54 mm header TE Connectivity 826468-6. Processor serial debug - factory use only.
	Ethernet	RJ-45 socket.
	Power	Lemo Redel PXG.M0.2GG.NG. To suit mating connector PAG.M0.2GL type as fitted to Pyramid power supply PSU24-100-1R.
	Ground lug	M4 threaded stud.
Controls and Indicators		
	Controls	Three illuminated front panel buttons for Vent / Sleep / Operate functions.
	Indicators	Illuminated front panel indications for operational states and error conditions: – System overall state ready / not ready – Excess oxygen detected – Remote sensor not present – Helium supply fault – Power was interrupted – Chamber is vented – Chamber pressure error
Processor		
	Type	TI Sitara AM335x (ARM Cortex A8) 1 GHz with dual PRU.
	Operating system	Debian Linux.
	Watchdog	Relays open (hardware action) and forced processor reset if watchdog is not tickled every millisecond.
Connectivity		
	Ethernet	Ethernet 10/100/1000 Mbps. Auto MDIX. Embedded EPICS channel access server allows client software to monitor and control device function.
Power		
	Power input	24 V (+/- 2V) DC, 1200 mA typical, 2500 mA max.

		Diode polarity protection. 30 V transorb overvoltage protection across input.
	Fuses	Self-resetting PTC fuses: – 24 V input 1100 mA on logic board – 24 V out (interlock circuit) 200 mA – Solenoid coil drive 6 x 200 mA – Cooling fan 200 mA
Case		
	HC-80	2U by 341 mm deep 19” rack mounting steel chassis with Al alloy front panel Filtered cooling fan fitted to rear panel.
	Remote sensor case	Aluminum box 97 mm x 56 mm x 30 mm excluding pipe connections. Underside of PCB forms one face of the case.
	Weight	HC-80 unit 7.6 kg (16.8 lb.) Remote sensor 0.3 kg (0.7 lb.)
Environment		
	Intended location	Particle therapy treatment rooms; can be located on gantry.
	Remote sensor unit location	Close to helium chamber exhaust in series in pipeline. Case should be mounted oriented with gantry rotation and such that descriptive decal is uppermost and parallel to the floor when gantry is at 90 degrees.
	Operating environment	15 to 30 C (18 to 25 C recommended for optimum performance), < 70% humidity, non-condensing, vibration < 0.1g all axes (1 to 100 Hz). Note: Due to its weight, the HC-80 main unit must be supported by full depth angle brackets in a 19” cabinet installation, not only from the front panel. Note: In a gantry installation, the unit must be supported to prevent strain to the front panel also for the inverted position.
	Shipping and storage environment	-10 to 50 C, < 80% humidity, non-condensing, vibration < 0.5g all axes, 1 to 100 Hz.

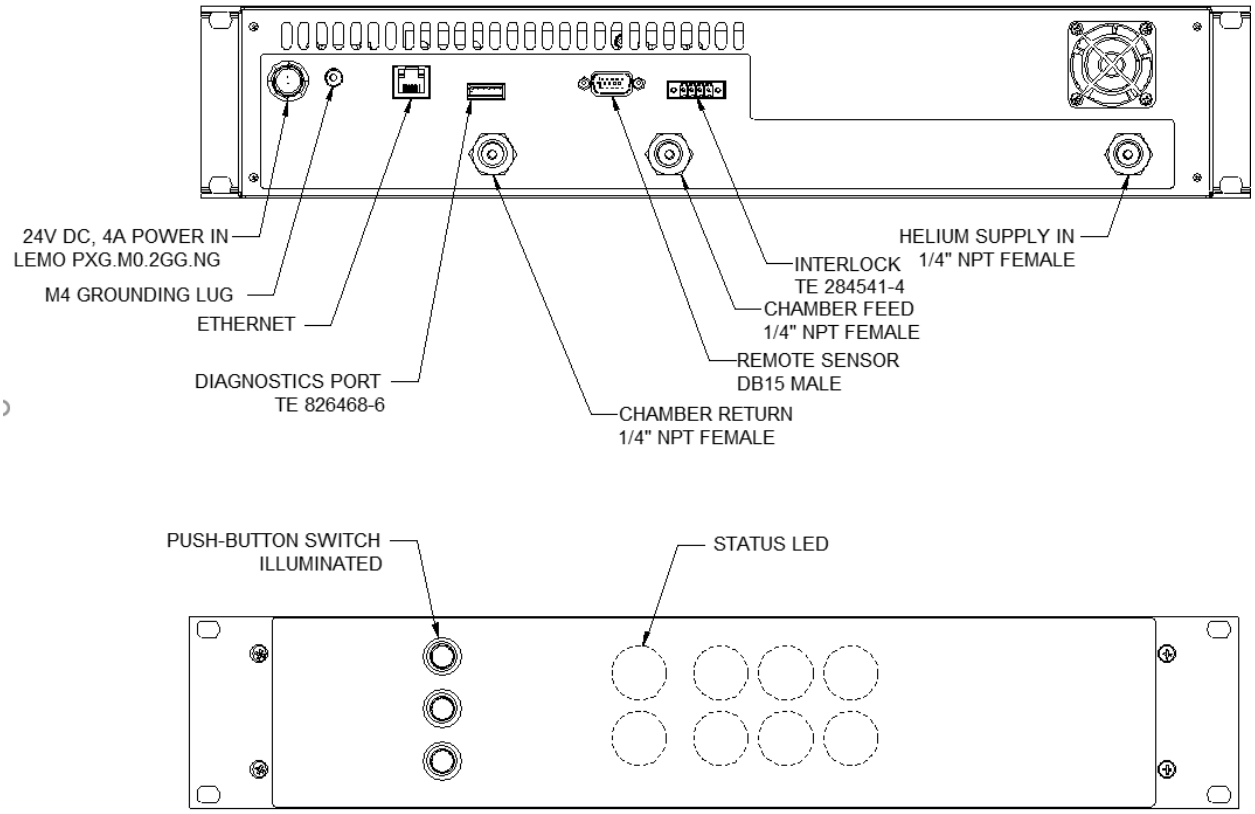


Figure 1 – HC-80 rear and front panels

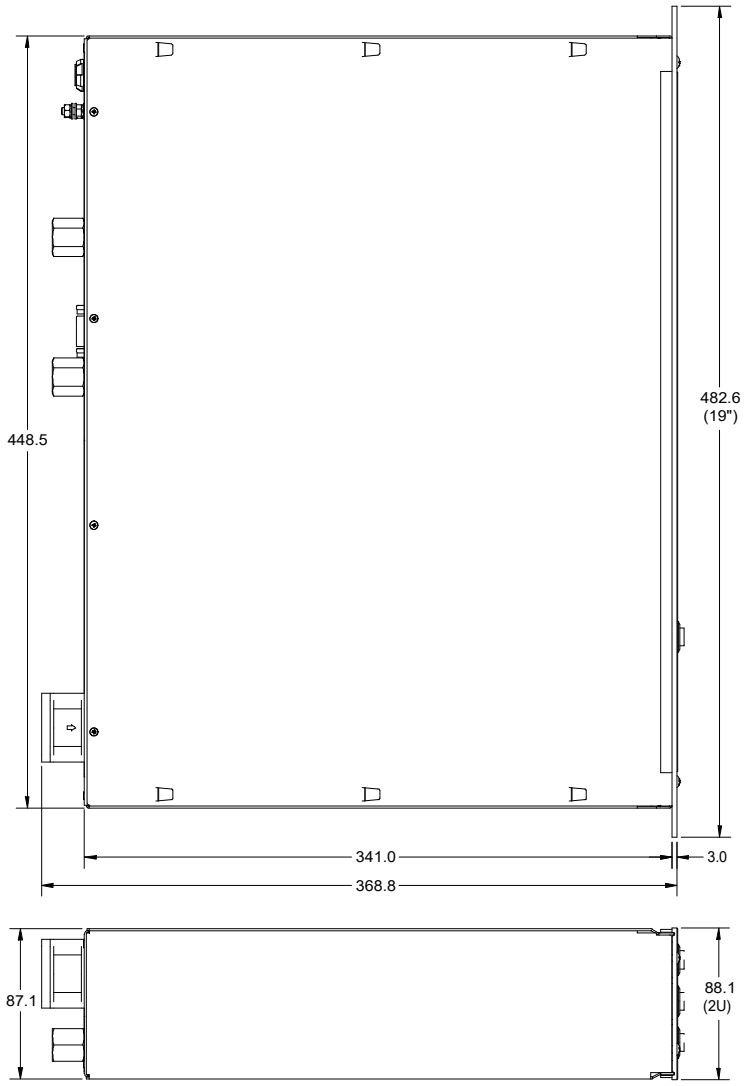


Figure 2 – HC-80 chassis (dimensions in mm)

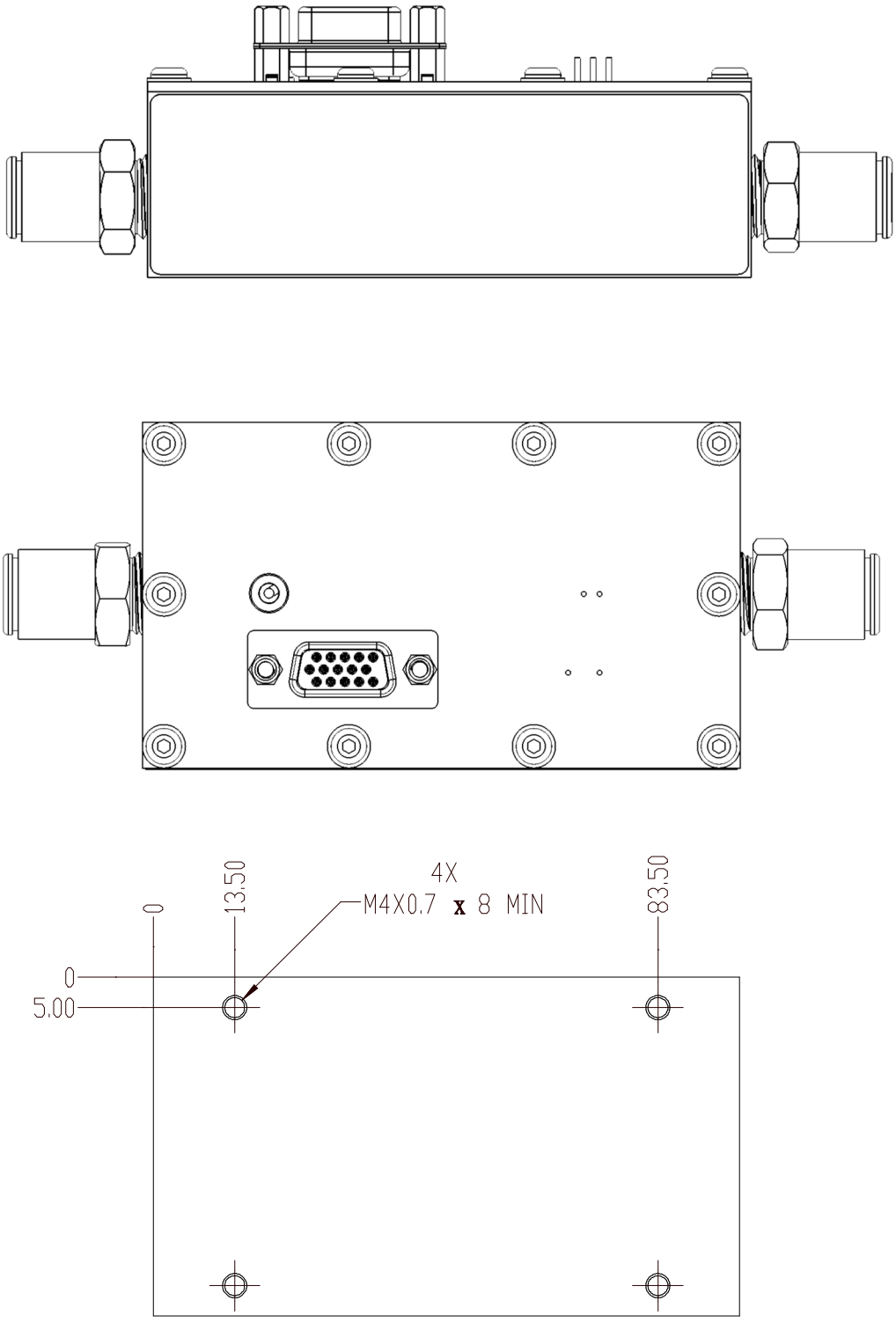


Figure 3 - Remote sensor unit showing mounting hole pattern

9 Installation

The HC-80 system is made up of the **HC-80 Electronic Unit**, the **Remote Sensor Unit,** the remote sensor cable, and connecting tubing. The target system is typically a beamline section or other helium chamber with a lightweight construction and thin beam exit and entrance windows (the "**Helium Chamber**").

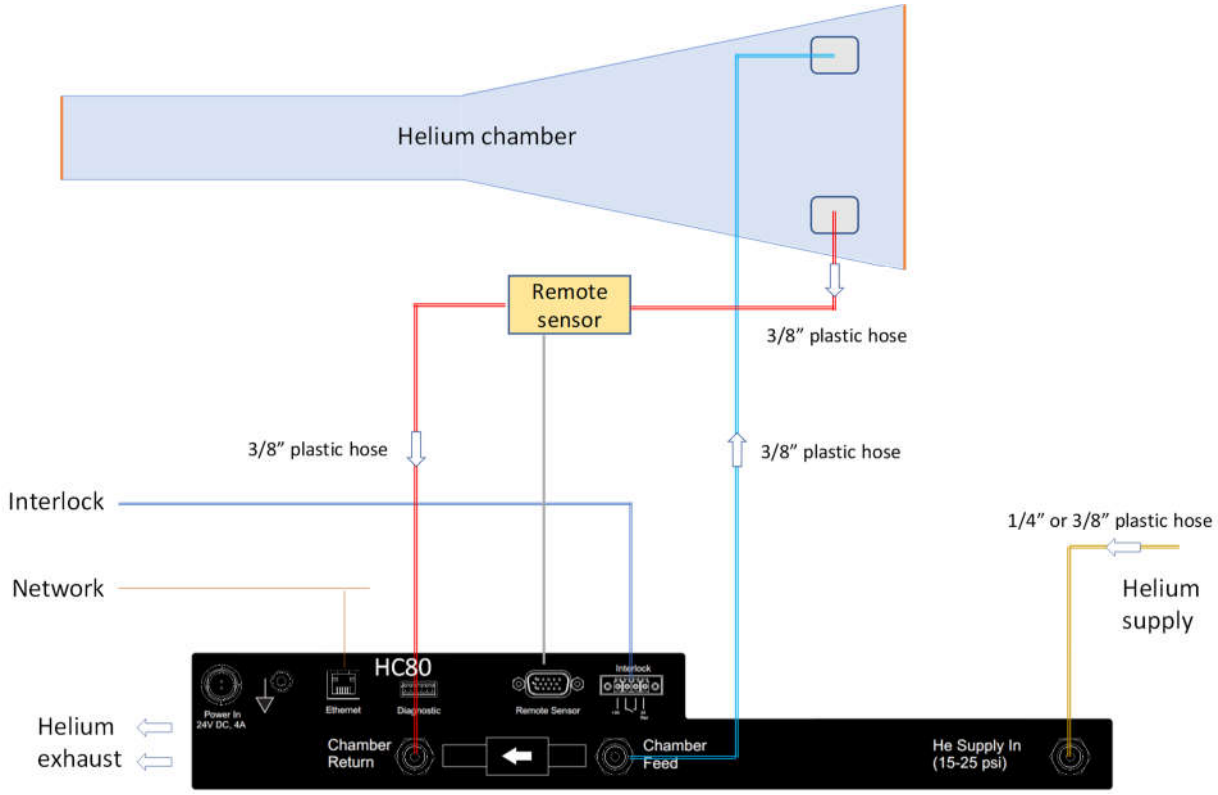


Figure 4 - HC-80 connections

9.1 HC-80 Electronic Unit

Mount the HC-80 to a 19" rack mounting. The location should not a known high-radiation location, but should be within 50' tubing length of the helium chamber. The HC-80 is designed to be mounted on a gantry structure and can be rotated.

9.2 Remote Sensor Unit

The Remote Sensor Unit is placed in the helium return line from the chamber. There is no preferred helium flow direction through the sensor. Either port can be the inlet.

The unit contains the oxygen, temperature, pressure and orientation sensors. Mount it securely to the nozzle structure using the four M4 threaded holes. It should be as close to the helium chamber, but not in the path of scattered beam.

If the helium chamber is on a rotating gantry, observe carefully the orientation instructions on the remote sensor which must be followed in other to obtain correct gantry orientation readout. For fixed beamlines, the orientation is not critical.

A screened cable with HD15 connectors is supplied to connect the HC-80 Electronic Unit to the Remote Sensor Unit. Connect the cable before use.

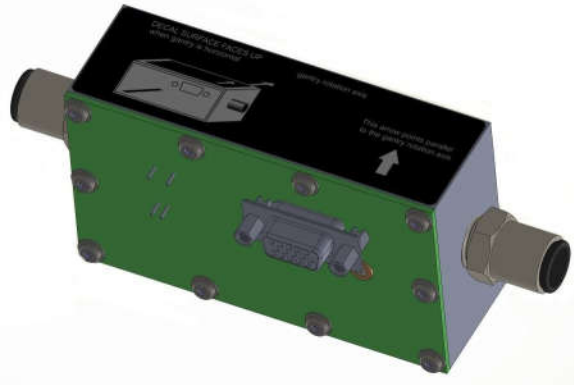


Figure 5 – Remote sensor unit

9.3 Gas connections

Gas connectors on the HC-80 are for 1/4" NPT to match the internal pipework. However, 3/8" tubing is recommended for the connections between the HC-80, the remote sensor and the helium chamber. The system is supplied with 1/4" NPT to 3/8" push fit adaptors on the HC-80 unit and the remote sensor. All tubing needed to connect the HC-80 to the chamber and remote sensor unit is supplied. It should be cut to the appropriate length.

The connections to the helium chamber are through two gas ports on the chamber, labelled as Inlet and Outlet. If unlabeled, the inlet will be at the lower point on the chamber in normal orientation. Connecting this way allows for the most efficient use of helium and faster purge time.

1) Run a single length of 3/8" tubing (blue/black striped) from the 1/4" to 3/8" adaptor on the HC-80 Electronic Unit "Chamber Feed" to the Helium Chamber Inlet (the higher of the two ports). This line can be up to 50 feet (15 meters) in length.

2) Connect the chamber outlet to the inlet of the remote sensor chamber through a short length of 3/8" flexible tubing (red striped). The outlet is the lower of the two connections on the helium chamber when the gantry is at zero degrees (horizontal).

3) Connect the a length of 3/8" flexible tubing (red striped) from the 3/8" to 1/4" adaptor on the remote sensor to the 3/8" to 1/4" adaptor on HC-80 "Chamber Return".

9.4 Connections to Helium Supply

The helium supply is connected to the supply inlet of the HC-80. **The supply pressure must be pre-regulated to a pressure of 15-25 PSI using a two-stage helium regulator**. There are mechanical pressure switches internal to the HC-80 at 10 PSI and 30 PSI that monitor these lower and upper limits respectively.

ATTENTION

DO NOT USE AN UNREGULATED (HIGH PRESSURE) HELIUM SUPPLY

The following connection should be made:

1. Connect the helium supply to the rear panel inlet of the HC-80.
2. Adjust the outlet pressure to 20 +/-5 psi (1.4 bar).

9.5 Grounding and Power Supply

+24 VDC power should be provided from a suitably-rated power supply with the following minimum performance:

Output voltage	+24 +/- 0.5 VDC
Output current	1000 mA minimum, 4200 mA maximum
Ripple and noise	< 1% pk-pk, 1 Hz to 1 MHz
Regulation	< +/- 5%

The HC-80 includes an internal automatically re-setting PTC fuse rated at 1.1 A that protects the internal circuitry. The battery charging circuit is not fused, so the external 24 V power supply must provide an overcurrent shutdown facility. The PSU24-100-1R power supply provides this protection.

The HC-80 chassis can be bonded to local ground using the M4 threaded lug on the rear panel.

9.6 Interlocks

The hardware relay signal generated by the HC-80 (potential-free contacts or 24 V logic) are routed directly to one or more beam abort systems. The decisions to open these interlocks are made by the HC-80 depending upon the configurable oxygen concentration, and the health state of the HC-80.

Make a connection to the interlock connector as appropriate for the dosimetry safety system. The mating connector is supplied. It is designed for bared wire ends and uses spring-loaded clamps for secure connection. The interlock cable should be nevertheless secured close to the HC-80 to prevent strain on the connection.

Note that the interlock relay will open when the unit power cycles.

9.7 Client Interface

The HC-80 connects to a client system via a standard CAT5 ethernet cable. Data is exchanged with the client via the EPICS protocol. It is possible to operate the HC-80 without any client system, but remote monitoring operation is very convenient when the unit is mounted on a gantry or is otherwise inconvenient to access.

10 How the HC-80 Works and How to Use it - An Overview

10.1 Initial Startup

Check that all connections are made as described in the previous chapter. Connect the 24V power to the HC-80 when you are ready to operate. On power-up, the system should perform the following functions:

- Boot and power-up tests (30-60 seconds)
- Illuminate all the front-panel icons for 5 seconds
- Attempt to enter Operation Mode
- Purge the chamber for 60 seconds
- Evaluate the oxygen concentration
- Continue to purge the chamber until the oxygen level is reduced to 0.5%
- Switch to a low-flow maintenance mode

If this is the first time the system has been used, the purge will take about 15-30 minutes, depending on the size of the chamber.

The HC-80 will indicate that the chamber is ready for use when:

- The incoming helium supply is between 10 and 30 PSI
- The connection to the remote sensor is good.
- The oxygen level is below 0.5% (corresponding to an air concentration below 2.5%)
- The PID loop on pressure has stabilized
- Chamber pressure is correct
- The MFCs are flowing at their setpoint

10.2 Front Panel Control

The basic operation of the HC80 can be accessed from its front panel. However, it is usually more convenient to access the controls remotely. The HC-80 serves a web-based interface via the Ethernet that provides both the front-panel functions, as well as additional functions and displays. The front-panel controls described below are duplicated on the web interface.

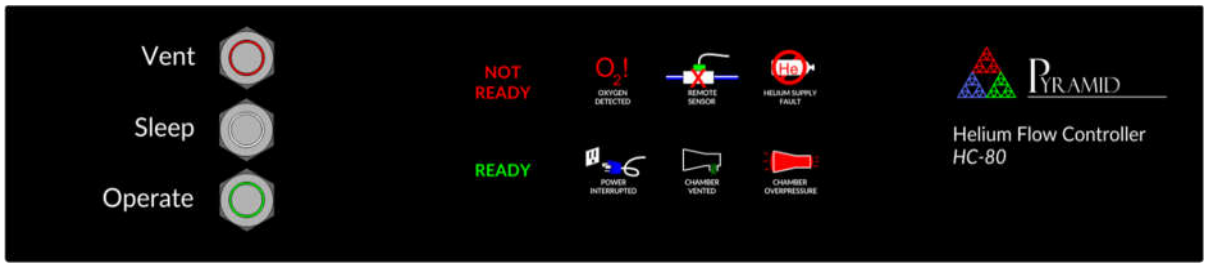


Figure 6 - HC80 front panel

Three pushbuttons select one of the three major modes of operation of the system.

10.2.1 **Operate**

This is the normal operating mode, and the unit will attempt to enter this mode upon power up. When this mode is first entered, the unit starts a high-flow flush, which will continue until minimal oxygen is detected at the remote sensor. The flush will continue for a minimum of 60 seconds. If the desired oxygen level is not achieved by 10 minutes, the system will go to Sleep mode, opening the interlock output. After the target oxygen level is achieved, the system switches to a constant low-flow state.

Pressing the Operate button triggers the sequence leading to normal operation. It is identical to the sequence executed on startup described above. The sequence is:

1. Purge the chamber for 30 seconds, using a high flow rate (5 liters/minute)
2. Evaluate the oxygen concentration. If it is less than 0.5%, go to step 4
3. Continue to purge the chamber until the oxygen level is reduced to 0.5%. Fault after 30 minutes
4. Switch to a low-flow maintenance mode
5. Continuously monitor the chamber and HC-80:
    a. If the oxygen level rises above 0.5%, purge at high flow for 30 seconds
    b. If the pressure rises to a dangerous level, go to Vent mode
    c. If the supply pressure goes out of limits, go to Sleep mode
    d. If there is an internal fault, go to Vent mode
    e. In all cases the safety relay is tripped

10.2.2 **Sleep**

This is a non-operating state used to shut the system down and stop the maintenance flow. The system is not vented to atmosphere, and the system actively monitors the chamber to maintain a slight positive pressure. It is recommended that you enter this state is the system is to be unused for an extended period of time.

Pressing the Sleep button places the system in a “zero-flow” mode but continues monitoring for faults. One odd effect of sealing the chamber is that the helium can diffuse out of the chamber while air can’t diffuse in. This can lead to an “under pressure” state that can damage the delicate polymer windows. The target pressure in sleep mode is higher than in operation mode.

This allows for confidence that the entire system maintains positive pressure and never drops below an operational pressure. While in sleep mode the HC80 will need to re-pressurize the chamber to this higher pressure. When this is happening the operate button LED will be blinking and the sleep button LED will be solid. The sequence is:

1. Close all valves
2. Turn off all flow controllers
3. Continuously monitor the chamber and HC-80
    a. Do not act on the chamber oxygen level
    b. If the pressure rises to a dangerous level, go to Vent mode
    c. If the pressure drops close to operation pressure, re-pressurize
    d. If there is an internal fault, go to Vent mode

10.2.3 **Vent**

This mode is the safest non-operating state. In vent mode, all MFC's are set to zero flow and both vent valves are opened to air. This allows the chamber to come to zero pressure relative to atmosphere. In this mode, air will eventually contaminate the chamber. This mode is selected automatically if certain major errors are detected. It is recommended that you enter this state before powering down the system for maintenance

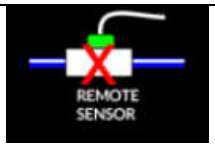
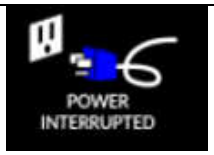
Pressing the Vent button places the system in a "zero-flow" mode, but fully vented to atmosphere. This is the safest mode and is the correct state in case of a major malfunction. An extended time in this state will require a longer purge to get back into normal operation. This is because air will gradually make its way back into the chamber. The sequence is:

1. Close all feed valves
2. Open both vent valves
3. Turn off all flows

10.3 Icons

The front panel icons alert the following states:

Name	Icon	Description
Ready		If READY is green, the system is fully operational.
Not Ready		If NOT READY is red, the system is not operational.
O_2		Oxygen level exceeds the operational level.

Remote Sensor		Sensor cable is disconnected, or the sensors are not reading correctly.
Helium Supply		Helium supply has dropped below 10 PSI or risen above 30 PSI.
Power Interrupt		Unit has powered up, but no commands have been received.
Chamber Vented		Chamber is open to air through the controller.
Overpressure		Chamber is above the nominal pressure setpoint.

11 Updating the HC-80

The HC-80 maintains its program and various options in files on its memory card. These files should be changed only by qualified service personnel. The procedure is listed here in case a change should be necessary, but it is strongly recommended that you contact Pyramid before proceeding with any change.

ATTENTION

If the HC-80 is in use in a medical therapy system, then following any change to software, it is mandatory that the system should be tested and re-certified as fit for its purpose by a qualified person.

11.1 Updating the Firmware

The firmware can be updated via two methods.

11.1.1 **Changing the SD card.**

The SD flash memory card can be changed, although this requires opening the unit by removal of the top panel. This will allow the operating system and running program to be updated. When this is done, it is important to preserve the System.xml file from the previous card and copy it to the appropriate location (see below). It is recommended that this procedure only be carried out at Pyramid.

11.1.2 **Copying program files**

The device firmware applications, including ARM/Linux service and UI, and PRUSS, can be remotely updated over Ethernet. This can only be performed by an authorized Pyramid support team member. Please contact Pyramid support if this option is needed.

After copying the program files, a special utility needs to be run at the factory that authorizes the installation by performing an MD5 hash of all files. The following screen will appear at boot time if this procedure was not properly followed, or if one of the file components has been changed or corrupted:

11.2 Changing IP Address

The IP address can be changed by editing the ethernet communications file **/etc/network/interfaces**. In this file, you can change the primary network interface called **eth0**.

A static or dynamic IP can be set by using one of the following two lines:

```
iface eth0 inet dhcp          // will give it a DHCP address.
iface eth0 inet static        // will give it a static address.
```

If using a static IP, you must follow that line with the following lines, the using actual addresses and masks appropriate for your network:

```
address 192.168.100.123
netmask 255.255.255.0
gateway 129.168.100.1
```

To activate the new settings, SSH into the device and run

```
ifdown eth0
ifup eth0
```

Otherwise, restart the HC-80 using reset button on the back of device.

11.3 Serial Number

The HC-80 serial number is kept in file **\opt\pyramid\hc80\Debug\Serial.txt**. Do not modify this file.

11.4 Loopback Address

The HC-80 loopback address is kept in file **\opt\pyramid\hc80\Debug\IPAdress.txt**. Do not modify this file.

12 Web Interface Control and Display

Although basic control and status can be done through the front panel controls, additional control and status is available through the web interface. This can be accessed through any standard web browser, although Google Chrome is recommended.

12.1 Initial Setup

With a browser connected to the local network then go to the address http://ADDRESS where you replace ADDRESS with the IP address of the HC-80m for example http://192.168.100.123. On the back panel of the device there is a label with the IP address set at time of shipment. If that doesn't work, the HC-80 always has a secondary static IP at 192.168.80.80. To use this backup address, you must set your computers IP to static on the 192.168.80.0/24 range and have a direct connection to the HC-80.

Pyramid provides a network scan app that is run from the Pyramid website ("ptcusa.com/scan") that will search a particular sub-net for active devices. This can be used to identify the HC-80 address.

Once the connection has been established, create an icon for the address link and place it on your desktop.

12.2 Display

Depending on the device used (PC, Phone, Tablet) the following display will appear in a single page, or over multiple pages.

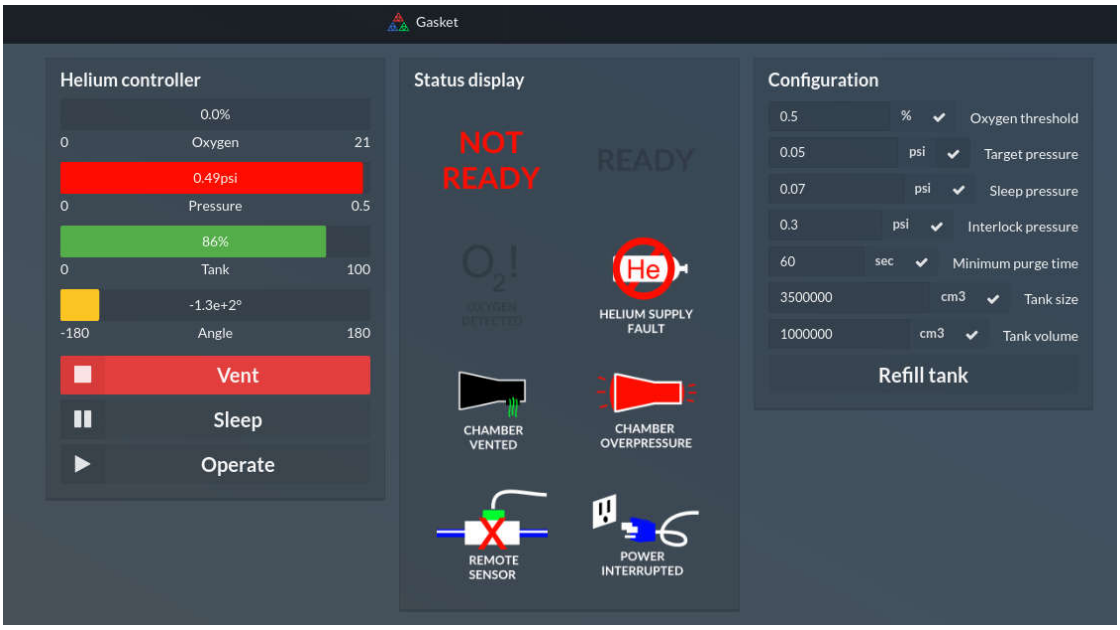


Figure 7 - Web Interface Display

12.2.1 **Helium Controller Panel**

The Vent, Sleep and Operate controls duplicate the functions on the front panel of the HC80, as described previously.

Other important parameters are displayed only through this interface:

Oxygen Concentration (%)	In normal operation, the concentration of oxygen should be very low, typically <0.5%. If higher concentrations are detected, air has contaminated the chamber, the system is considered to be out of the operational state, and the interlock relay will open.
Pressure (PSI)	In normal operation, the chamber is pressurized slightly above atmospheric pressure. This pressure value is actively controlled by the HC80 through closed-loop feedback. In this system, the target pressure is set to 0.05 PSI. Upon initial startup, this pressure value will vary as the system attempts to reach the operating state. This should settle down after 10 minutes or so.
Tank (%)	For systems that use pressurized tanks to supply the helium, the HC80 will attempt to estimate the percentage of the tank remaining. This is an approximate value but is a good way to remind the operator to check the tank pressure at the tank regulator. A more definite measurement of low tank pressure is through the HC80 pressure switch, which will alert the operator when the input pressure drops below 15 PSI. Once the tank pressure drops to the point that flow cannot be maintained, the system moves out of the operational state.
Rotation Angle (degrees)	The Remote Sensor can detect its rotation relative to gravity. For the most rapid initial purging of the helium chamber, it is preferred that the chamber be horizontal (zero degrees).

12.2.2 **Status Display Panel**

The alert icons are duplicates of those on the front panel.

12.2.3 **Configuration Panel**

The behavior of the system is determined by the settings displayed on this panel. The settings are read-only and have usually been optimized for the system. These parameters can be modified by an authorized user (see Access, below), but unless you are trained in the operation of the system, this is not recommended, since it is possible to damage the helium chamber or compromise the overall operation through the selection of bad parameters.

Oxygen Threshold(%)	The maximum allowable concentration of oxygen that is acceptable for normal operation. In figure 7 this has been set to 0.5%.

<table>
<tr><td>Target Pressure (PSI)</td><td>The value of chamber pressure that will be established under normal operation. In figure 7 it has been set to 0.05 psi, which is safe for most thin windows.</td></tr>
<tr><td>Sleep Pressure (PSI)</td><td>In Sleep mode, the HC80 stops the continuous flow of helium. If the chamber pressure should drop below the nominal Target Pressure, the HC80 will re-pressurize the chamber to this value.</td></tr>
<tr><td>Interlock Pressure (PSI)</td><td>If the pressure in the tank rises to a value that is potentially damaging to the chamber, the HC80 will enter Vent mode, and leave the operational state.</td></tr>
<tr><td>Minimum Purge Time (minutes)</td><td>When either (1) the Operate state is selected or (2) upon startup, the HC80 will execute a purge cycle in which a relatively high rate of flow is used to flush out any air from the chamber. This will run for a minimum time determined by this value.</td></tr>
<tr><td>Tank Capacity</td><td>The amount of gas that is contained in a full tank, expressed as a volume in liters at STP.</td></tr>
<tr><td>Refill Tank</td><td>When the helium supply tank is exhausted, press this button to reset the He supply tracking value. The pop-up will ask for the capacity of the new supply in liters. Refer to the following tables to estimate this value, if it is not available from the supplier:
<table>
<tr><td>Tank</td><td>Liters</td></tr>
<tr><td>Size 300</td><td>8500</td></tr>
<tr><td>Size 200</td><td>5600</td></tr>
<tr><td>Size 125</td><td>3500</td></tr>
<tr><td>Size 80</td><td>2200</td></tr>
<tr><td>Size K</td><td>5000</td></tr>
<tr><td>Size A</td><td>4400</td></tr>
</table>
</td></tr>
</table>

Pounds	Liters		kG	Liters
0.2	535.8		0.1	590.8
0.4	1071.6		0.2	1181.6
0.6	1607.4		0.3	1772.4
0.8	2143.2		0.4	2363.2
1	2679		0.5	2954
1.2	3214.8		0.6	3544.8
1.4	3750.6		0.7	4135.6
1.6	4286.4		0.8	4726.4
1.8	4822.2		0.9	5317.2
2	5358		1	5908
2.2	5893.8		1.1	6498.8
2.4	6429.6		1.2	7089.6
2.6	6965.4		1.3	7680.4
2.8	7501.2		1.4	8271.2
3	8037		1.5	8862
3.2	8572.8		1.6	9452.8

The values listed in the Configuration Panel above can be changed from a protected control panel. Access to the system control parameters is done by clicking on the “Gasket” icon at the top of the screen

System parameters can be modified by the user with the proper access code. Unless you are trained in the operation of the system, this is not recommended, since it is possible to damage the helium chamber or compromise the overall operation through the selection of bad parameters.

13 Communications Interface

The HC-80 connects to the client via an Ethernet interface. The device acts as an EPICS server, and all information with client applications is exchanged using this protocol. For more information on EPICS please go to the EPICS website at http://www.aps.anl.gov/epics/index.php.

13.1 EPICS Process Variables

The PV names will start with the HC-80 unit's serial number so that they are unique. The following parameters are supported. Network Configuration

The HC-80 uses EPICS communication over standard local area network hardware. Addressing is using the IP4 standard, and it supports static and dynamic (DHCP) address assignment. The device can be configured via the PTC DiagnosticG2, via the serial interface, or by your own host software using the appropriate procedure calls.

Most control and data acquisition systems are set up with fixed addresses assigned by the network administrator. It is also typical to isolate such networks from the internet to prevent unauthorized access, and to allow operation without firewalls which can disrupt communications.

In order for the host computer and the HC-80 to communicate, they must be within the same subnet. It is typical to limit a local network to 256 addresses by setting the IP4 subnet mask to 255.255.255.0. Then the HC-80 and the host must have the first three bytes of their addresses common and must differ in the last byte. For example, the host could be 192.168.100.11 and the I128 at 192.168.100.20. The last byte must also not conflict with any other devices on the same subnet. Addresses with last byte 0 and 255 are reserved for special functions in TCP/IP. See the section on "File Setups" for information on changing the IP address of the unit.

Following is a list of all available process variables. Each variable's name must have the IP address of the unit appended with a colon preceding the address. For example, for the variable c_led_ready, the name would be formed as c_led_ready:192.168.100.81 for the IP address 192.168.100.81.

PV Name	Description	Read Only	Type
r_helium_controller_state	The state of the HC80 as an integer. 0=Initializing 1=Venting 2=Operating 3=Purging 4=Sleeping	TRUE	Int32
r_helium_controller_time_in_state	Amount of time spent in the present state	TRUE	Bool
c_led_ready	The ready state of the HC80 1=Ready 0=Not ready	TRUE	Bool
c_led_not_ready	The NOT ready state of the HC80 1=Not ready 0=Ready	TRUE	Bool
c_led_power_interrupted	1=If there was a power failure, clears to 0 if a button is pressed	TRUE	Bool

c_led_oxygen_detected	1=If there is more oxygen than acceptable in the chamber	TRUE	Bool
c_led_chamber_vented	1=If the chamber is vented to air	TRUE	Bool
c_led_remote_sensor	1=If the remote sensor is not connected	TRUE	Bool
c_led_chamber_overpressure	1=If the chamber is overpressure	TRUE	Bool
c_led_helium_supply_fault	1=If the helium supply tank is under or over pressure	TRUE	Bool
r_helium_controller_oxygen	The oxygen percent from the remote sensor. (%)	TRUE	Float32
r_helium_controller_pressure	The pressure inside the chamber. (PSI)	TRUE	Float32
r_helium_controller_angle	The remote sensor angle. (Degrees)	TRUE	Float32
c_helium_controller_button_vent	Set to 1 to mimic pressing the vent button.	FALSE	Bool
c_helium_controller_button_operate	Set to 1 to mimic pressing the operate button.	FALSE	Bool
c_helium_controller_button_sleep	Set to 1 to mimic pressing the sleep button.	FALSE	Bool
c_luminox_zero	Set to 1 to zero the oxygen sensor, the zero will be saved to a file for reboot.	FALSE	Bool
c_configuration_oxygen_threshold	The upper limit to the chamber oxygen percent allowed (%)	FALSE	Float32
c_configuration_target_pressure	The pressure maintained in operate mode (PSI)	FALSE	Float32
c_configuration_sleep_pressure	The pressure maintained in sleep mode (PSI)	FALSE	Float32
c_configuration_interlock_pressure	The upper limit to the chamber pressure allowed (PSI)	FALSE	Float32
c_configuration_minimum_purge_time	The minimum time to purge the tank (Seconds)	FALSE	Float32

14 Connectors

All connections for the HC-80 are located on the rear panel, shown in the drawing below.

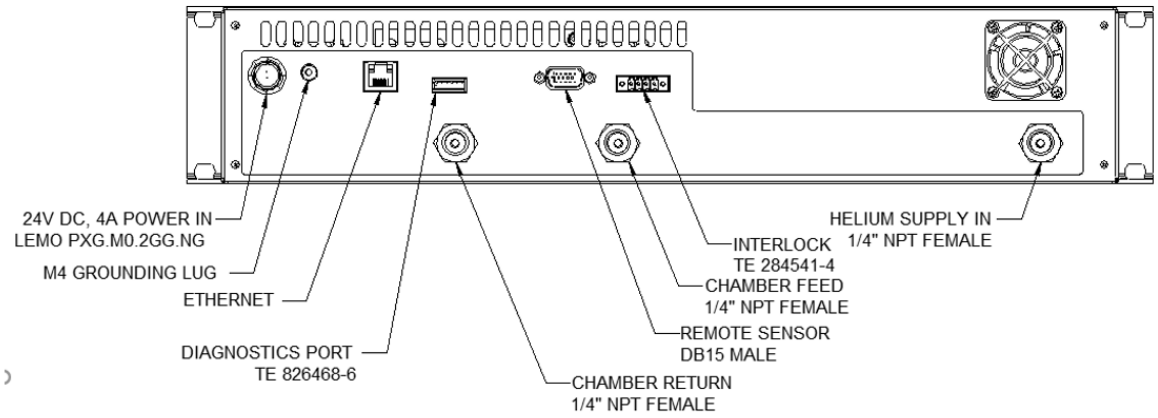
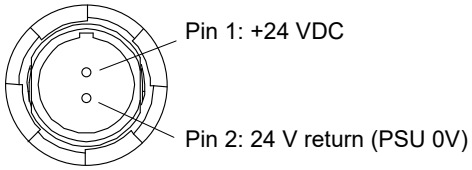


Figure 8 - HC-80 rear panel

14.1 Power input, 24 VDC

Two-pin Redel PXG.M0.2GG.NG female. To mate with Redel PAG.M0.2 type or PFG.M0.2 type free plugs. Suitably terminated 24 V power supplies and leads are available from Pyramid Technical Consultants, Inc.



14.2 Grounding lug

M4 threaded stud. To mate with M4 ring lug.

14.3 Ethernet Communications

RJ-45 jack. To mate with standard RJ-45 plug.

Auto MDIX facility - cable can be direct or crossover type.

14.4 Diagnostic port

Six pin header for diagnostic serial connection to internals processor board. Used for low-level service diagnostics onlyl. Mating connector TE Connectivity 926475-6.

1	DGnd	2	n/c	3	n/c	4	Rx	5	Tx	6	n/c

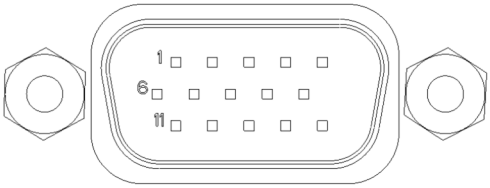
14.5 Chamber Return

¼" NPT female fitting, fitted with an adaptor to 3/8" tubing (push fit)

Supplied tubing is 3/8" polyethylene, color coded red stripes, length to suit.

14.6 Remote Sensor

One Dsub high-density 15 pin male.



(View looking at connector

1	X acceleration	6	Gnd	11	Y acceleration
2	Gnd	7	Pressure	12	Gnd
3	O2 sensor xmt	8	O2 sensor rcv	13	Gnd
4	Temperature	9	Gnd	14	5 V ref
5	+15 V	10	Gnd	15	-15 V

Use matching cable supplied with unit to connect to remote sensor.

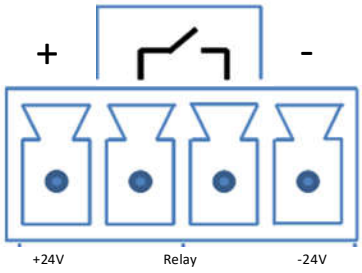
14.7 Chamber Feed

¼" NPT female fitting, fitted with an adaptor to 3/8" tubing (push fit)

Tubing is 3/8" polyethylene, color coded blue/black striped, length to suit up to 50 feet (15.25 meters).

14.8 Interlock

Four pin 3.81 mm header TE Connectivity 284541-4. Mating connector 284511-4 is included.



1	+24 V out, 200 mA fused	2	Relay contact	3	Relay contact	4	24 V return

14.9 Helium Supply In

¼” NPT female fitting

Tubing is 3/8” polyethylene, color coded blue, length to suit up to 50 feet (15 meters).

15 Fault Finding

Symptom	Possible Cause	Confirmation	Solution
Device will not boot or communicate	Damage to HC-80.		Contact Pyramid Technical Consultants, Inc.
	Failed firmware update.	Reboot does not clear problem.	Contact Pyramid Technical Consultants, Inc.
	Network IP addresses between HC-80 and client not compatible.	Check network addresses and IP masks are compatible.	Change addresses or configuration as needed.
	Duplicate Ethernet address of HC-80.	Check other device addresses on network.	Change HC-80 address.
Excess scattering of beam	Wrong gas	Check gas supply	Use helium supply
	O2 threshold set too high	Check setting	Use recommended setting 0.5%
	HC-80 not in regulation and interlock not connected.	Check operation and connections.	Use interlock output to inhibit beam.
Excessive helium consumption	Flow rate set too high	Check setting	Reduce rate to level that maintains low oxygen level
	Small leak in chamber	Inspect chamber for damage.	Repair as necessary.

Purge times out or takes excessive time.	Leak in helium chamber	Inspect chamber for damage, especially to windows.	Rectify damage

16 Maintenance

There are no user-serviceable parts inside the HC-80.

16.1 Operation check

A regular quality assurance check should be made to check that the following function as expected:

- Interlock relay opens on low Helium concentration

17 Returns Procedure

Damaged or faulty units cannot be returned unless a Returns Material Authorization (RMA) number has been issued by Pyramid Technical Consultants, Inc. If you need to return a unit, contact Pyramid Technical Consultants at support@ptcusa.com, stating

- model
- serial number
- nature of fault

An RMA will be issued, including details of which service center to return the unit to.

18 Support

Manual and software driver updates are available for download from the Pyramid Technical Consultants website at **www.ptcusa.com**. A secondary site can be found at **www.ptceurope.com**. Technical support is available by email from support@ptcusa.com. Please provide the model number and serial number of your unit, plus relevant details of your application.

19 Disposal

We hope that the HC-80 gives you long and reliable service. The HC-80 is manufactured to be compliance with the European Union RoHS Directive 2002/95/EC, and as such should not present any health hazard. Nevertheless, when your HC-80 has reached the end of its working life, you must dispose of it in accordance with local regulations in force. If you are disposing of the product in the European Union, this includes compliance with the Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC. Please contact Pyramid Technical Consultants, Inc. for instructions when you wish to dispose of the device.

If you suspect that the HC-80 or the Remote Sensor Unit may have been struck by a proton beam and thus become activated, the affected part should be surveyed by a trained radiation officer before being moved out of the controlled area.

20 Revision History

The release date of a Pyramid Technical Consultants, Inc. user manual can be determined from the document file name, where it is encoded YYMMDD. For example, HC80_UM_180105 would be a HC-80 manual released on 5 January 2018.

Version	***Changes***
HC80_UM_180904	First general release.
HC80_UM_180911	Revisions and minor corrections following internal review.

DOCUMENT APPROVAL

This document has been reviewed and approved by the following individuals:

X _____ P. Boisseau / Author	X _____
X _____ J. Gordon / Physicist	X _____
X _____ W. Nett / Quality	X _____

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