Section 6

Installation

Section 6: Installation

6.1 Introduction

The entire section on the installation of the liquid helium plant should be reviewed before installing the system.

CAUTION

Failure to follow these installation guidelines could result in voiding the warranty.

If the system is installed in an enclosed, confined space, an oxygen monitor/alarm should be installed to protect against an elevated or deficient oxygen level. Helium is an asphyxiant in high concentrations.

If the liquid helium dewar ruptures or develops a leak, the liquid helium will quickly vaporize and may create dangerously low oxygen concentrations in the ambient air.

If a leak develops in the helium gas supply line to the dewar, a dangerously low oxygen concentration in the ambient air is possible.

Being odorless, colorless, tasteless, and nonirritating, helium has no warning properties. Humans possess no senses that can detect the presence of helium. At low oxygen concentrations, unconsciousness and death may occur in seconds and without warning.

WARNING

Personnel, including rescue workers, should not enter areas where the oxygen concentration is below 19.5% unless provided with a self contained breathing apparatus or air-line respirator.

6.2 System installation

- Confirm that the physical space containing the liquid helium plant has an ambient temperature in the range of 45 to 100°F (7 to 38°C).
- Place the liquid helium plant in a level position. For the helium compressor package to operate under optimal conditions, it must be oriented within 5° of being level.

WARNING

The liquid helium plant must be positioned to provide easy access to the circuit breaker mounted on the front panel of the compressor.

- Position the system so there is sufficient space around it for attaching the gaseous helium supply to the helium inlet regulator and the water lines to the compressor. Consideration should also be given to the space required for the user to remove liquid helium from the dewar.
- Once in position, lock the system's wheels.

6.2.1 Remove the liquid helium extraction line (optional)

The system is supplied with the extraction line installed in the dewar. When installed, the extraction line will introduce losses into the dewar, reducing the liquid helium production rate approximately 10%. To maximize the production rate, the extraction line can be removed during production and inserted to withdraw liquid helium.

Follow the steps below to remove the extraction line. If the extraction line will be left in the dewar, skip to the next section.

1) Open the vent valve to release the pressure in the dewar.
2) When the compound pressure gauge reads 0 PSIG, close the vent valve.
3) To remove the extraction line, loosen the extraction port sleeve by turning counterclockwise with one hand while pulling the extraction line straight up and out with the other hand.

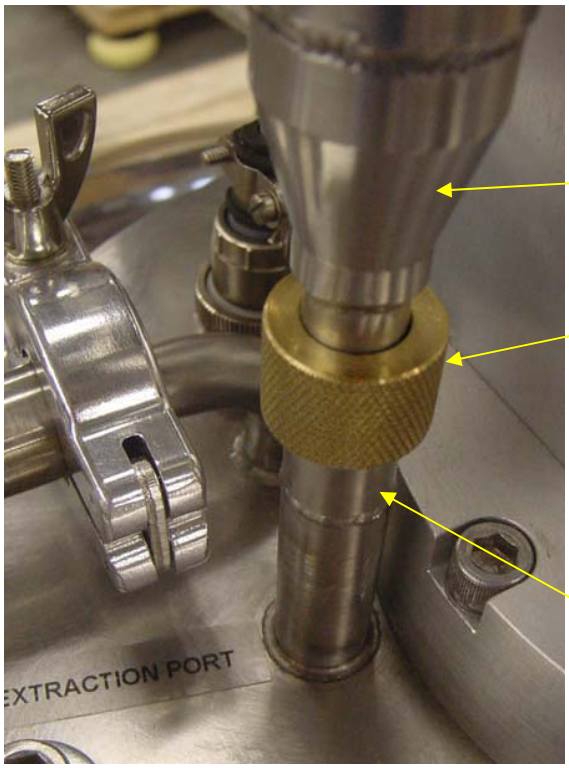

Figure 6-1: Extraction line installed in dewar

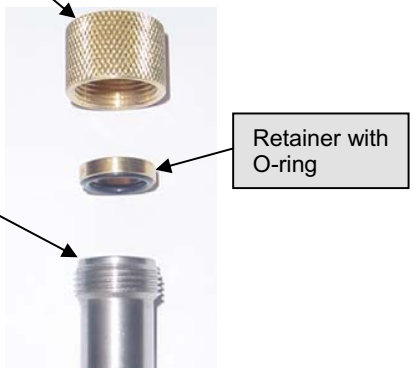

Figure 6-2: Extraction port detail

4) Insert the extraction port plug (supplied with the system) into the extraction port.
5) Hand tighten the extraction port sleeve by turning clockwise.

6.2.2 Connect the helium supply to the dewar

The dewar is shipped with a positive pressure of helium gas inside. If the dewar's compound pressure gauge reads 0 PSIG, the dewar must be evacuated and charged with helium before use. See Section 8 for the evacuation and charging instructions.

CAUTION

Failure to evacuate and charge the dewar will contaminate the condensing surfaces and decrease the liquid helium production. *The warranty does not cover this type of damage.*

The regulator has been preset at the factory for an operating pressure of approximately 1 PSIG (0.07 bar) when the dewar is at liquid helium temperature. When the dewar is at room temperature and during the early stages of cool down, the dewar pressure will be approximately 3 PSIG. Alignment marks on the regulator denote the factory setting.

Figure 6-3: He inlet regulator marked with factory setting

The regulator should not be adjusted, unless a higher operating pressure is required. To increase the operating pressure, turn the regulator's knob in the direction of the INCR arrow noted on the top of the adjustment knob. The maximum operating pressure is approximately 9 PSIG (0.6 bar), due to the dewar's 10 PSIG pressure relief valve.

CAUTION

The helium supply to the dewar must have a purity of 99% or greater. Helium purities less than 99% will contaminate the condensing surfaces and decrease the production of liquid helium. *The warranty does not cover this type of damage.*

The helium inlet regulator attached to the dewar is fitted with a quick connect coupling for connection to the helium supply. The mating quick connect coupling supplied with the system must be attached to the helium supply line. The mating coupling thread size is a 3/8 MPT (3/8" Male National Pipe Thread).

Both ends of the quick-connect couplings are self-sealing. When disconnected, they will prevent the helium gas in the supply line and dewar from escaping.

The helium supply line should be made from a flexible material to allow for connecting and disconnecting the quick connect coupling. The supply line must be terminated with a 3/8 FPT (3/8" Female National Pipe Thread) fitting.

1) Make sure that the helium supply is turned OFF.
2) Apply Teflon tape or pipe sealant to the 3/8 MPT threads on the quick connect coupling.
3) Thread the quick connect coupling into the helium supply line fitting and tighten with a wrench.
4) Turn the helium supply ON and check for leaks.
5) Connect the helium supply line to the dewar regulator. To make the connection, push the supply line coupling onto the mating coupling on the helium inlet regulator. A click will be heard when the couplings are locked together.

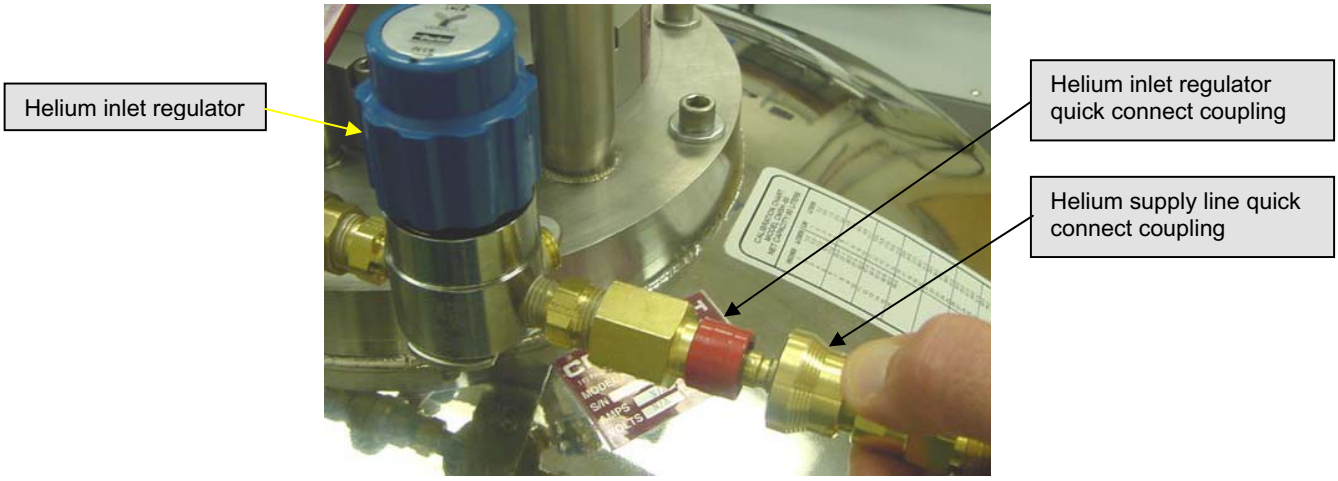

Figure 6-4: Connecting the helium supply line to the dewar

6) To unlock the couplings, push the flared section of the female coupling towards the red collar on the male coupling. Once unlocked, the couplings can be separated.

6.2.3 Connect the water lines to the helium compressor package

CAUTION

Cooling water must meet the requirements in Section 5. *If water that does not meet the cooling water specifications in Section 5 is introduced into the system, even for cleaning purposes, it will void the warranty.*

The inlet and outlet cooling water connections are fitted with quick connect couplings. The mating quick connect couplings supplied with the system must be attached to the water supply and drain lines. The mating coupling thread size is a 3/8 FPT (3/8" Female National Pipe Thread).

Both ends of the quick-connect couplings are self-sealing. When disconnected, they will prevent water in the compressor as well as the supply and drain lines from escaping.

The supply and drain lines should be made from a flexible material to allow for connecting and disconnecting the quick connect coupling. The lines must be terminated with a 3/8 MPT (3/8" Male National Pipe Thread) fitting.

1) Make sure that the cooling water supply is turned OFF.
2) Apply Teflon tape or pipe sealant to the threads on the 3/8 MPT (3/8" Male National Pipe Thread) fittings on the ends of the supply and drain lines.

3) Thread the quick connect couplings onto the supply and drain lines and tighten with a wrench.

4) Connect the supply line to the *Cooling Water In* port and the drain line to the *Cooling Water Out* port. To make the connection, pull the collar on the female coupling back, slide the coupling onto the compressor's male coupling, release the collar and push the couplings together. A click will be heard when the couplings are locked together.

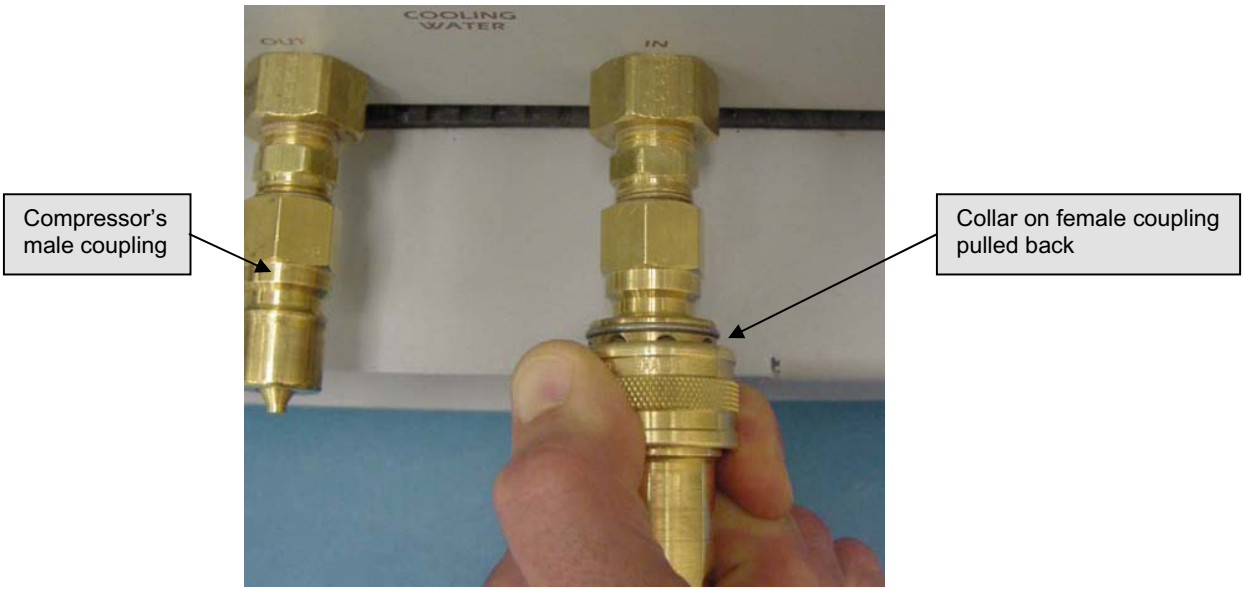

Figure 6-5: Connecting the water line couplings to the compressor package

5) Turn the cooling water supply ON and check for leaks.

6) Make certain the cooling water flow rate and inlet temperature meets the requirements in Section 5.

7) To disconnect the couplings, pull the collar back.

6.2.4 Connect the helium compressor package to the main power

CAUTION

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

1) The liquid helium plant MUST be connected to a dedicated circuit breaker. The breaker must be mounted near the system, within easy reach of the operator, and must be marked as the disconnecting device for the system. Specifications for circuit breakers vary according to the system's operating voltage. See the electrical specification tables in Section 5 for more information.

2) The helium compressor package comes with a main power cord attached. Assure that the length of the cord is sufficient to safely connect to the power source. If the cord is not sufficiently long, adjust the location of the liquid helium plant.

WARNING

Be sure to follow all local electrical codes and guidelines.

3) Make sure that the dedicated circuit breaker is turned OFF.

4) The ground (or earth) wire in the power cord is either green (60 Hz systems) or green/yellow stripe (50 Hz systems). Connect the ground wire in the power cord to the ground (or earth) connector in the breaker panel, making sure to tighten the wire into the connector securely. It is important not to disable this wire.

5) Connect the remaining hot wires in the power cord to the corresponding lugs on the dedicated breaker in the breaker panel, making sure to tighten the connector securely. The order of the wires is not important at this time - correct order will be determined in Section 7.

WARNING

One lead of the helium compressor package is grounded. Never bypass this ground or attach the helium compressor package to an ungrounded circuit. A dangerous electrical hazard will develop.

Section 7

Operation

Section 7: Operation

7.1 Starting the liquid helium plant

With the installation complete, make the following checks before starting the liquid helium plant. Automatic operation of the liquid helium plant is controlled by the liquid level monitor. Carefully follow the steps outlined in this section to ensure proper starting and operation of the liquid helium plant.

7.1.1 Checks before operating

1) Check the helium pressure in the compressor package - the gauges should read the pressure specified in Section 5.
   - If the pressure is too high, vent some of the helium following the instructions in Section 8.
   - If the pressure is too low, add helium following the instructions in Section 8.
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.
4) Check that the dedicated circuit breaker is on.
5) Check the pressure in the dewar. The gauge should read approximately 3 PSIG.

7.1.2 Startup procedure

1) Switch on the compressor package power at the MAIN circuit breaker.
2) Switch on the power to the compressor controls by switching on the POWER circuit breaker. The green ON light above the circuit breaker and the yellow Compressor Off light will both illuminate. A series of beeps will be heard and the front panel display will initially show the compressor model number, date and time. After a few seconds the top line of the display will read “COMPRESSOR OFF” and the bottom line will read “RMT START INTERLOCK”.

Figure 7-1: Display panel of the compressor package after power up

3) Switch on the liquid level monitor's power switch. The top line of the display will read "Liquid Helium Level". The bottom line will be blank.

Figure 7-2: Display panel of the liquid level monitor after power up

4) To start the system, press the monitor's ENTER button. An asterisk will appear on the bottom line for a few seconds before the bottom line displays a "negative cm value" and "FA". At this point the system will start.

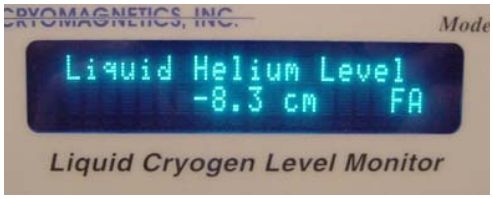

Figure 7-3: Representative view of the display panel of the liquid level monitor at start up

5) The green ON light above the Compressor On Button will illuminate and the top line of the display will read "COMPRESSOR ON". The bottom line will display the temperature of the silicon diode attached to the cold head's helium condenser. The Diode 2 Port is not used causing the display to read "D2=????K".

Figure 7-4: Display panel of the compressor package at start up

6) If the compressor's front panel display indicates "PWR PHASE ORDER BAD", perform the following steps to correct the phase error in the compressor package:

   a) Switch off the liquid level monitor.

   b) Switch off the two circuit breakers on the front panel of the compressor package.

   c) Turn off the dedicated circuit breaker to disconnect the system from power at the source (to prevent electrical shock).

   d) Examine the power cord and wire colors at the panel circuit breaker. Re-wire the input to the compressor by switching any 2 of the 3 input power wires.

   e) Energize the dedicated circuit breaker.

   f) Perform steps 1 – 4.

7) The compressor can be manually stopped and restarted by pushing the black Compressor Off Button and the green Compressor On Button. There is a 10 second time delay built in to allow pressure equalization in the event that the Compressor On Button is pushed immediately after the Compressor Off Button is pushed.

7.2 Normal operation behavior

7.2.1 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.

7.2.2 Normal sounds

When operating properly, the cryorefrigerator will emit a rhythmic squeak or chirp approximately 80 times per minute. This noise is an indication of the proper flow of helium gas within the system.

7.2.3 Normal cold head temperatures

On initial start up, the cold head's condenser temperature, shown on the compressor's display screen, will read approximately 300K. The temperature will drop steadily for the first 4 to 6 hours of operation. The cooling rate will slow once the temperature reaches approximately 100K.

The temperature will continue to drop until the liquefaction point is reached. The liquefaction point is dependent on the pressure inside the dewar.

For a dewar pressure of 1 PSIG the temperature sensor should indicate approximately 4.17K. If the dewar pressure is at its upper limit of 10 PSIG the temperature will read approximately 4.76K.

When the system is producing liquid and the dewar pressure is stable, the condenser's temperature will fluctuate less than ± 0.1K.

If the helium gas supply to the dewar drops below the liquefaction rate of the system, the pressure inside the dewar will decrease as will the condenser's temperature. If the temperature drops below 3.9K, the system will automatically shut itself off to prevent the dewar from operating under vacuum for an extended period of time.

7.2.4 Cool down time

When the cold head's condenser reaches the liquefaction temperature, liquid helium will drip off the condenser and fall to the bottom of the dewar. The liquid helium evaporates when it contacts the dewar, slowly cooling the dewar to liquid helium temperature. The dewar will take approximately 20 hours to cool to 4.2K. Once the dewar is cooled, liquid helium will begin to accumulate in the bottom of the dewar.

7.2.5 Normal dewar pressure

On initial start up and during the initial stages of cool down, the dewar pressure will be approximately 3 PSIG. As the dewar cools to liquid helium temperature, the pressure in the dewar will drop to approximately 1 PSIG.

The regulator is adjustable if a higher pressure is required. Refer to Section 6 for instructions on increasing the dewar pressure.

7.2.6 Normal production and automatic operation

The liquid helium plant will generate 12 liters of liquid helium a day once the dewar has cooled completely. The liquid level monitor displays the amount of liquid in the dewar.

The monitor will automatically shut the system off when the dewar is full, placing the system in standby mode. When in standby mode, the compressor's display will read "COMPRESSOR OFF" and the monitor will show a level of 39.5 cm or greater.

If the system is not running and the compressor's display reads "COMPRESSOR ERROR", then a malfunction somewhere in the system has occurred. Refer to the Troubleshooting Section to diagnose the problem.

The pressure inside the dewar will increase, due to the boil-off of the liquid helium, when the system is in standby mode. The pressure relief valve on the dewar will open when the internal pressure in the dewar reaches approximately 10 PSIG. Frost and condensation may accumulate near the relief valve when activated.

If the dewar pressure gauge shows a pressure greater than 15 PSIG, close the helium inlet valve and relieve the pressure through the vent valve. The problem must be diagnosed and corrected immediately.

CAUTION

A dewar pressure greater than 15 PSIG indicates a problem with the dewar's safety relief valves. The problem must be diagnosed and corrected immediately to prevent damage.

When the liquid helium level in the dewar has dropped below 39.5 cm, the level monitor will automatically restart the system. When the system restarts, the compressor's display will read "COMPRESSOR ON".

7.3 Compressor display panel

The screen normally shown on the display is referred to as the run-time screen. The messages described in Section 7.9 are displayed on the top line of the run-time screen. The bottom line of the run-time screen displays the temperature of the cold head's helium condenser.

Status and error messages will be shown on the display screen. The status messages, error messages, and set points at which error conditions will occur are listed in Section 7.9.

The SERVICE/RTN button is used to switch from the run-time screen to the top level of the menu – Diode Temperatures / Monitor Sensors / Error Log / Event Log / User Settings / Service / Comm Settings. See Appendix A - CMAS Menu System - for the detailed depiction of the menu system.

The SERVICE/RTN button can also be used to return to the run-time screen from any part of the menu.

The INC and DEC buttons are used to navigate back and forth along the top level of the menu. The SELECT button is used to navigate down each menu, and the CANCEL button is used to move back up.

7.4 Liquid level monitor display panel

The monitor's display panel always reads "Liquid Helium Level" on the top line. The second line will normally show the level of liquid helium in the dewar. The monitor is factory set to turn the system off when the dewar is full (40 cm) and to restart when the level has dropped to 39.5 cm. Dewar boil off is kept to a minimum at these settings.

The monitor has been programmed to take a level reading and update its display every 30 minutes. This interval was selected to minimize the amount of heat introduced into the liquid each time a reading is taken. When a level reading is being taken, a ✸ symbol will appear on the display screen.

To force a level reading before the interval has elapsed, press the ENTER button.

If the word "Open" is displayed instead of a liquid helium level, refer to the Troubleshooting Section.

7.4.1 Adjusting the monitor's factory settings

The monitor has been set at the factory for optimal performance. However, the factory settings are user adjustable in order to operate the system in a manner that best fits the needs of the user. The following diagram indicates options and the menu headings under which they are found.

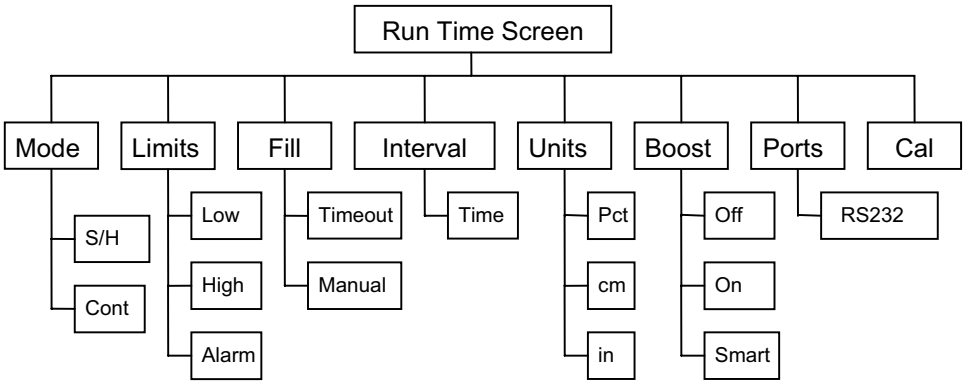

Figure 7-5: Level monitor menu diagram

Push the MENU button to move between the run time screen and the menu options.

To move along the menu items use the ▼ button to move to the right and the ▲ button to move to the left.

The ENTER button is used to navigate down from the menu items to their options.

Use the ▲ and ▼buttons to move between the options.

Pressing the ENTER button will allow the user to change the option settings.

Mode

Under the Mode menu item, the user can select either the Sample/Hold or Continuous operational mode. Pressing ENTER while ►Mode◄ is selected toggles the unit between Sample/Hold and Continuous modes. The display will indicate the selected mode. Press MENU to escape.

Factory setting is Sample/Hold.

Limits

The set points for the high and low limits and the audible alarm are set in the Limits menu. Press the ▼ button to move from ►Mode◄ to ►Limits◄. Pressing ENTER will display "►Alarm◄ Low High" on the top line and their current settings on the bottom line. Press the▼ button to toggle between the three. Pressing ENTER will allow the user to set the level of each menu item.

Factory settings are Alarm – 0.0, Low – 39.5 cm, High – 40.0 cm

The monitor has an internal audible alarm that can be set to activate when the liquid helium falls below a user settable threshold. The alarm function also gives a front panel display when it is activated – "A" appears when an alarm indication is present. The audible alarm can be silenced by pressing any front panel key, however the visual indication of the alarm condition, "A" on the display, is maintained until the liquid level is read by the monitor and is found to be above the alarm level set point.

Fill

The Fill menu does not apply to the liquid helium plant.

Factory setting is Fill Timeout - 0 min.

Interval

The Interval (Intvl) menu item allows the user to select the interval of time between readings of the liquid helium sensor in Sample/Hold mode. With ►Intvl◄ selected, press ENTER to bring up the interval setting display. Then use the ▲ and ▼buttons to bring the sample interval to the desired time. Press ENTER again when the correct time is displayed, or MENU to escape without changing the interval.

Factory setting is 00:30:00 (30 minutes).

Units

The Units menu item allows the user to set the display units. Available options are percent (%), centimeters (cm), or inches (in). With ►Units◄ selected, pressing ENTER will display "percent ►cm◄ in". Use the ▲ and ▼buttons to toggle between the units. Press ENTER to select the unit.

Factory setting is cm.

Boost

The Boost menu item allows the user to set the sensor de-ice mode of the monitor. Options under this item are:

Off Current to the sensor is never boosted to a higher setting to clear contaminants on the sensing filament.

On Current to the sensor is briefly boosted to a higher setting at the beginning of each liquid level reading to clear contaminants on the sensing filament.

Smart Current to the sensor is only boosted to a higher setting at the beginning of a liquid level reading to clear contaminants if the sensor has not been activated within the past five minutes of operation.

Factory setting is Off.

Ports

The Ports menu item allows the user to select the baud rate for the RS-232 computer interface. All front panel functions, except calibration functions, may be accessed over

the RS-232 port. The baud rate may be set to 9600, 4800, 2400, or 1200. The default is 9600.

Calibrate

The Calibrate (Cal) menu item is used to set the parameters for the sensor installed in the dewar. The parameters are set at the factory and should not be changed.

Factory settings are Ch 1 Sensor Length – 41.0 cm, Sensor 1 Resistance – 4.550 Ω/cm, Ch 1 Lead Resistance – 0.00 Ω.

7.5 Shutdown procedure

Press the black “Compressor Off” button on the front panel of the compressor package. This will switch off the compressor system. Switch off the front-panel mounted circuit breakers to shut down the entire system.

7.6 Extracting liquid helium

WARNING

Before extracting liquid helium from the dewar, carefully read the following safety precautions. Improper handling of liquid helium may result in serious injury or death.

- *Transferring and handling liquid helium can be extremely hazardous if the proper precautions are not taken. The hazards associated with liquid helium are exposure to cold temperatures, over pressurization of inadequately vented vessels due to the expansion of small amounts of liquid into large volumes of gas, and asphyxiation due to the displacement of oxygen in the air in confined areas.*
- *Liquid helium is a colorless, odorless, extremely cold liquid, -452°F (-269°C), and can produce cryogenic burns of the skin and freeze underlying tissue almost instantaneously upon contact. The recommended personal protective equipment for handling liquid helium includes a full face shield over safety glasses, loose-fitting thermal insulated or leather gloves, long sleeve shirts, boots and trousers without cuffs. Never tuck trousers inside the boots. Gloves should be loose fitting so they can be quickly removed if liquid helium is spilled on or in them. Insulated gloves are not made to permit the hands to be put into liquid helium. They will only provide short-term protection from accidental contact with liquid helium.*
- *Liquid helium vaporizes into large amounts of gas. One liter of liquid helium will vaporize to 754 equivalent volumes of gas at room temperature, 68°F (20°C). When filling a vessel with liquid helium, make certain the vessel is adequately vented. If a sufficient amount of liquid helium is vaporized in a closed container, it will produce enormous pressures that could rupture the vessel. For this reason, pressurized liquid helium vessels must be protected with multiple pressure relief devices.*
- *As liquid helium vaporizes the resulting gas displaces the oxygen in the air. Since it is odorless, colorless, tasteless, and non-irritating, the undetectable gas can reduce the air's oxygen content below the level needed for safe breathing. Inhalation of helium in excessive amounts can cause dizziness, nausea, vomiting, loss of consciousness, and death. At low oxygen concentrations, unconsciousness and death may occur in seconds without warning. Thus, liquid helium must be stored and used only in a well-ventilated area. Oxygen monitors are recommended whenever liquid helium is handled in enclosed areas.*

WARNING

If a large spill of liquid helium occurs, open all windows and doors to ventilate the area.

- *The white colored vapor cloud observed when working with liquid helium is condensed moisture and extremely cold helium gas. When exposed to cold helium gas, delicate tissues such as those of the eyes can be damaged even when the contact is too brief to affect the skin of the hands and face.*

Liquid helium can be extracted from the dewar at any time. The pressure inside the dewar pushes the liquid helium out of the dewar. Use the flexible, stainless steel extraction line to remove liquid helium from the dewar. The valve and extraction line are vacuum jacketed to minimize boil off losses when transferring liquid as well as helping to protect the operator from coming in contact with extremely cold surfaces.

If the extraction line was removed from the dewar, follow the steps outlined below to insert the extraction line. If the extraction line is installed in the dewar, skip to the next section.

7.6.1 Inserting the extraction line

To remove liquid helium from the dewar, the extraction line must be inserted into the dewar's extraction port. Referring to Section 5.6, perform the following steps to install the extraction line.

WARNING

The operator should be outfitted with the recommended personal protective equipment outlined above before inserting the extraction line into the dewar.

1) Turn off the system by pressing the black Compressor Off button on the compressor package.
2) Close the helium regulator shut off valve to stop the flow of helium into the dewar.
3) Open the vent valve to release the pressure in the dewar.
4) When the compound pressure gauge reads 0 PSIG, close the vent valve.
5) To remove the extraction port plug, loosen the extraction port sleeve by turning counterclockwise with one hand while pulling the extraction port plug up and out with the other hand.

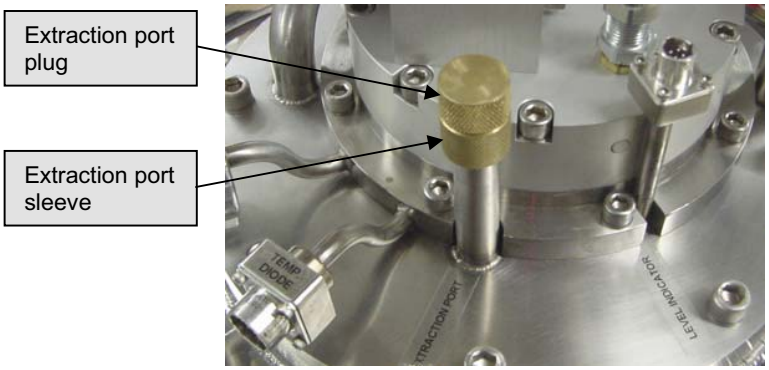

Figure 7-6: Dewar extraction port

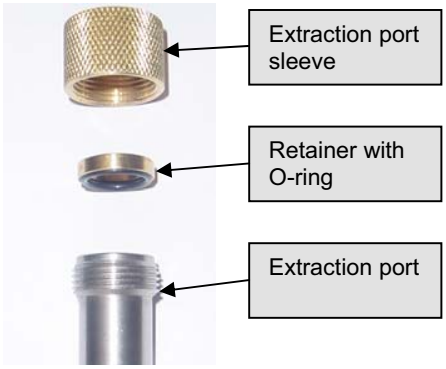

Figure 7-7: Extraction port detail

6) Very slowly insert the extraction line's withdrawal tube into the extraction port.

INFORMATION

Inserting the withdrawal tube slowly allows the vapor to cool the withdrawal tube, which reduces the amount of liquid helium boil off.

7) Hand tighten the extraction port sleeve by turning clockwise.
8) Slowly open the helium regulator shut off valve to pressurize the dewar.

When the compound pressure gauge shows a pressure of 1 PSIG or greater, withdraw liquid helium from the dewar as outlined in the next section.

To remove the extraction line from the dewar reverse the steps outlined above.

7.6.2 Withdrawing liquid helium

WARNING

The operator should be outfitted with the recommended personal protective equipment outlined above before extracting liquid helium.

Remove liquid helium by opening the valve on the extraction line. When the valve is first opened, escaping gas will be heard and a white colored vapor will be seen exiting the end of the extraction line. Liquid helium will not flow from the hose until the internal line of the extraction hose has cooled to liquid helium temperature.

When closing the valve, do not over-tighten. Once the valve stem contacts the valve seat, light finger pressure is all that is needed to close the valve. Damage to the valve stem will occur if the valve is over tightened. After closing the valve, the small quantity of liquid helium remaining in the extraction hose will continue to drain.

CAUTION

Damage to the valve stem and seat will occur if the valve is over-tightened.

7.7 DAILY INSPECTIONS

The liquid helium plant has been designed to give continuous, trouble free service. There are, however, daily inspections that will help detect and prevent system failure. Observe the following list carefully.

INFORMATION

It is helpful to monitor the liquid helium plant daily in order to detect changes in performance early. These changes can signify degradation in performance that could result from the beginning of a problem that requires attention.

7.7.1 Dewar

Check and record the dewar pressure. Unless the factory setting was changed, the gauge should read approximately 1 PSIG when the system is operating and the dewar is at liquid helium temperature. When the system is off, the gauge should read 10-12 PSIG maximum.

If the dewar pressure gauge shows a pressure greater than 15 PSIG, close the He regulator shut off valve and relieve the pressure through the vent valve. The problem must be diagnosed and corrected immediately. Contact Cryomech if the cause of the over-pressurization is not determined.

CAUTION

A dewar pressure greater than 15 PSIG indicates a problem with the dewar's safety relief valves. The problem must be diagnosed and corrected immediately to prevent damage.

7.7.2 High and low pressure

Changes in the high and low pressure readings on the compressor package's gauges are used for diagnosing several different types of problems. It is important to know whether changes are sudden or gradual and to know how the high and low pressures are changing relative to each other.

The high and low pressures should be monitored daily.

Cryomech recommends that you maintain a regular record, at intervals that make sense for the way you use your system, of the high and low pressure readings. The RS232/488 port can be used to remotely monitor and record the pressure data.

7.7.3 Cold head temperature

Temperature changes are the other key diagnostic.

A temperature sensor is attached to the cold head's helium condenser.

Cryomech recommends that you keep a regular record of the temperature at intervals that make sense for the way you use your system. The RS232/488 port can be used to remotely monitor and record the temperature data.

7.7.4 Cooling water input and output

If possible, Cryomech recommends keeping a regular record of the input and output cooling water temperatures and of the cooling water flow rate. The RS232/488 port can be used to remotely monitor and record the water temperature data.

7.8 Disassembling the system for transport or storage

Use the following steps to prepare a Cryomech Liquid Helium Plant for eventual transport or storage. Assure that the plant is packaged in an appropriate container and/or stored in an acceptable location.

7.8.1 Helium compressor

1) Make sure that the display on the front panel indicates that the compressor system is OFF.
2) Disconnect the power to the system by switching the front panel breakers to the OFF position
3) Disconnect the main power to the system by switching the dedicated circuit breaker to the OFF position.
4) Disconnect the power cord from the external breaker panel. Coil up the power cord in preparation for transport or storage.
5) Turn off the water supply at the source.
6) Disconnect the supply and drain quick connect couplings from the compressor's inlet and outlet fittings. To disconnect the couplings, pull the collar back as shown below.

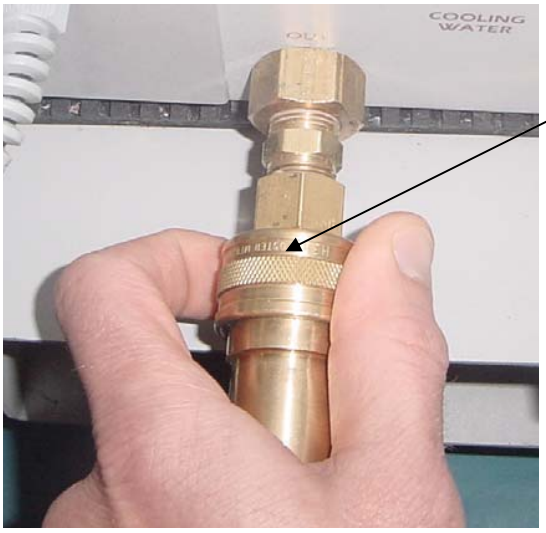

Figure 7-8: Disconnecting the cooling water quick connect coupling

7.8.2 Dewar

1) Close the helium regulator shut off valve.
2) Turn off the helium supply to the dewar.
3) Disconnect the helium supply line's quick connect coupling from the dewar's quick connect coupling attached to the He inlet regulator. To unlock the couplings, push the flared section of the female coupling towards the red collar on the male coupling. Once unlocked, the couplings can be separated.

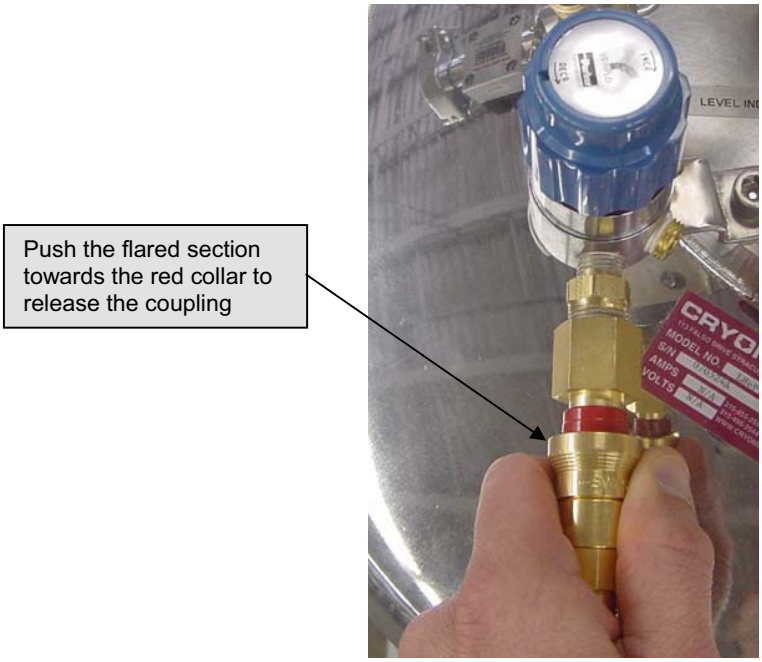

Figure 7-9: Disconnecting the helium supply's quick connect coupling

7.9 Troubleshooting

7.9.1 Helium compressor will not start

SYMPTOM	Helium compressor will not start.
POSSIBLE CAUSE	1) No power supplied to the helium compressor. 2) Circuit breaker off. 3) “Compressor Error” message displayed on display screen.
REMEDY	1) Check the power supply to the helium compressor and verify that it meets the requirements outlined in Section 5. 2) Make certain both circuit breakers, located on the front panel of the compressor package, are on. 3) Refer to Section 7.9.6 for error message diagnostics.

7.9.2 Helium compressor starts, no pressure fluctuation

SYMPTOM	Helium compressor starts, no bounce in the pressure gauges, diode temperature not decreasing.
POSSIBLE CAUSE	1) Cold head motor cord not connected to the cold head and/or to the compressor package. 2) Aeroquip® connector(s) not completely tightened. 3) High and low pressure helium flex lines reversed.
REMEDY	1) Turn off the compressor and connect the cold head motor cord to the cold head and/or to the compressor package. 2) Tighten all Aeroquip® connectors. 3) Verify that one of the helium flex lines connects the high pressure port on the helium compressor package to the high pressure port on the cold head and that the other helium flex line connects the low pressure ports.

7.9.3 System has shut itself down

SYMPTOM	System has shut itself down.
POSSIBLE CAUSE	1) Circuit breaker tripped. 2) Interruption of the power supply to the compressor package. 3) “Compressor Error” message displayed on front panel screen.
REMEDY	1) Reset the circuit breaker on the front panel of the helium compressor. See Section 5. 2) Check the power supply to the system and verify that it meets the requirements outlined in Section 5. 3) Refer to Section 7.9.6 for error message diagnostics.

7.9.4 Liquid level monitor display reads “Open”

SYMPTOM	Display reads “Open” instead of a liquid helium level.
POSSIBLE CAUSE	1) Sensor is not connected. 2) Connection is broken in the current path.
REMEDY	1) Make certain the level monitor cable is properly connected to the level monitor and the dewar as outlined in Section 6.* 2) Please contact Cryomech for instructions on checking for a broken connection.* * When the monitor displays “Open” it will immediately abort further attempts to sense the liquid helium level. After correcting the “Open” problem, press the MENU button to show ►Mode◄ on the top line and “Disabled” on the second line. Press ENTER to select Sample/Hold and MENU to escape.

7.9.5 Compressor run time display screen description

Run time messages are displayed on the top line of the display screen. The temperature of the cold head’s helium condenser is displayed on the bottom line when the system is running.

Top line message on the display screen	Message description
“COMPRESSOR OFF”	Front panel or remote interface turned off compressor. All is well.
“COMPRESSOR ON”	Compressor is running. All is well.
“STARTING…WAIT X” (X is a number, counting down. When X is zero compressor will start)	Compressor On request received. Compressor will start within 10 seconds unless an error occurs or a stop request is received. This message will show only when the compressor has not been off for more than 10 seconds and a start request is received. This state allows the high and low helium pressures to balance.
“WAITING FOR POWER”	Compressor is waiting for good power. Will be displayed for a short time while the power tracking state machine is checking the line power, which takes 5 seconds minimum. In this state, WHEN POWER COMES BACK, THE COMPRESSOR WILL START.
“COMPRESSOR ERROR”	An error has occurred. The error will be displayed on the second line. If more than one error is lodged, the highest priority error will be displayed on screen. See below for error display and description.
“ERR HOLD…WAIT x” (x is a number, counting down, in seconds. When x is zero compressor will start)	Compressor On request received and compressor will start in x seconds unless an error occurs or a stop request is received. This message will show when the compressor has encountered certain errors that require a minimum off time.

“CALL FACTORY”	The compressor has entered a locked-out state due to experiencing 6 errors within one hour. The compressor cannot be restarted until a special code is entered. You must contact Cryomech to obtain this code. Have the CPU serial number and compressor hours ready – both are stored in the SERVICE menu. The lockout contributors are noted in Section 7.9.6.
“ERROR! NO MESSAGE!”	This message should never be seen. It indicates the compressor is in a state with no description available.

7.9.6 Error diagnostics on compressor display screen

Errors will cause the compressor system to stop. Errors are displayed on the bottom line of the display screen. If more than one of the errors below is present, only the highest priority one will be displayed. The table lists errors from highest to lowest priority. If the error is a lockout contributor, it will be noted in the Explanation column.

When an error has occurred, the Compressor On indicator light will blink and the panel will emit a beeping sound. To stop the beeping sound, press the Compressor Off Button. Once the error condition has cleared, the compressor can be restarted by pressing the Compressor On Button. The light will stop blinking once the compressor has restarted.

If the error condition still exists the compressor will not restart and the light will continue to blink.

Error Message	Explanation
“FATAL ERROR: I2C”	This occurs if the I2C bus fails or a part on the I2C bus fails. Cycle power. If the condition persists, contact factory. Lockout contributor.
“FATAL ERROR: 5V HIGH”	The 5V power as measured by the system exceeds the limit of 5.25 volts. Contact factory. Lockout contributor.
“FATAL ERROR: 5V LOW”	The 5V power as measured by the system is below the limit of 4.75 volts. May be caused by a shorted sensor. Contact factory. Lockout contributor.
“SYSTEM LOCKOUT 1”	The compressor is in lockout mode due to more than 6 errors within one hour; the compressor cannot be started until a code is entered. Contact factory. Lockout contributor.
“PWR PHASE ORDER BAD”	The order of the phase power is wrong. Re-wire the input to the compressor by switching any 2 of the 3 input power wires.
“REMOTE INTERLOCK 1”	Digital I/O line *RMT_INTERLOCK* went TRUE while compressor was running or start attempted while *RMT_INTERLOCK* line was TRUE.
“RMT STOP INTERLOCK”	Start attempted while digital I/O line *RMT_OFF* line was TRUE. Not logged.
“RMT START INTERLOCK”	Start attempted while digital I/O line *RMT_ON* line was FALSE and *RMT_SLVL* was TRUE. Not logged.
“HIGH He PRESSURE”	This occurs when high side helium pressure is too high. Release helium from the system. Lockout contributor.

“LOW WATER FLOW”	This occurs when the output water temperature exceeds a threshold. Check flow rate and inlet temperature of cooling water. Lockout contributor.
“HIGH He GAS TEMP”	This occurs when the helium gas temperature exceeds a threshold. Probable cause is insufficient oil in the top sump of the compressor module. Check oil level in top sump sight glass when system is operating. Lockout contributor.
“LOW He PRES”	This occurs when the helium gas pressure is below the threshold. Add helium to the system. Lockout contributor.
“COMP MOTOR CURRENT”	This occurs when the compressor module motor current is below threshold while the motor is requested running. Can be caused by an overheated compressor module. Lockout contributor.
“HIGH OIL TEMP”	This occurs when the compressor oil temperature exceeds a threshold. Check flow rate and inlet temperature of cooling water. Lockout contributor.
“DEWAR VACUUM”	Liquid Helium Plants Only–Temperature reading of Diode 1 too cold. Indicates a vacuum in the dewar. Make sure dewar has He gas supply.
“LOW VOLTS ON MAINS”	Compressor wants to be on but cannot run because one or more of the mains power “legs” has failed (phase loss or low voltage). When the power error has been corrected, THE COMPRESSOR WILL START!

7.9.7 Warning diagnostics on compressor display screen

Warnings do not cause the compressor to stop and do not prevent the compressor from starting. Warnings are displayed on the bottom line of the display screen. If more than one of the warnings below is present, only the highest priority one will be displayed. The table lists warnings from highest to lowest priority.

Warning Message	Explanation
"*WARN:STALL DETECTED"	The compressor has detected no cold head activity, the cold head has stalled or been disconnected.
"*WARN:NO HI PSI SENS"	This occurs when the high side helium pressure sensor has published a reading that is out of the range of the sensor. Indicates a bad sensor or shorted wiring.
"*WARN:NO LOW PSI SNS"	This occurs when the low side helium pressure sensor has published a reading that is out of the range of the sensor. Indicates a bad sensor or shorted wiring.
"*WARN:HIGH DP"	The DP (Delta Pressure) has exceeded the threshold.
"*WARN:NO IN WTR SENS"	This occurs when the input water temperature sensor has published a reading that is out of the range of the sensor. Indicates a bad sensor or shorted wiring.
"*WARN: IN WTR TEMP HI"	The temperature of the input water has exceeded the threshold.
"*WARN:NO OUT WTR SNS"	This occurs when the output water temperature sensor has published a reading that is out of the range of the sensor. Indicates a bad sensor or shorted wiring.
"*WARN:NO He TMP SENS"	This occurs when the helium temperature sensor has published a reading that is out of the range of the sensor. Indicates a bad sensor or shorted wiring.
"*WARN:NO OIL TMP SNS"	This occurs when the oil temperature sensor has published a reading that is out of the range of the sensor. Indicates a bad sensor or shorted wiring.

7.9.8 Compressor error and warning set points

The trip and clear set points for all the errors and warnings are listed in the following table. All errors and warnings have a 1 second debounce time except for COMP MOTOR CURRENT, which has a 9 second debounce time. There is a 5 minute delay on restart for a HIGH He GAS TEMP error.

Error Description	Trip	Clear
"HIGH He PRESSURE" **CP2800** Series Compressors – LHeP12	High side PSI > 399 PSIG (27.5 bar)	High side PSI ≤ 398 PSIG (27.4 bar)
CP1000 Series Compressors – LHeP20	High side PSI > 360 PSIG (24.8 bar)	High side PSI ≤ 359 PSIG (24.7 bar)
"LOW WATER FLOW"	126°F (52°C)	100°F (38°C)
"HIGH He GAS TEMP" **CP2800** Series Compressors – LHeP12	190°F (88°C)	120°F (49°C)
CP1000 Series Compressors – LHeP20	220°F (104°C)	120°F (49°C)
"LOW He PRES"	< 35 PSIG (2.4 bar)	≥ 36 PSIG (2.5 bar)
"COMP MOTOR CURRENT"	< 5A	≥ 5 A
"HIGH OIL TEMP"	120°F (49°C)	100°F (38°C)
"DEWAR VACUUM"	D1 < 3.9K	D1 ≥ 4.22K

Warning Description	Trip	Clear
"*WARN:STALL DETECTED"	DP < 1 PSI (0.07 bar)	DP ≥2 PSI (0.1 bar)
"*WARN: IN WTR TEMP HI"	85°F (29°C)	80°F (27°C)
"*WARN:HIGH DP"	> 265 PSI (18.3 bar)	≤ 264 PSI (18.2 bar)

7.10 Contact Cryomech with Questions

It is hoped that the Operations Section of this manual has helped you to obtain satisfactory results in the use of your Liquid Helium Plant. While the information offered should facilitate set up and operation, you may have a special situation that requires further considerations. If after reading the Operations Section, you still have questions, contact Cryomech for further information.

7.10.1 Contact Information

Cryomech, Inc.
113 Falso Drive
Syracuse, NY 13211

Phone: (315) 455-2555
Fax: (315) 455-2544

Email: cryoservice@cryomech.com

Website: www.cryomech.com

Section 8

Routine Maintenance

Section 8: Routine Maintenance

8.1 Introduction

This section contains basic, essential maintenance information. For more detailed information please contact Cryomech.

8.2 Maintenance schedule

Maintenance	Frequency	Comment
Replace adsorber	Every 20,000 hours	See Section 8.4
Vent helium gas from the compressor	As required	See Section 8.5
Charge helium gas to the compressor	As required	See Section 8.6
Dewar evacuation and charging	As required	See Section 8.7

8.3 Cold head

CAUTION

The cold head contains no user-serviceable parts. *Attempting to disassemble the cold head will void the warranty.*

CONTACT CRYOMECH IF THE COLD HEAD NEEDS TO BE RETURNED FOR SERVICING.

8.4 Replace the adsorber

Required tools:

Quantity	Description	Comment
1	1” Open end wrench	For Aeroquip® coupling
1	1-1/8” Open end wrench	For Aeroquip® coupling
1	1-3/16" Open end wrench	For Aeroquip® coupling
1	1-3/8" Open end wrench	For Aeroquip® coupling
1	1-5/8" Open end wrench	For Aeroquip® coupling
1	Slotted screwdriver	For hose clamp
1	Phillips head screwdriver	For side panel of compressor

CAUTION

At no time should the Aeroquip® couplings be removed from the adsorber when replacing the adsorber. Replacement can be completed without relieving system pressure since the adsorber is equipped with Aeroquip® couplings for sealed removal.

1) Shut down the system.

2) Disconnect both rigid lines from the compressor and external volume housing. When loosening the Aeroquips®, alternate between the compressor and external volume housing Aeroquips® couplings to remove the line evenly.

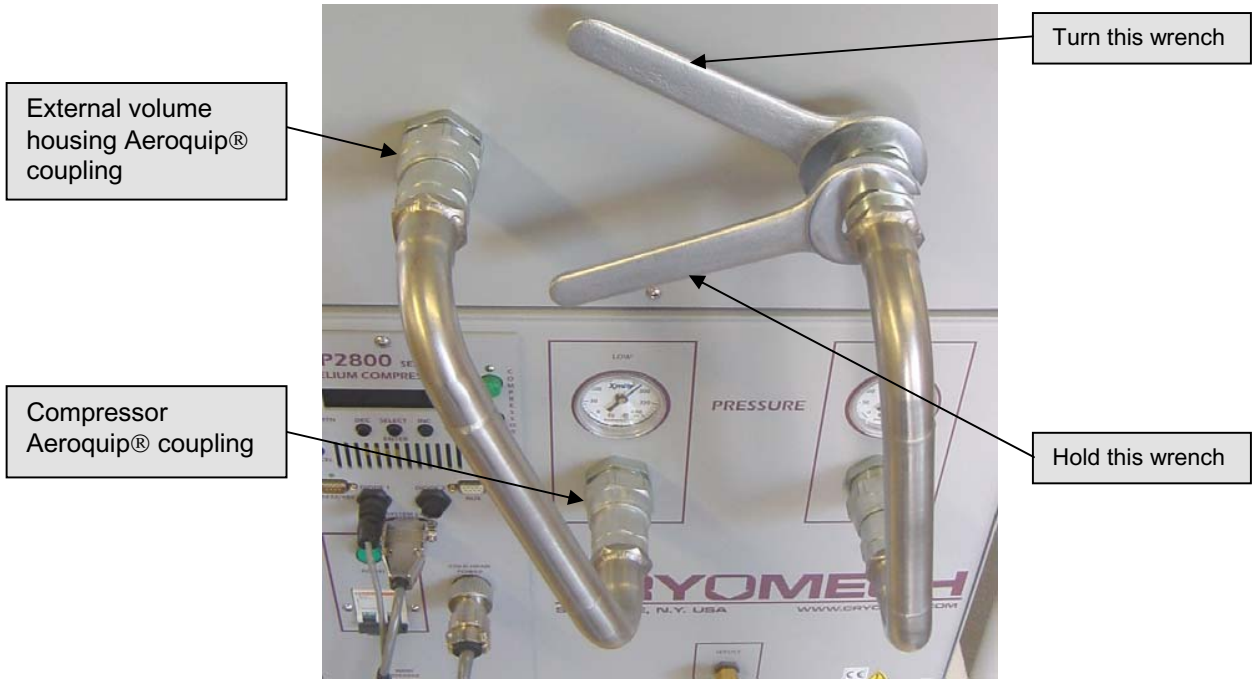

Figure 8-1: Disconnecting the rigid lines from the compressor and volume housing

3) Completely disconnect the female Aeroquip® couplings from the compressor and pivot them away from the male couplings as shown below.

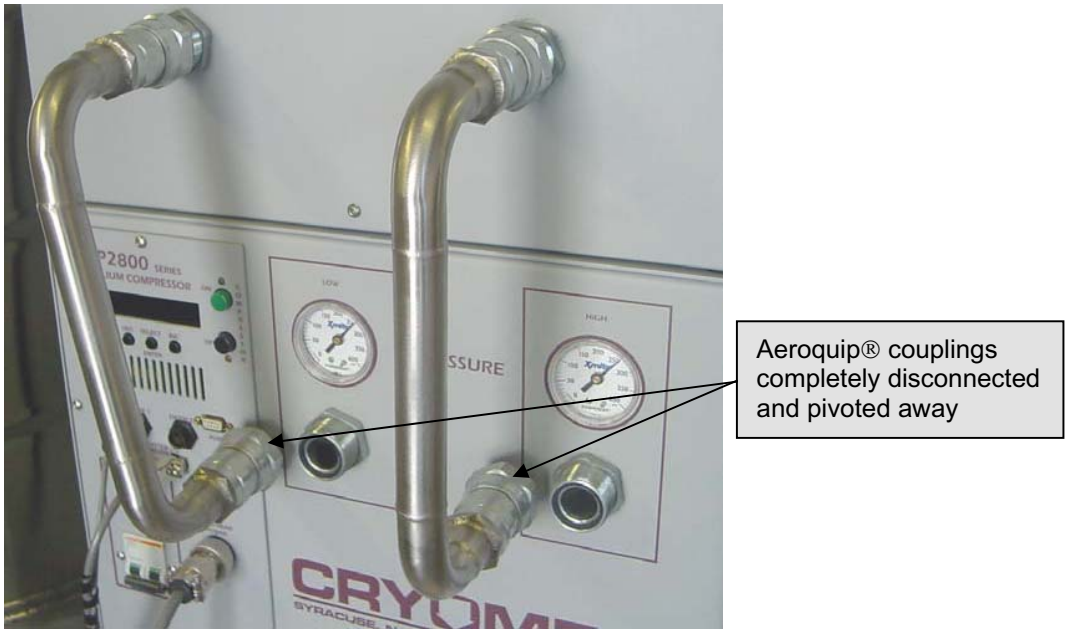

Figure 8-2: Aeroquip® couplings disconnected from the compressor

4) Remove the side panel from the right hand side of the compressor package.
   a. Remove the 6 quarter-turn screws that hold the cover on and retain them.
   b. Pull the panel away from the compressor package.

5) Using three wrenches disconnect the Aeroquip® coupling between the adsorber and the oil separator as shown below.

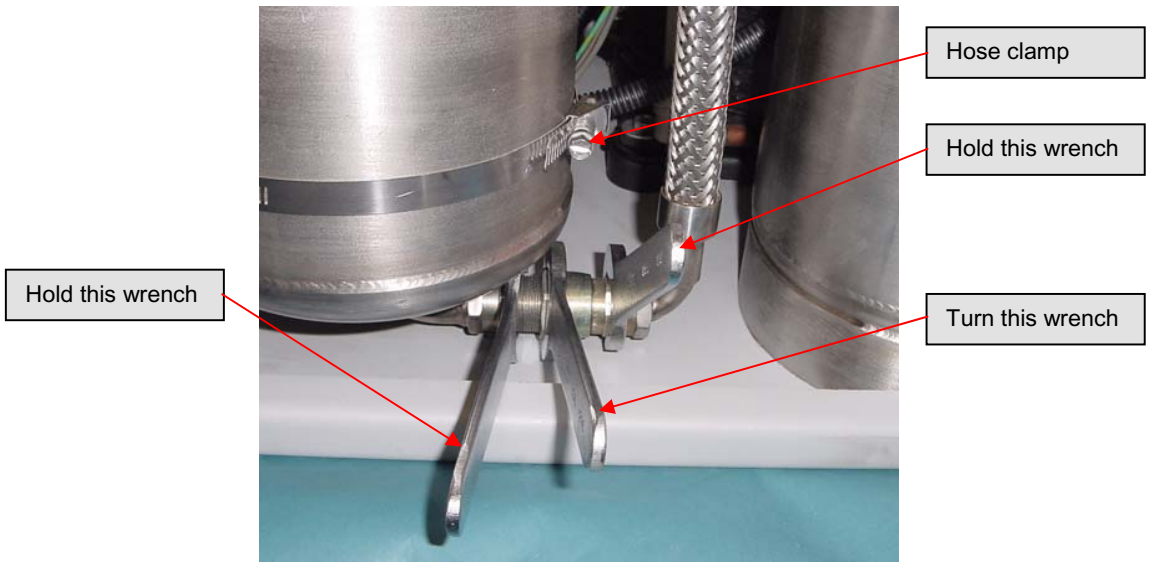

Figure 8-3: Disconnecting the adsorber Aeroquip®

6) Remove the nut holding the high-pressure Aeroquip® coupling to the front panel.
7) Loosen and disconnect the hose clamp that attaches the adsorber to the front panel.
8) Remove the adsorber from the compressor package.
9) Check the Aeroquip® couplings for oil residue. If oil is present, contact Cryomech for further assistance.
10) Remove the lock washer from the top Aeroquip® and install it on the new adsorber.
11) To install the new adsorber, reverse steps 5 through 8.
12) Reconnect both rigid lines to the compressor and external volume housing.
13) Reattach the side panel to the compressor package.

8.5 Vent excess helium from the compressor

Required tools:

Quantity	Description	Comment
1	3/4” Open end wrench	For Aeroquip® coupling
1	Service Aeroquip® coupling	For service access port

CAUTION

Venting more than 5 PSIG (.34 bar) of helium per minute will lead to improper oil migration within the system. If this condition occurs, factory service will be required.

This procedure should only be used to vent small quantities of helium from an overcharged system.

1) Make sure the service valve is closed. See Figure 8-4.
2) Attach the small service Aeroquip® coupling to the service access port.
3) Open the service valve slowly. Do not vent more than 5 PSIG (.34 bar) of helium per minute.
4) After venting the helium, close the service valve and remove the service Aeroquip® from the service access port.

8.6 Recharge helium to the compressor

Required tools and equipment:

Quantity	Description	Comment
1	3/4” Open end wrench	For Aeroquip® coupling
1	Service Aeroquip® coupling	For service access port
1	Vacuum/charging system	For adding helium

CAUTION

When adding helium to the compressor, the helium must be 99.999% pure. Contamination by other gases will result in the freezing of the contaminant gases in the cold head because their freezing temperature is much higher than that of helium. Contaminants in the helium charge will severely degrade the cold head's function and it will require factory servicing.

Contamination of the helium by other gases is a common cause of premature failure and, unless resulting from a system failure, is not covered by the warranty.

This procedure should be performed with the compressor package shut down. Adding helium is possible whether or not the cold head is attached to the compressor package. Both the service access and service valve are connected to the low-pressure manifold of the compressor.

1) Turn the system off.
2) Allow the entire system, both the compressor package and the cold head, to come to room temperature.
3) Use only high purity helium with a minimum purity of 99.999%.
4) Check that the helium source and regulator are capable of pressurizing to the desired pressure.
5) Make sure the service valve is closed.
6) Attach the service Aeroquip® coupling to the service access port.

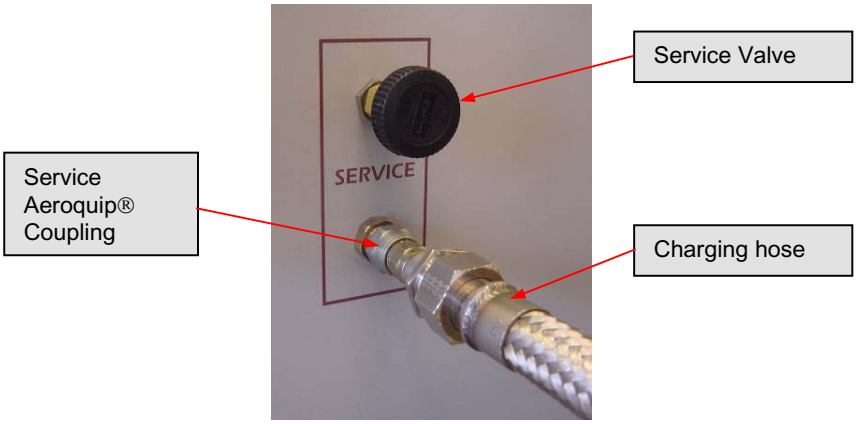

Figure 8-4: Service valve and access port

7) Attach a charging line from the service Aeroquip® to a typical vacuum/charging system as shown below.

Figure 8-5: Vacuum/charging system

8) Evacuate to 50 microns.

9) Isolate the vacuum pump and add 50 PSIG (3.4 bar) of helium.

10) Vent the helium and repeat steps 8 to 10.

11) Final evacuation should be to 25 microns.

12) Pressurize the line to the service access with the desired amount of helium pressure.

13) Slowly open the service valve to add helium to the system. The final helium charge in the system is specified in Section 5.

CAUTION

No more than 5 PSIG (.34 bar) of gas should be added per minute to prevent internal oil contamination to the system. If such contamination occurs, factory service will be required.

14) After adding the helium, close the service valve and remove the service Aeroquip® from the service access.

8.7 Dewar evacuation and charging

Required tools and equipment:

Quantity	Description	Comment
1	Vacuum/charging system	For evacuating and adding helium
1	Evacuation/charging line	For connection between dewar and vacuum/charging system

Before starting the system, check the dewar's compound pressure gauge. If the gauge reads 0 PSIG or less, the dewar must be evacuated and charged with helium before use.

CAUTION

Failure to evacuate and charge the dewar will contaminate the condensing surfaces and decrease the liquid helium production. *The warranty does not cover this type of damage.*

1) Close the helium inlet valve.
2) Attach an evacuation/charging line to the dewar's evacuation valve. The valve is fitted with a KF16 flange.
3) Attach the opposite end of the evacuation/charging line to a typical vacuum/charging system as shown in Figure 8-5.
4) Open the dewar's evacuation valve completely.
5) Start the vacuum system and evacuate the dewar to approximately 30" Hg.
6) Isolate the vacuum pump and charge the dewar with approximately 5 PSIG (0.34 bar) of helium with a minimum purity of 99%.

CAUTION

The helium supply to the dewar must have a purity of 99% or greater. Helium purities less than 99% will contaminate the condensing surfaces and decrease the production of liquid helium. *The warranty does not cover this type of damage.*

7) Close the dewar's evacuation valve.
8) Shut off the vacuum system and disconnect the evacuation/charging line from the evacuation valve.

8.8 Cleaning

8.8.1 Compressor package, cold head, and dewar

The compressor package, cold head, and dewar require no cleaning other than wiping the outside of each if it becomes dusty or dirty.

CAUTION

Never wet any part of the system. *Water getting into the system will void the warranty.*

8.8.2 Aeroquip® couplings

WARNING

Never remove an Aeroquip® coupling from the helium flex lines, cold head, adsorber or compressor without first relieving the helium charge. The pressure in any of the components can blow off the coupling with sufficient force to cause injury.

If operated in a clean environment, the only parts of the cryorefrigerator system that are likely to require cleaning are the Aeroquip® couplings. The mating surfaces of the Aeroquip® couplings can get particles on them when the helium flex lines or rigid lines are detached from the compressor package, volume housing or the cold head.

If an Aeroquip® coupling needs cleaning:

- Wipe the mating surfaces of the coupling with a dry, lint-free cloth.
- After wiping, blow off the coupling with clean, dry compressed air.
- Solvents should never be used.
- If any grease or oil gets on the Aeroquip® coupling, contact Cryomech.

8.9 Manufacturer only parts

The following parts are available only from Cryomech:

Helium flex lines

If the helium flex lines become damaged and need to be replaced, new ones must be obtained from Cryomech.

Adsorber

The adsorber needs to be replaced after every 20,000 hours of use. See Section 8.4 for instructions on replacing the adsorber.

Cold head

The cold head contains no user-serviceable parts and must be serviced by Cryomech authorized technicians. *Attempting to disassemble the cold head will void the warranty.* See Section 8.3.

Main power cord

If the power cord becomes damaged, a replacement should be obtained from Cryomech.

Cold head motor cord

If the cold head motor cord becomes damaged, a replacement must be obtained from Cryomech.

Liquid level monitor cable

If the liquid level monitor cable becomes damaged, a replacement must be obtained from Cryomech.

Diode cable

If the diode cable becomes damaged, a replacement must be obtained from Cryomech.

Appendix A

Cold Head Drawing CMAS Menu System

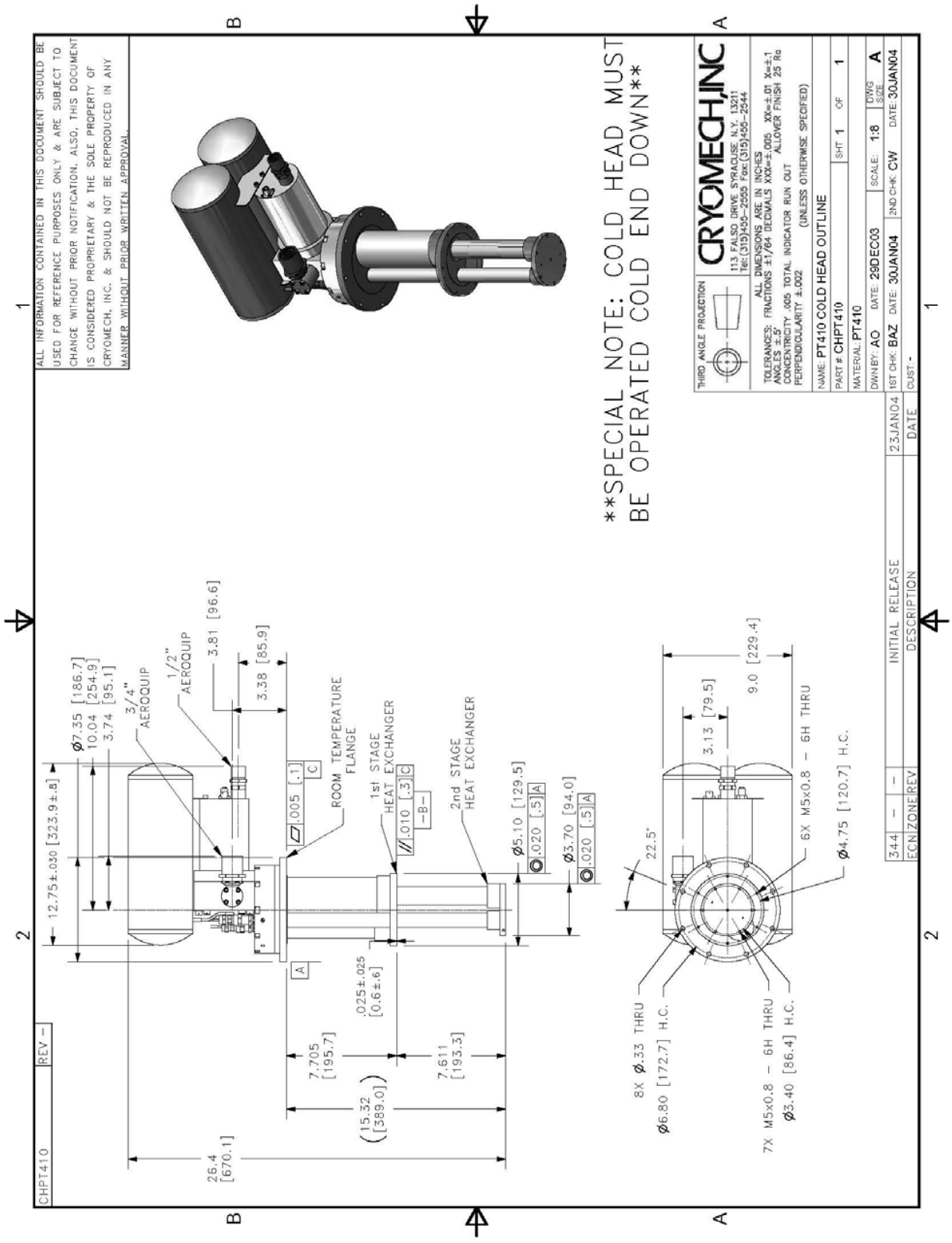

Figure A-1: Cold Head Drawing

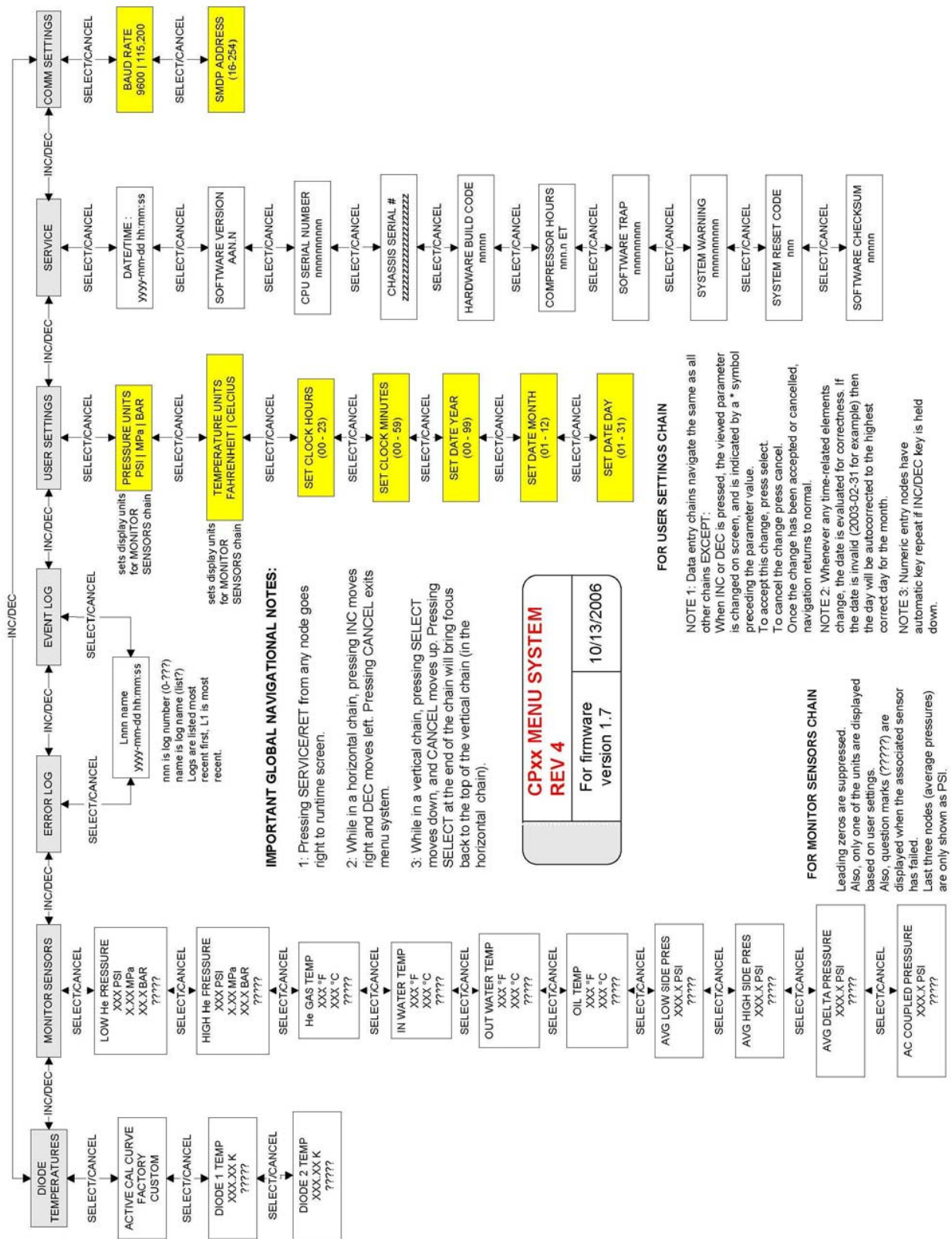

Figure A-2: CMAS Menu System