CRYOMECH

Model PT410

Cryogenic Refrigerator

TECHNICAL INSTRUCTION MANUAL

INCLUDES CP2880 COMPRESSOR PACKAGE

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1 Section 1: Overview

This section provides an overview discussion of cryorefrigerators and the PT410 in particular. It also provides an overview of this manual, including the organization, basic definitions of terms used and expansion of acronyms used in the manual.

1.1 Cryogenic refrigeration system

The operation of a cryogenic refrigeration system is based on a closed-loop helium expansion cycle. A complete system consists of two major components: one is the compressor package, which compresses refrigerant and removes heat from the system; the other is the cold head, which takes refrigerant through one or more additional expansion cycles to cool it down to cryogenic temperatures. The refrigerant gas used in the Cryomech cryogenic systems is 99.999% pure helium. Flexible stainless steel lines called helium flex lines carry compressed helium from the compressor package to the cold head and carry low-pressure helium back.

The compressor package works as follows. An oil-lubricated compressor compresses the pure low-pressure helium that is returned from the cold head. The heat of compression is removed via a heat exchanger, and the oil from the compression process is removed in a series of oil separators and filters. The compressed helium is then fed to the cold head via the high-pressure helium flex line.

In the cold head, adiabatic expansion of the helium and further heat removal allows cooling to cryogenic temperatures. The low-pressure helium then returns to the compressor package via the low-pressure helium flex line.

1.1.1 Definitions

The terms defined below are used with precision in the manual. For example, distinction is made between the (cryorefrigerator) system, the (compressor) package, and the (compressor) module.

The terms are in alphabetical order, and italicized terms within the definitions are terms that are also defined in this section.

Aeroquip® Couplings:

The term "Aeroquip® couplings" is used generically to describe the self-sealing fittings that connect components e.g. that connect *helium flex lines* to the *compressor package* and *helium flex lines* to the remote motor assembly.

Cold Head:

The cold head is an expansion device, which is capable of reaching *cryogenic temperatures*. In the PT410 system the cold head is a *Pulse Tube.*

Cold Head Motor Cord

The cold head motor cord is pre-wired and fitted with electrical connectors on each end that attach to the *cold head* and *compressor package*. The cold head motor cord provides electrical power from the *compressor package* to the *cold head* motor.

Compressor Module:

Located inside the *compressor package*, the compressor module is an oil-lubricated commercial compressor that compresses low-pressure helium to the necessary high pressure.

Compressor Package:

The compressor package houses the *compressor module* and all other components that compress and purify helium and that provide system safety control. The compressor package compresses the low-pressure helium returning from the *cold head* and provides clean high-pressure helium to the *cold head*.

Cryorefrigerator (Cryocooler):

A cryorefrigerator is a cryogenic refrigeration *system* based upon a closed loop helium expansion cycle. It consists of a *compressor package*, *helium flex lines* and a *cold head* (expansion device).

Cold Head Heat Exchanger:

The first and second stage heat exchangers on the *cold head* provide cooling at cryogenic temperatures by transferring heat to the helium within the system.

Helium Flex Lines:

The helium flex lines are corrugated stainless steel hoses that transport helium between the *compressor package* and the *cold head*.

Pulse Tube Cryorefrigerator:

A pulse tube cryorefrigerator is a *cryorefrigerator* in which the *cold head* expands the helium using a pulse tube instead of a displacer or piston.

System:

The term "system" is used as a synonym for *cryorefrigerator*. It consists of a *compressor package*, *helium flex lines* and *cold head*.

2 Section 2: Specifications

2.1 Technical specifications

Following are the detailed technical specifications for the PT410 Pulse Tube and the CP2800 Series Compressor Package.

IMPORTANT

Operation of the cryorefrigerator in any situation that does not meet the specifications in this section will void the warranty. If you plan to operate the system outside any of the specified conditions, contact Cryomech.

2.1.1 Weights and dimensions

Parameter	Value	
Cold Head Weight	43 lb	19.5 kg
Cold Head Dimensions	See Outline Drawing	
Compressor Package Weight	263 lb	119 kg
Compressor Package Dimensions, (L x W x H)	18 x 19 x 24.5 in	46 x 48 x 62 cm

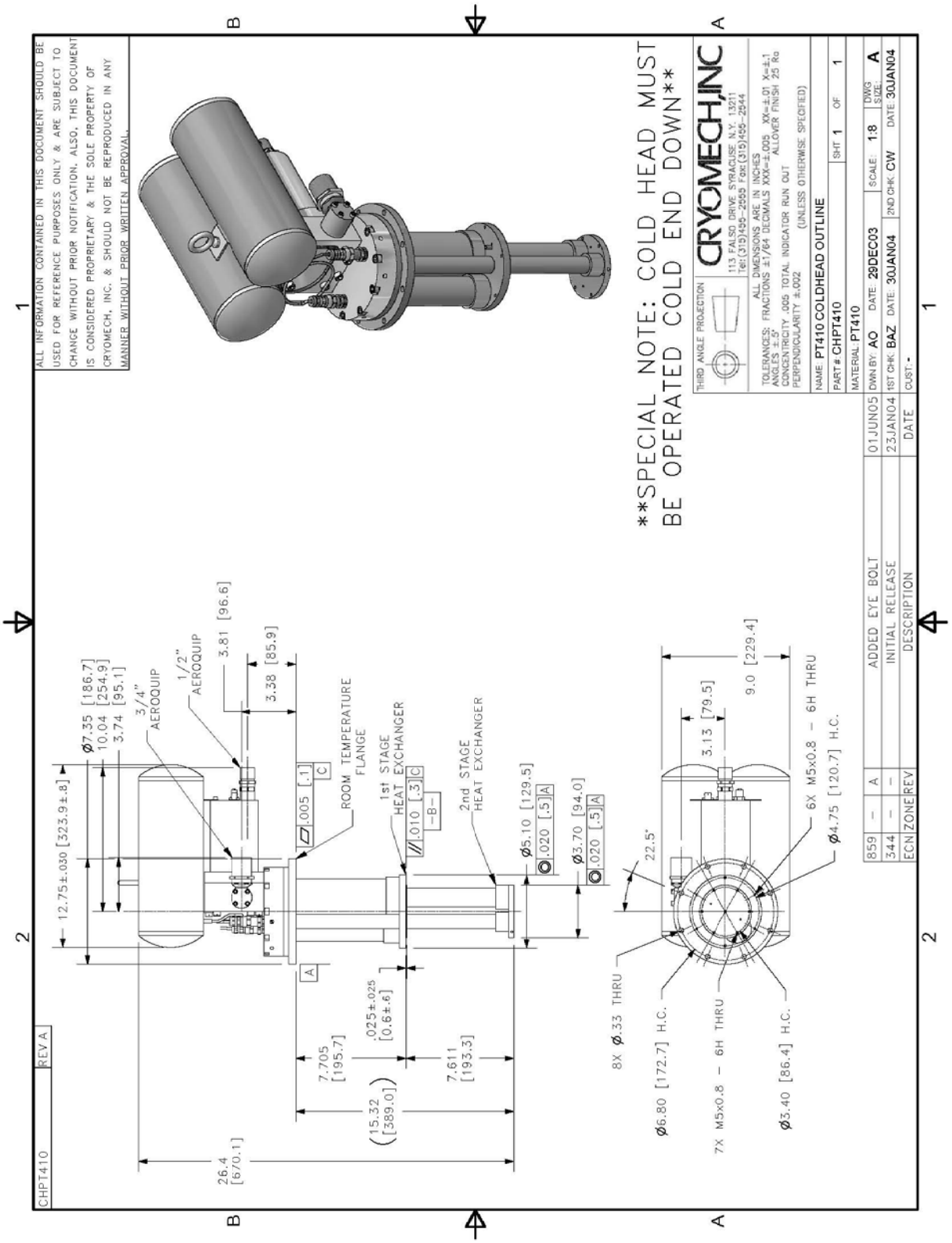
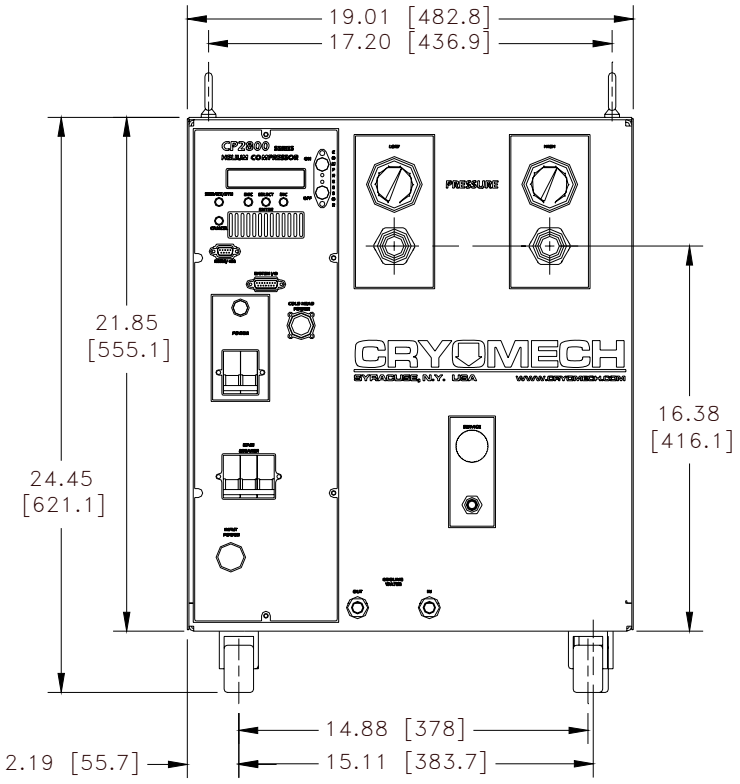


Figure 1: Cold Head Outline Drawing



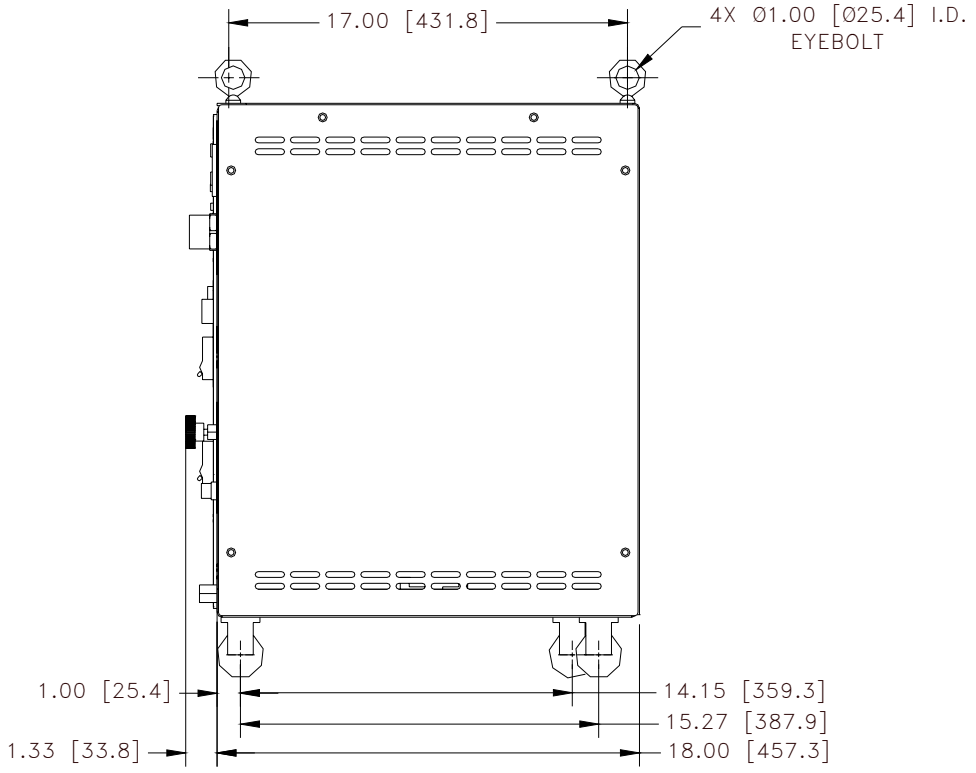


Figure 2: Compressor Outline Drawing

2.1.2 Cooling water specifications

Parameter	Value	
Cooling Water: minimum flow @ maximum temperature See Figure 3 for details.	2.3 GPM @ 80 F	8.8 LPM @ 27 C
Maximum Inlet Pressure	110 PSIG	7.6 bar
Alkalinity	5.8 < pH < 8.0	5.8 < pH < 8.0
Calcium Carbonate	Concentration < 80 PPM	Concentration < 80 PPM

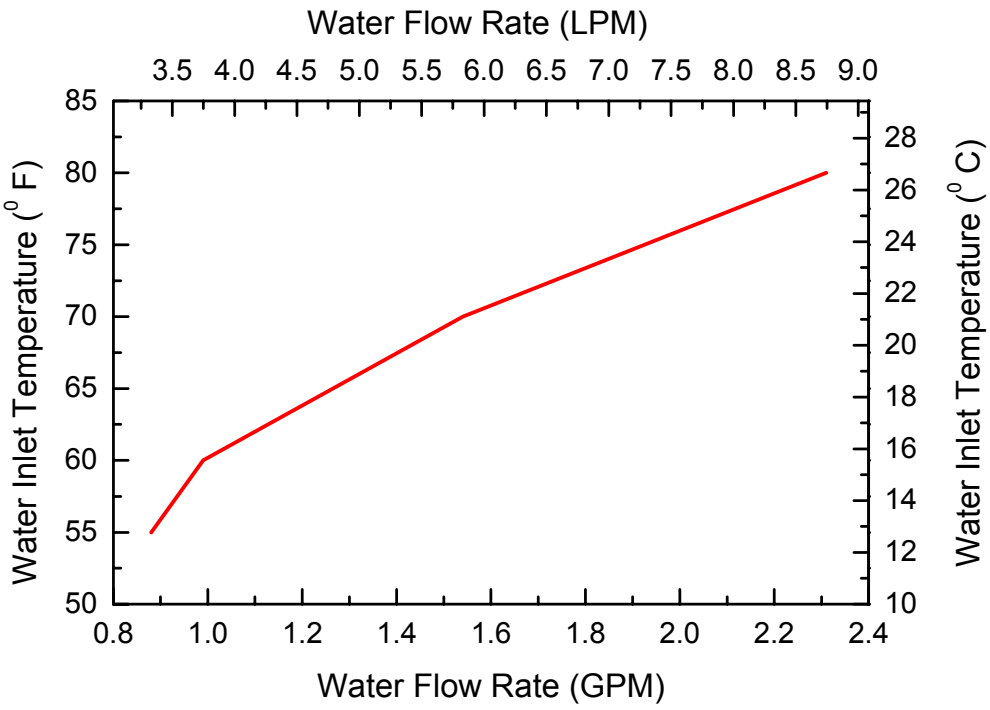


Figure 3: Cooling Water Requirement *

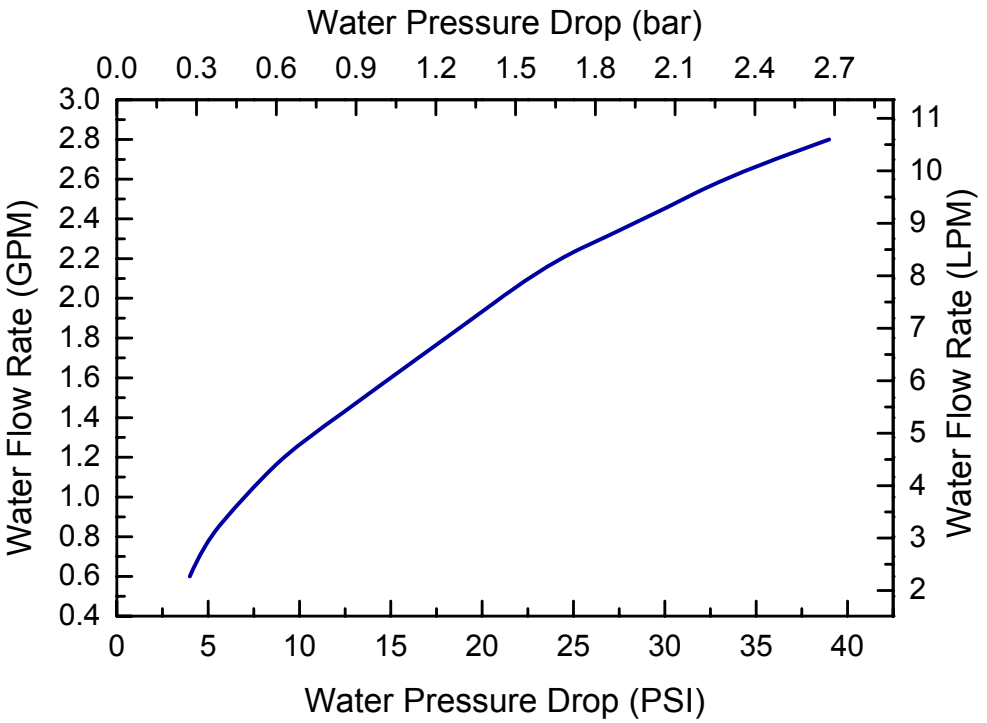


Figure 4: Cooling Water Pressure Drop *

* When using a 50-50% mixture of ethylene glycol and water increase the flow rate 10%. Pressure drop values will increase 40%.

2.1.3 Electrical specifications

Parameter	200/220 Volt 50 Hz	220/230 Volt 60 Hz	380/420 Volt 50 Hz	460 Volt 60 Hz
Nominal voltage	200/220 VAC	220/230 VAC	380/420 VAC	460 VAC
Operating voltage range	180 - 242 VAC	200 - 253 VAC	342 - 462 VAC	414 - 506 VAC
Frequency	50 Hz	60 Hz	50 Hz	60 Hz
Phase	3	3	3	3
Nominal Input Power Maximum: Steady state:	 9 kW 7.2 kW	 9 kW 7.2 kW	 9 kW 7.2 kW	 9 kW 7.2 kW
Current	27 A	27 A	16 A	13 A
Dedicated circuit breaker	40 A	40 A	25 A	25 A
Mains supply voltage fluctuations	Up to ± 10% of the nominal voltage	Up to ± 10% of the nominal voltage	Up to ± 10% of the nominal voltage	Up to ± 10% of the nominal voltage

2.1.4 Operating parameters

Parameter	Value	
Ambient temperature range*	45 to 100 °F	7 to 38 °C
System helium pressure – all components @ 25C	250 ± 5 PSIG @ 60 Hz (17.2 ± .34 bar @ 60 Hz)	(260 ± 5 PSIG @ 50 Hz) 17.9 ± .34 bar @ 50 Hz
Acceptable location	Indoors only	Indoors only
Maximum altitude for use	6560 ft	2000 m
Environment	Pollution Degree 2	Pollution Degree 2
Installation	Category II	Category II
Maximum relative humidity	80% for T< 88°F Decreasing linearly to 50% at 104°F.	80% for T< 31°C Decreasing linearly to 50% at 40°C.
Maximum sound level	70 dBA at 1 meter	70 dBA at 1 meter
Cold head 1st stage maximum load	22 lb	10 kg
Cold head 2nd stage maximum load	11 lb	5 kg

*The compressor package is designed to operate in an ambient temperature range from 45°F to 100°F (15-37°C). If the temperature is below 45°F, the increased viscosity of the oil could prevent start-up and/or cause poor lubrication. Operation above 100°F will cause overheating and subsequent problems. *If a unit must be subjected to either extreme, Cryomech must be consulted.*

2.2 Description of compressor

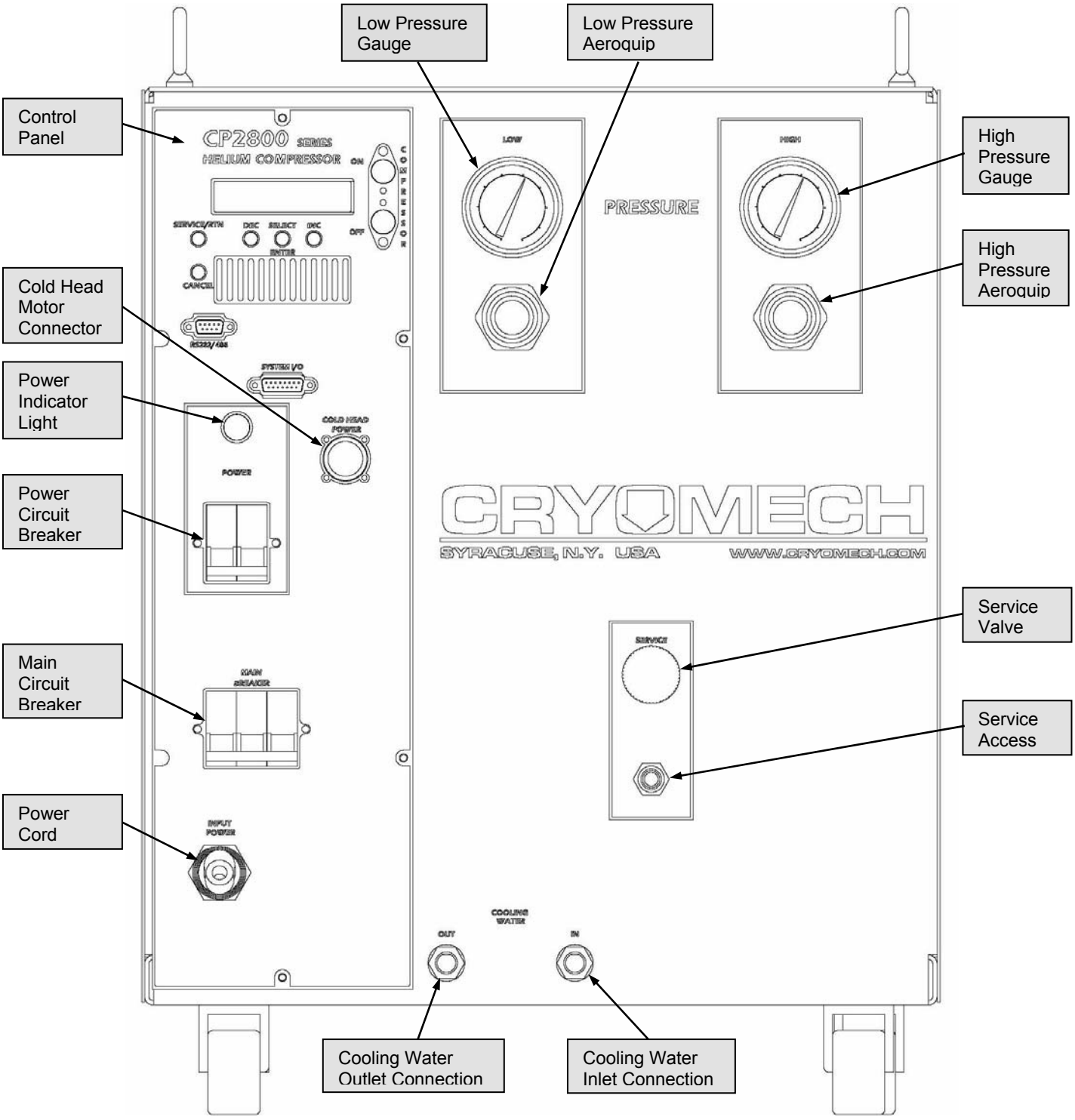


Figure 5: Front Panel of the Compressor Package

2.2.1 Front panel interfaces

This section describes the function of all operator interfaces on the front panel of the CP2800 Series Compressor Package, including switches and valves. It also describes the functions of all connectors, electrical cords and gauges on the front panel.

Low-Pressure Aeroquip®

The low-pressure helium flex line (not shown) fastens to the low-pressure Aeroquip® that returns helium gas from the cold head to the compressor package.

Low-Pressure Gauge

The low pressure gauge displays the pressure of the helium gas that is being returned to the compressor package. When the compressor package is off and the complete system, including the PT410, is at room temperature, the gauge should read 250 ± 5 PSIG (17.2 ± .34 bar) for 60 Hz models or 260 ± 5 PSIG (17.9 ± .34 bar) for 50 Hz models.

High-Pressure Aeroquip®

The high-pressure helium flex line (not shown) attaches to the high-pressure Aeroquip® that supplies compressed helium gas from the compressor package to the cold head.

High-Pressure Gauge

The high-pressure gauge displays the pressure of the compressed helium gas that is transported from the compressor package. When the compressor package is off and the complete system, including the PT410, is at room temperature, , the gauge should read 250 ± 5 PSIG (17.2 ± .34 bar) for 60 Hz models or 260 ± 5 PSIG (17.9 ± .34 bar) for 50 Hz models.

Control Panel

The control panel houses the compressor controls and display screen.

Cold Head Motor Connector

The cold head motor cord attaches to the cold head motor connector to provide power from the compressor package to the cold head motor.

Main Circuit Breaker

The main circuit breaker provides over-current protection for the cryorefrigerator and also functions as a main power disconnect.

Power Circuit Breaker

The power circuit breaker protects the control panel circuitry and also functions as a power disconnect for the control panel.

Power Indicator Light

The power indicator light illuminates when the power circuit breaker is switched to the on position.

Service Valve

The service valve is the valve used to regulate the amount of helium being added to or released from the system.

Service Access

The service access is used in conjunction with the service valve for adding helium to or releasing helium from the system.

Cooling Water Inlet Connection

The cooling water inlet connection provides water to the compressor package from your facility to cool the compressor package during operation. The connector thread size is a 3/8 FPT (3/8” Female National Pipe Thread).

The water must meet the requirements outlined in Section 2.1.2, Cooling Water Specifications.

Cooling Water Outlet Connection

The cooling water outlet connection carries heated water away from the compressor package after the water has been heated by cooling the compressor package during operation. The connector thread size is a 3/8 FPT (3/8” Female National Pipe Thread).

Power Cord

The power cord supplies power from the wall to the entire system.

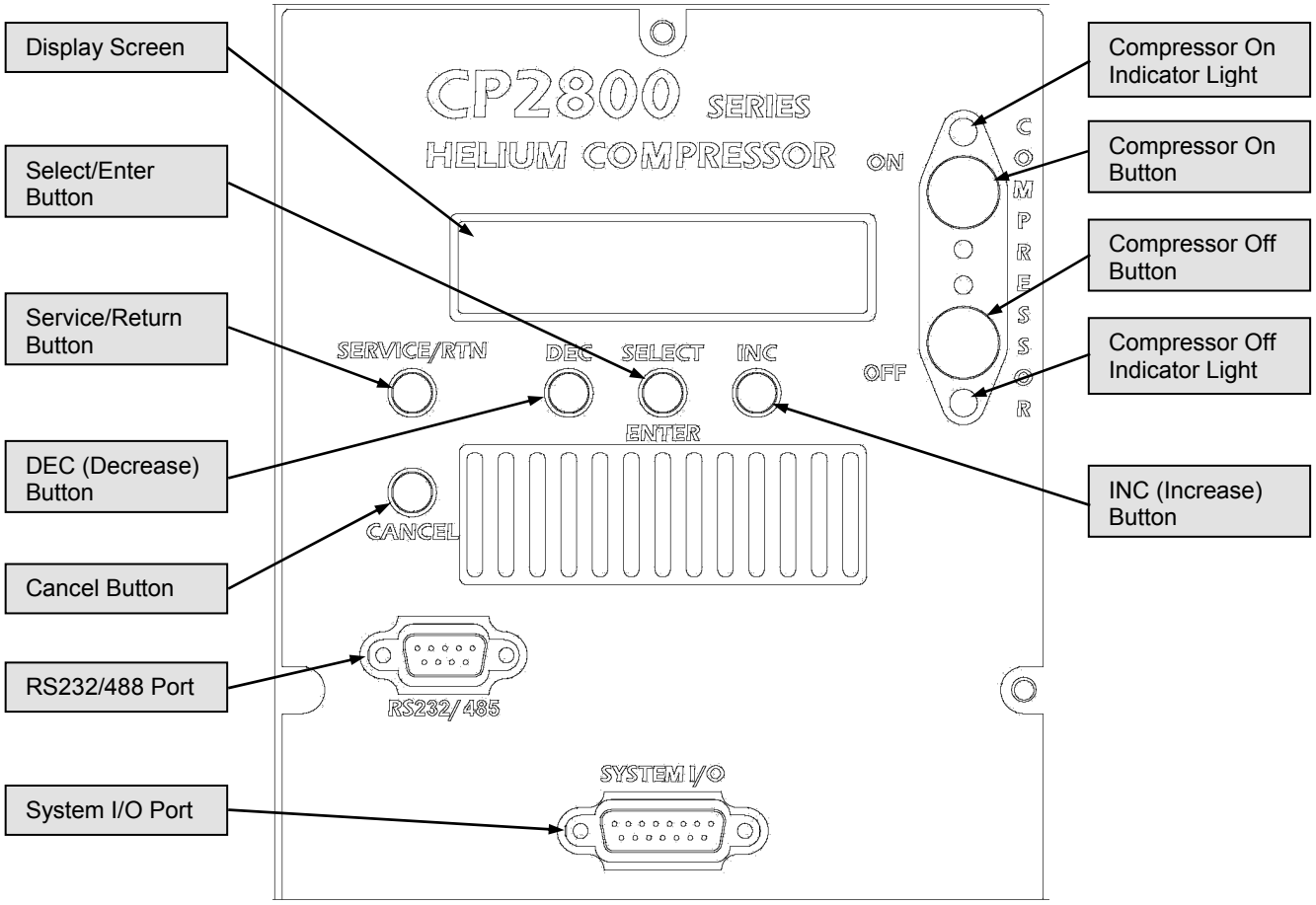


Figure 6: Control Panel of the Compressor Package

2.2.2 Control panel description

Compressor On Button

The Compressor On button is used to start the compressor system.

Compressor On Indicator Light

The Compressor On indicator light is illuminated when the compressor is operating.

Compressor Off Button

The Compressor Off button is used to switch the compressor system off.

Compressor Off Indicator Light

The Compressor Off indicator light is illuminated when the compressor is switched off with the Compressor Off button or when one of the compressor's internal safety switches has tripped.

Display Screen

The Display Screen (also known as the run-time screen) displays system status, warnings, error messages, and the various menus available.

Select/Enter Button

The Select/Enter button is used to navigate down each menu, and to enter changes in values.

INC (Increase) Button

The INC button is used to navigate back and forth along the top level of the menu.

DEC (Decrease) Button

The DEC button is used to navigate back and forth along the top level of the menu.

Service/Return Button

The Service/Return button is used to switch from the run-time display to the top level of the menu (Monitor Sensors/Error Log/Event Log/User Settings/Service).

Cancel Button

The Cancel button is used to move back up the menu.

RS232/488 Port

The RS232/488 port can be used to remotely monitor and control the compressor system.

System I/O Port

The System I/O port is a DB15 female socket that can be used to remotely control the compressor package and monitor a limited number of its parameters. See Section 2.6 for further details.

2.3 Helium gas, oil, and water flow in the compressor

A brief description of the helium gas, oil and water flows in the compressor system follows. Refer to the flow diagram, Figure 7.

2.3.1 Helium flow

Low pressure helium gas returning from the cold head enters the volume.

The helium gas enters the suction port of the compressor module where it is compressed and discharged to the helium gas heat exchanger.

The hot, high pressure helium gas is cooled in the heat exchanger before it enters the oil separator.

The cooled, high pressure helium gas flows through the oil separator where most of the entrained oil is separated from the helium.

The high pressure helium exits the oil separator and enters the adsorber where the remaining contaminants in the helium gas are removed.

The pure, high pressure helium exits the adsorber and flows to the cold head.

2.3.2 Oil injection flow

Hot, high pressure oil is discharged from the compressor module to the oil heat exchanger.

The heat exchanger cools the oil before it enters the oil filter.

Any contaminants in the cooled, high pressure oil are removed in the filter before the oil flows through the check valve and into the compressor manifold.

The compressor manifold's internal orifice controls the amount of oil injected into the compression chamber of the compressor module.

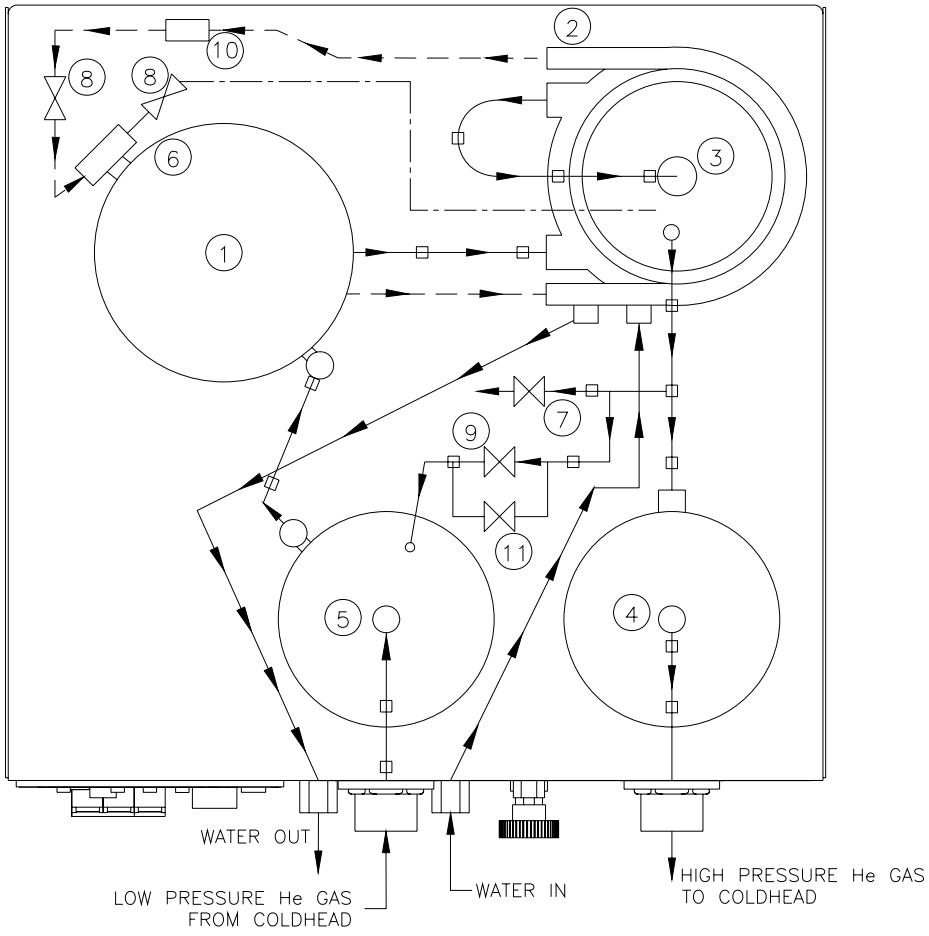
2.3.3 Oil return line

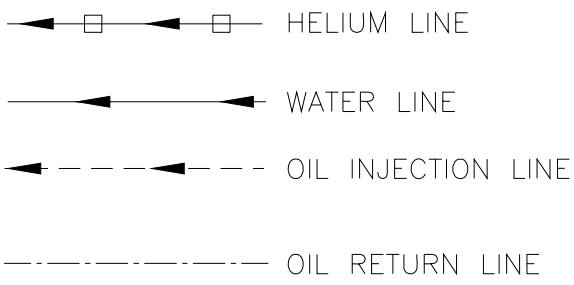
The oil collected in the high pressure sump of the oil separator is returned to the compressor module through the oil return line.

The oil is pushed through a check valve and into the compressor manifold where it mixes with the oil injection flow.

2.3.4 Cooling water flow

Cooling water flows through the oil heat exchanger first and then passes through the helium gas heat exchanger before it exits the compressor system.





1) COMPRESSOR MODULE
2) HEAT EXCHANGER
3) OIL SEPARATOR
4) ADSORBER
5) VOLUME
6) OIL INJECTION MANIFOLD
7) ATMOSPHERIC RELIEF VALVE
8) CHECK VALVE
9) INTERNAL BY-PASS VALVE
10) OIL FILTER
11) SOLENOID VALVE

Figure 7: CP2800 Flow Diagram

2.4 Internal components of the compressor

Following are descriptions of the compressor's major components and their function. Please refer to Figures 8, 9, and 10.

2.4.1 Compressor module

The compressor module is a hermetically sealed, oil lubricated, scroll compressor, which has been designed especially for helium service. The compressor module generates heat in the compression of the helium. To remove the heat the lubricating oil is circulated out of the compressor module, through a water cooled heat exchanger, and then is injected back into the compressor module. This removes more than 80% of the heat produced during the compression process. The high-pressure helium also carries heat from the compressor module.

The compressor module is fitted with two sight glasses; one on the lower sump and the other on the upper sump. When the system is operating properly, both sight glasses should show an oil level. Typically, the bottom sight glass is ¾ full and the top sight glass is ½ full. The levels vary with each compressor.

2.4.2 Heat exchanger assembly

There are two separate heat exchangers attached together in the heat exchanger assembly. One heat exchanger cools the helium gas bound for the cold head. It is necessary to lower the temperature of the helium before it reaches the oil separator in order for it to perform properly. The second heat exchanger cools the compressor oil. The flow rate and temperature of the cooling water is very important. Failure to maintain proper flow rates and temperature will reduce the effectiveness of the oil separator, cause overheating and the likelihood of compressor shutdown or failure.

2.4.3 Oil injection circuit

The oil injection circuit plays a major part in cooling and lubricating the compressor module. The circuit originates from the compressor module and consists of a heat exchanger, a filter, a check valve, and a flow control orifice. The orifice controls the amount of oil allowed to pass through the circuit.

2.4.4 Oil separator

During the compression process oil particles are entrained in the helium gas. After the compressed helium is cooled in the heat exchanger, the helium/oil mixture enters the oil separator. Inside the oil separator, the oil particles accumulate on the fiber surfaces and drip to the bottom of the oil separator. The helium gas continues on to the adsorber and the trapped oil is returned to the compressor module.

A sight glass is attached to the shell of the oil separator. The sight glass should always be empty. If oil is seen in the sight glass, a problem has developed in the oil return line and the system should be shut down and serviced.

2.4.5 Oil separator return line

The oil collected in the sump at the bottom of the oil separator is returned to the compressor module through the oil separator return line. The oil separator has an internal float and valve mechanism that permits the return of oil. The oil level in the sump rises until it lifts the float, which in turn opens the valve. When the valve opens, the high-pressure helium in the oil separator pushes the oil through the return line and into the low-pressure intake of the compressor module. Once the collected oil has been returned, the float drops, closing the valve.

2.4.6 Adsorber

After the entrained oil has been removed in the oil separator, the helium continues on to the adsorber. The remaining vaporous contaminants will be trapped on the filtering media, thus allowing only pure helium gas to travel on to the cold head.

If moisture is inadvertently admitted into the system during a service procedure, the adsorber will collect it. If excessive amounts are admitted, the moisture will eventually migrate through the adsorber and will lead to a malfunction in the cold head, requiring service.

2.4.7 Solenoid valve

The solenoid valve opens when the system is turned off in order to equalize the high and low helium gas pressures inside the compressor system. When the compressor system is operating, the solenoid valve is closed and there is no helium flow through it.

2.4.8 Internal bypass valve

The internal bypass valve limits the helium pressure differential to a maximum of 250 PSIG.

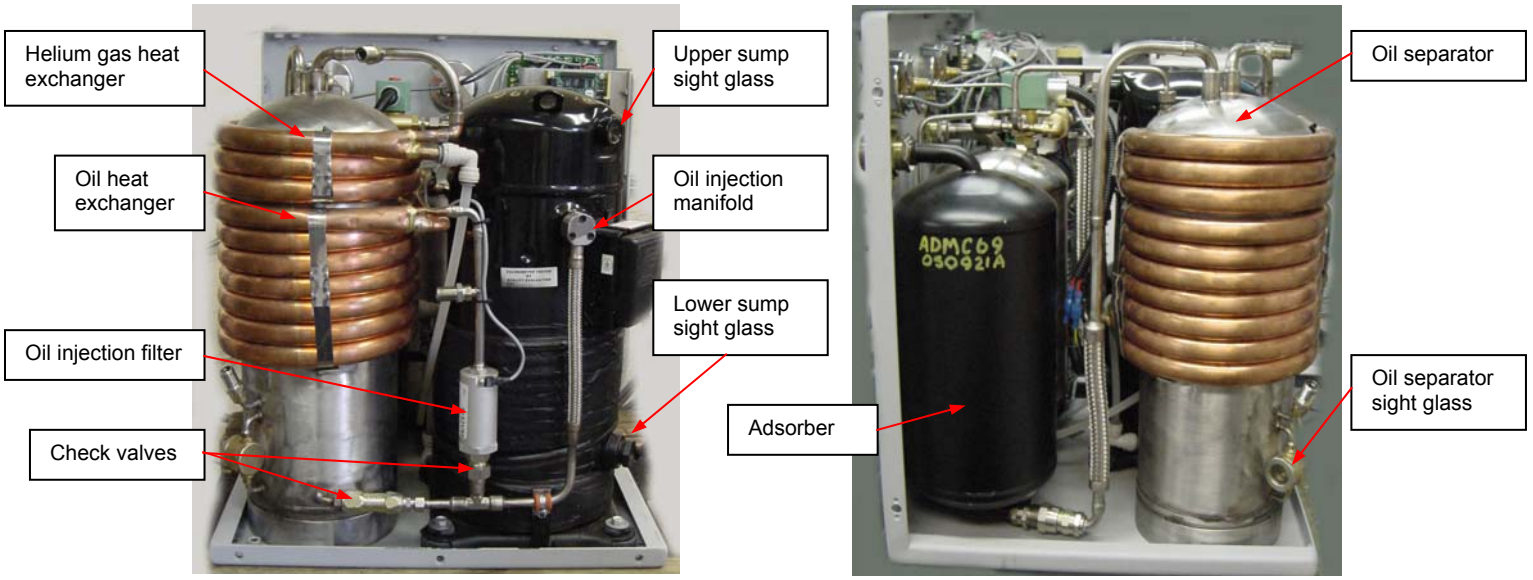


Figure 8: Rear and Right Side Views

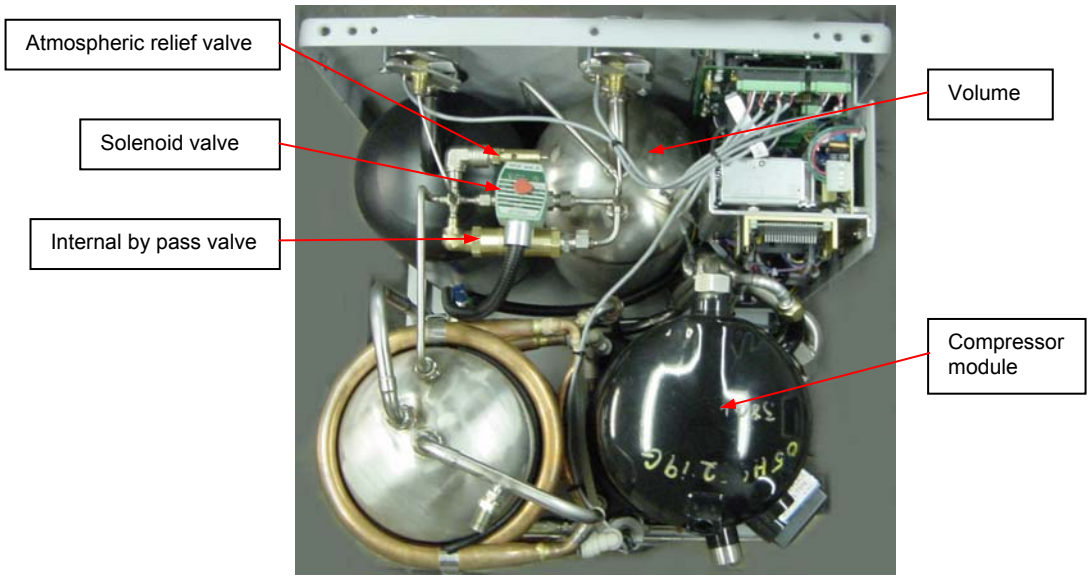


Figure 9: Top View

2.5 Safety devices

A number of safety switches and valves are located inside the compressor package and on the cold head. They operate automatically to protect the compressor package and cold head from developing extreme conditions that can damage them.

2.5.1 High pressure atmospheric relief valve

The compressor package high-pressure atmospheric relief valve is set at 420 ± 5 PSIG (29 ± .34 bar). At pressures above 420 PSIG (29 bar) the relief valve will open automatically and relieve pressure to the atmosphere.

2.5.2 Internal motor overload switch

An internal motor overload switch, located inside the compressor module, protects the system by sensing excessive current draw and temperature. This switch automatically resets itself after the compressor module cools to an acceptable level.

2.5.3 Cold head high pressure relief valve

The cold head high-pressure atmospheric relief valve is set at 425 ± 5 PSIG (29.3 ± .34 bar). At pressures above 425 PSIG (29.3 bar) the valve will open automatically and relieve pressure to the atmosphere.

2.6 System I/O

A 15 pin digital I/O connector with selected input controls and relay outputs is provided for limited monitoring and control. The digital I/O and its associated DB15 female (socket) connector are described in this section.

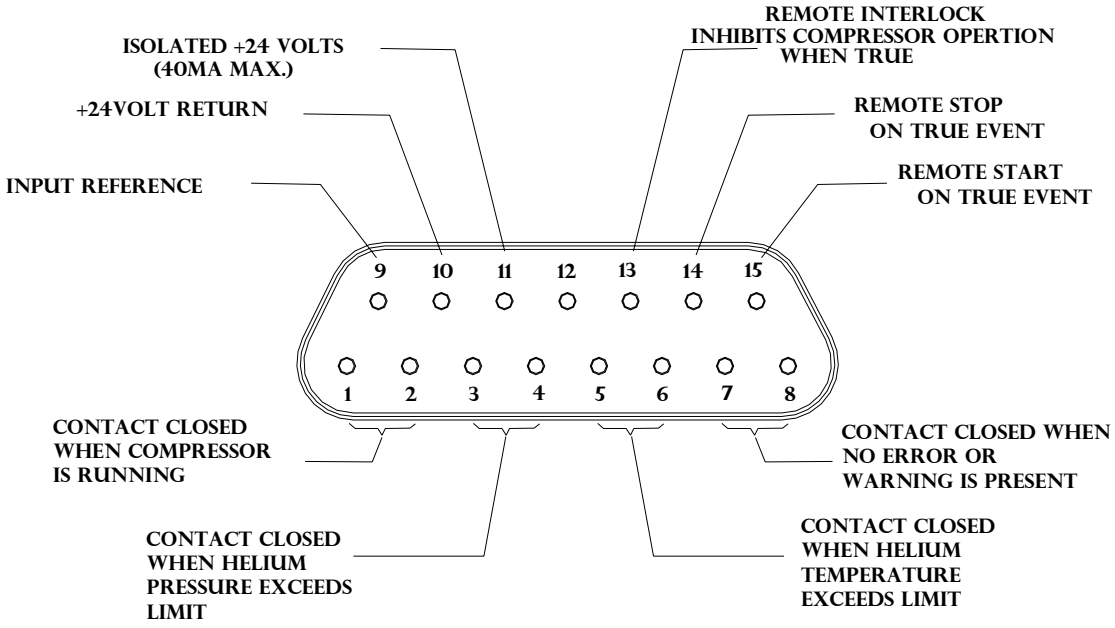


Figure 10: Connector Diagram

2.6.1 Inputs

Three remote inputs are provided to start, stop and inhibit operation of the compressor.

For INPUTS, a low or false is a voltage differential of less than 3VDC between the input pin and IN_REF (pin 9). The input pin being – (neg) and the IN_RET pin being + (pos).

An open circuit (no connection to the input pin) is also low (false).

High or true is a voltage differential between the input pin and IN_RET that exceeds 12VDC. The input pin being – (neg) and the IN_RET pin being + (pos).

Rising edge is a change in the pin state from false to true.

Falling edge is a change in pin state from true to false.

Again, all inputs reference to pin 9. For example, to generate a true condition on an input connect the input reference IN_REF to a positive DC voltage (greater than 12 volts and less than 50 volts) and close the selected input pin to the return of that supply. (An isolated 24 volt supply and return is provided on pins 11 and 10 of this connector respectively.)

The minimum pulse width (high or low) for an input signal to be recognized is 200ms. It is possible for a signal to be recognized sooner, but due to the asynchronous nature of the design, a 200ms pulse width is necessary to guarantee the signal is recognized.

Maximum input voltage without damage to the hardware is ±50V, indefinite time.

Minimum guaranteed "TRUE" voltage is +12VDC.

Negative voltages are considered FALSE.

Input "impedance" is about 10K.

Inputs are ESD protected.

2.6.2 Outputs

Four standard outputs are provided. They are relay closures which indicate that the compressor motor is running, the helium temperature or pressure has exceeded set limits or that no errors or warnings have been detected.

All outputs are contact closures (rated at 2amps 30 VDC).

2.6.3 Isolated voltage supply

Pin 11 is an isolated (1000VDC) +24VDC source referenced to pin 10, 24V_RET. The maximum current available is 40mA.

This supply can be used to power the inputs for interfacing the input system to a contact-closure type system. This supply may also be used for other purposes provided the current limit is not exceeded.

2.6.4 Input pin descriptions

Pin 15, RMT_ON: Issues START compressor command on RISING edge.

Pin 14, RMT_OFF: Issues STOP compressor command on RISING edge.

Pin 13, RMT_INTERLOCK: Disables operation of compressor when TRUE. Level sensitive.

Pin 12: UNUSED

2.6.5 Output pin descriptions

Pins 7 and 8: Contact closed when all sensed parameter are within limits. Contact is open when operational error in compressor package is detected or warnings appear. Also open when line power is not on or either circuit breaker is off. All error type indications are latched and must be reset by front panel button or a start compressor request. Warnings are self-clearing if and when condition ceases to exist.

Pins 1 and 2: Contact closed while compressor module is running. Open otherwise.

Pins 5 and 6: Contacts closed when high helium temperature error condition is latched. Contacts open when the helium temperature drops to a certain level (see operating manual for set points) AND a compressor START or STOP event is issued.

Pins 3 and 4: Contacts closed when high helium pressure error condition is latched. Contacts open when the helium pressure drops to a certain level (see Section 3.5) AND a compressor START or STOP event is issued.

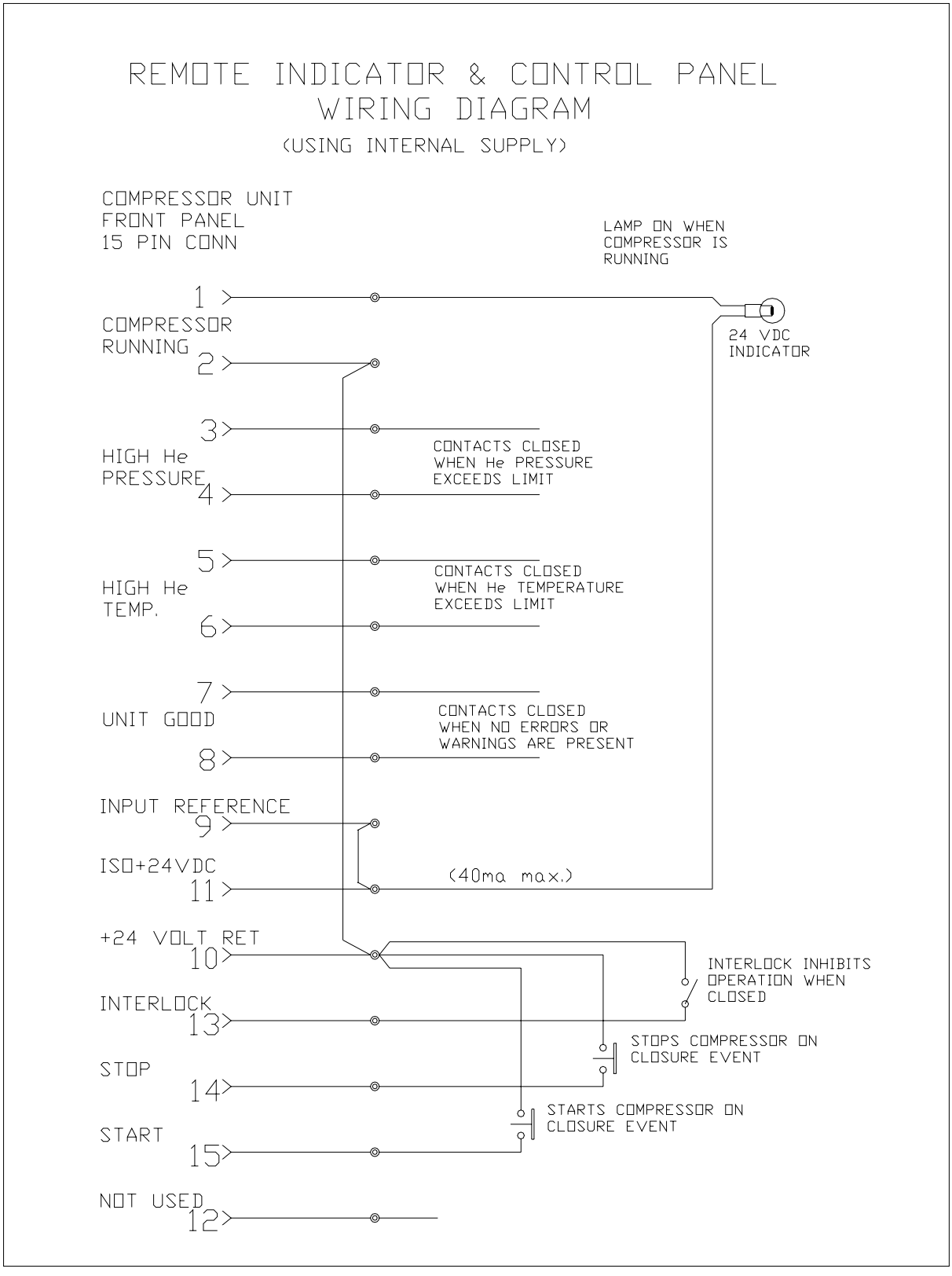


Figure 11: System I/O Wiring Diagram – Internal Supply

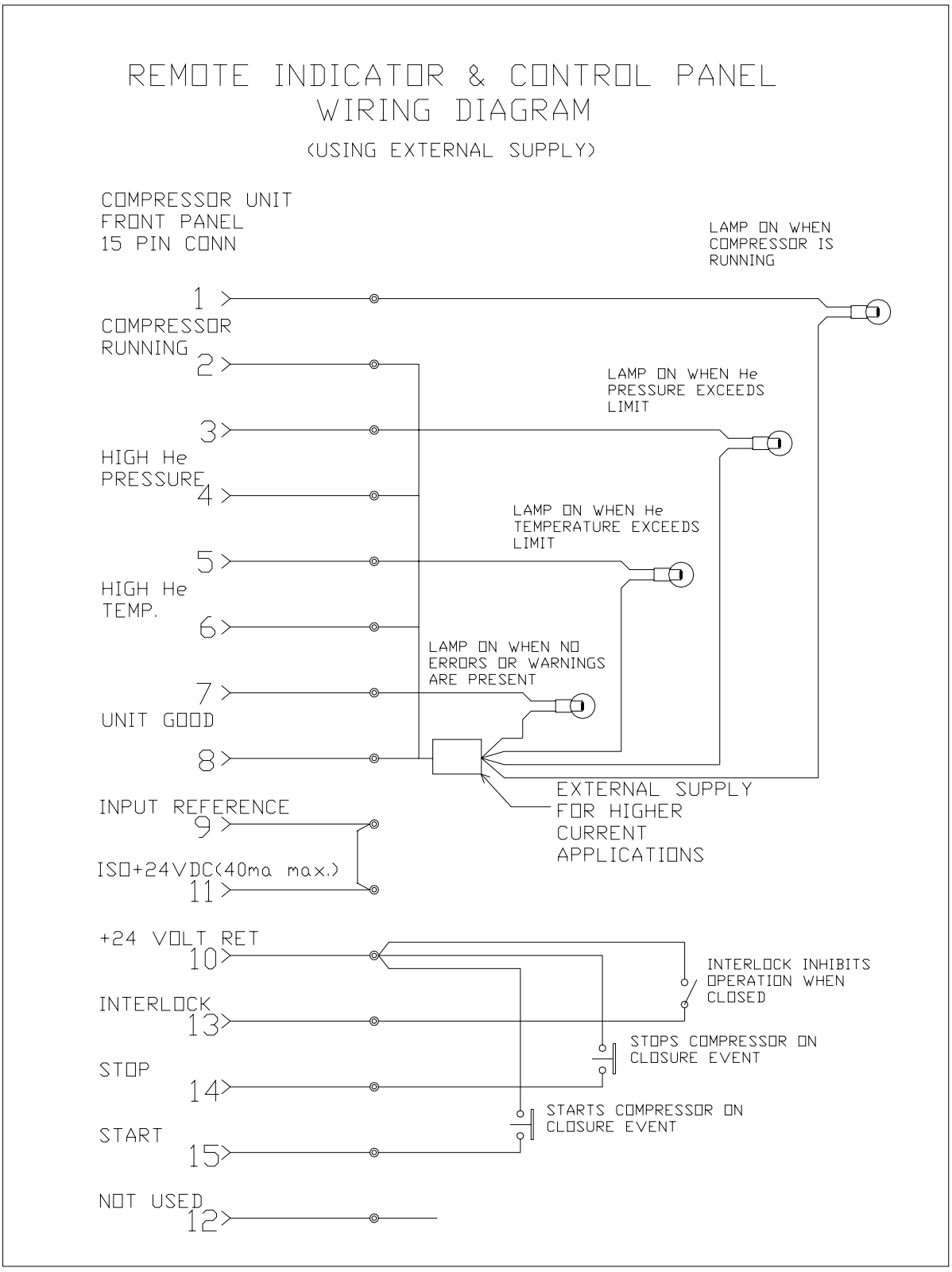


Figure 12: System I/O Wiring Diagram – External Supply

3 Section 3: Display Panel

3.1 Use of the display panel

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 the following sections.

The screen normally shown on the display is referred to as the run-time screen. The messages described in Section 3.2 are displayed on the top line of the run-time screen. The bottom line displays the compressor hours in place of the hour meter used on previous Cryomech products.

The Service/Return button is used to switch from the run-time display to the top level of the menu - Monitor Sensors / Error Log / Event Log / User Settings / Service / Comm Settings. See Figure 13 - CMAS Menu System - for the detailed depiction of the menu system.

The Service/Return 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.

3.2 Run time display screen description

Run time messages are displayed on the top line of the display screen. The number of hours the system has operated are displayed on the bottom line.

Top line message on the display screen	Message description
POWERING UP…	Shown during the first 2 seconds of power up. Hidden by splash screen.
COMPRESSOR ERROR	One of the errors 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 Section 3.3 for error display and 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, and compressor will start within 10 seconds unless an error occurs or a stop request is received. This message will show when the compressor has not been off for more than 10 seconds and a start request is received. This state allows the helium pressures to balance.
WAITING FOR POWER	Compressor is waiting for good power. This will be shown when one or more power phases are missing. Will also 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!
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 (see Service menu). The lockout contributors are noted in Section 3.3.
ERROR! NO MESSAGE!	This message should never be seen. It indicates the compressor is in a state with no description available.

3.3 Error diagnostics on 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 are 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.

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 too many errors within a certain time; 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	Occurs when the “remote interlock” parameter is enabled (default) and the digital remote interlock line is TRUE.
REMOTE INTERLOCK 2	General purpose user interlock can only be set via the computer interface.
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.
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!

3.4 Warning diagnostics on 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 are present, only the highest priority one will be displayed. The table lists warnings from highest to lowest priority.

Warning message	Explanation
*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:STALL DETECTED	The compressor has detected no cold head activity, the cold head has stalled or been disconnected.
*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.

3.5 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 message	Trip	Clear
HIGH He PRESSURE	High side PSI > 399 PSIG (27.5 bar)	High side PSI ≤ 399 PSIG (27.5 bar)
LOW WATER FLOW	125°F (52°C)	100°F (38°C)
HIGH He GAS TEMP	190°F (88°C)	120°F (49°C)
LOW He PRES	< 35 PSIG (2.4 bar)	≥ 36 PSIG (2.5 bar)
COMP MOTOR CURRENT	< 5A	≥ 5A
HIGH OIL TEMP	120°F (49°C)	100°F (38°C)

Warning message	Trip	Clear
*WARN:STALL DETECTED	DP < 1 PSI	DP ≥2 PSI
*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)

3.6 Event logs

Descriptions of the messages displayed when the Event Log is accessed on the display screen are included in the table. Each event log is tagged with the date and time of its occurrence.

Displayed log	Description
POWER UP	Time when compressor system was powered up – plugged into the wall and both the “Main Circuit Breaker” and “Power Circuit Breaker” turned on.
POWER DOWN	Time when the compressor system was turned off by the “Power Circuit Breaker”, “Main Circuit Breaker” or unplugged from the wall.

COMPRESSOR ON	Time when the compressor system was successfully started with the “Compressor On” button.
COMPRESSOR OFF	Time when the compressor system was shut off via the “Compressor Off” button, error condition, remote interface, etc.

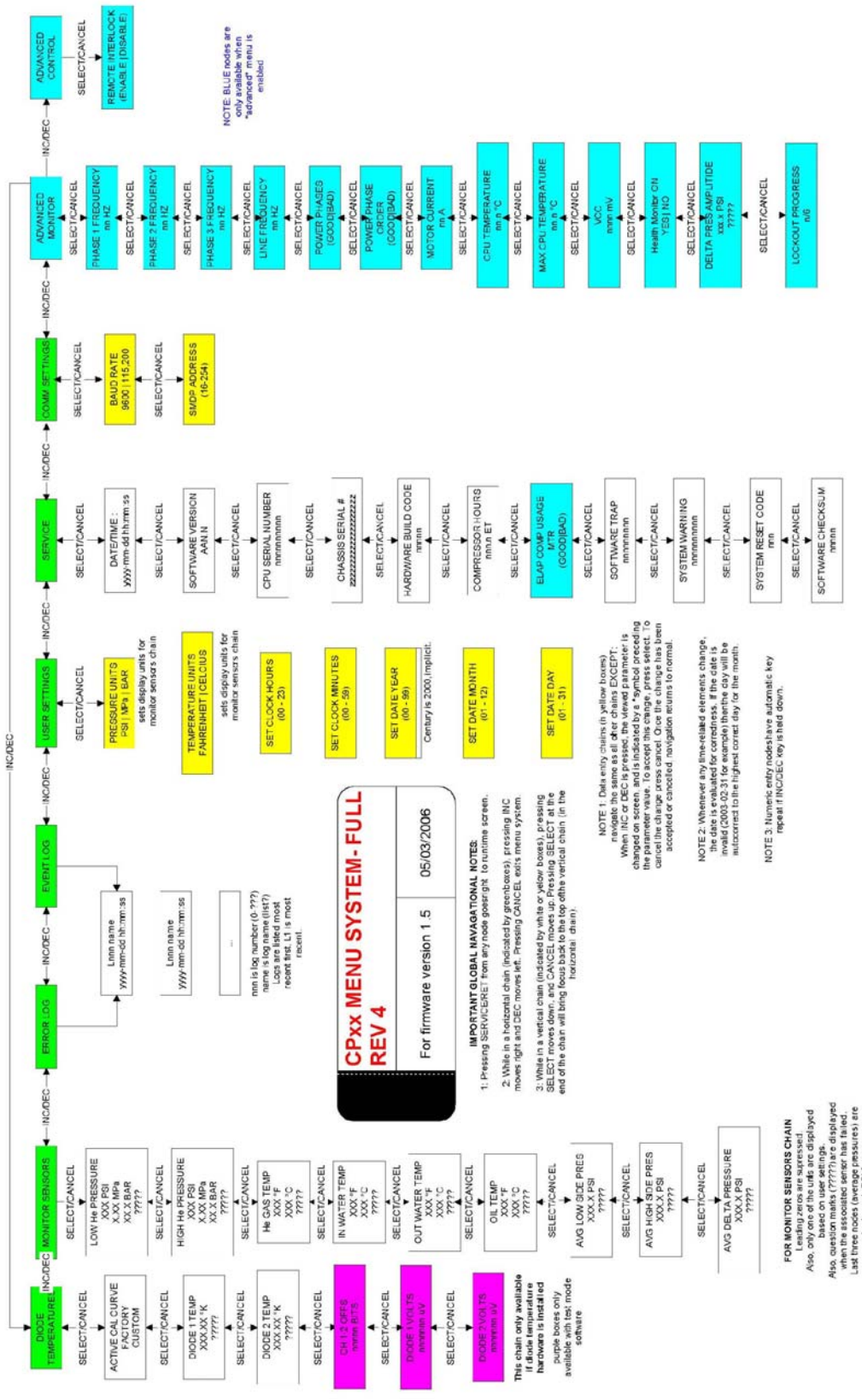


Figure 13: CMAS Menu System

4 Section 4: Maintenance

The only routine required maintenance is to replace the adsorber every 20,000 hours. Venting or charging helium gas to the system is on an "as needed" basis. This section contains procedures to perform these tasks as well as the required tools and equipment required.

4.1 Maintenance Schedule

Maintenance	Frequency	Comment
Replace adsorber	Every 20,000 hours	See Section 4.2
Charge helium gas	As required	See Section 4.4
Replace cold head	As required	See Section 4.5

4.2 Replace the adsorber

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.

Required tools:

Quantity	Description	Comment
1	Pressure checking device	For checking helium charge in replacement adsorber
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

1) Attach the pressure checking device to the adsorber. If the helium pressure is less than 250 PSIG (17 bar), check the adsorber for leaks before installing.
2) Shut down the system.
3) Disconnect both helium flex lines 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 side panel on and retain them.

b. Pull the panel away from the compressor package.

4) Using three wrenches disconnect the Aeroquip® coupling between the adsorber and the oil separator as shown in Figure 14.

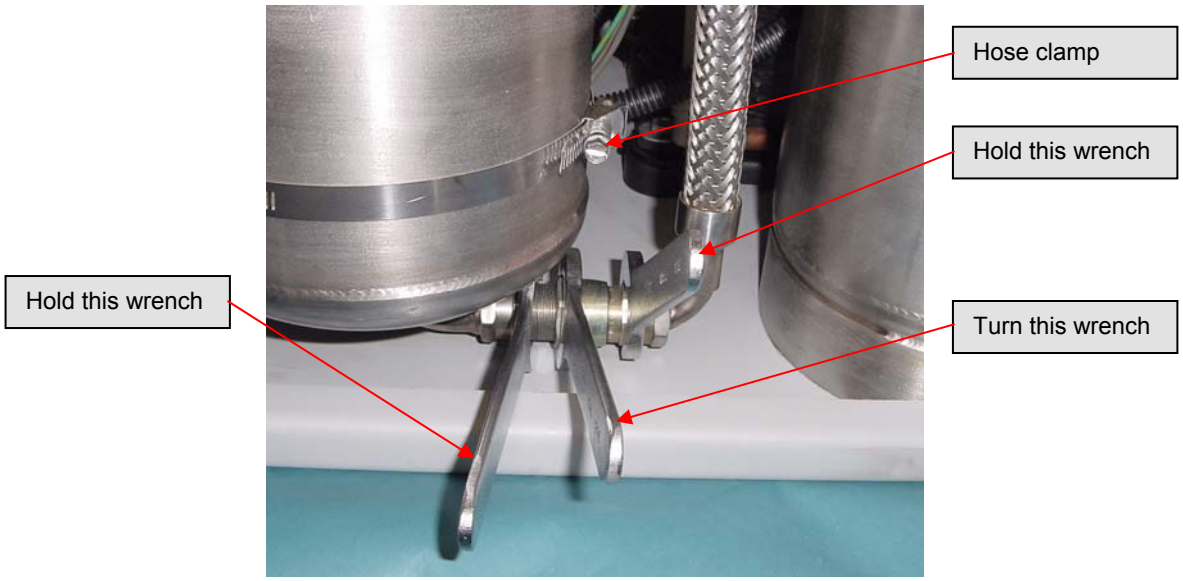


Figure 14: Disconnecting the Adsorber.

5) Remove the nut holding the high-pressure Aeroquip® coupling to the front panel.

6) Loosen and disconnect the hose clamp that attaches the adsorber to the front panel.

7) Remove the adsorber from the compressor package.

8) Check the Aeroquip® couplings for oil residue. If oil is present, contact Cryomech for further assistance.

9) Remove the lock washer from the top Aeroquip® and install it on the new adsorber.

10) To install the new adsorber, reverse steps 3 through 6.

11) Reconnect both helium flex lines to the compressor.

12) Reattach the side panel to the compressor package.

4.3 Adjust helium pressure - vent excess helium

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.

Required tools:

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

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 15.
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.

4.4 Adjust helium pressure - recharge helium

CAUTION

When adding helium, 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.

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 station	For adding helium

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) Use only high purity helium. The helium must be 99.999% pure.
3) Check that the helium source and regulator are capable of pressurizing to the desired low-pressure.
4) Make sure the service valve is closed.
5) Attach the service Aeroquip® coupling to the service access port.

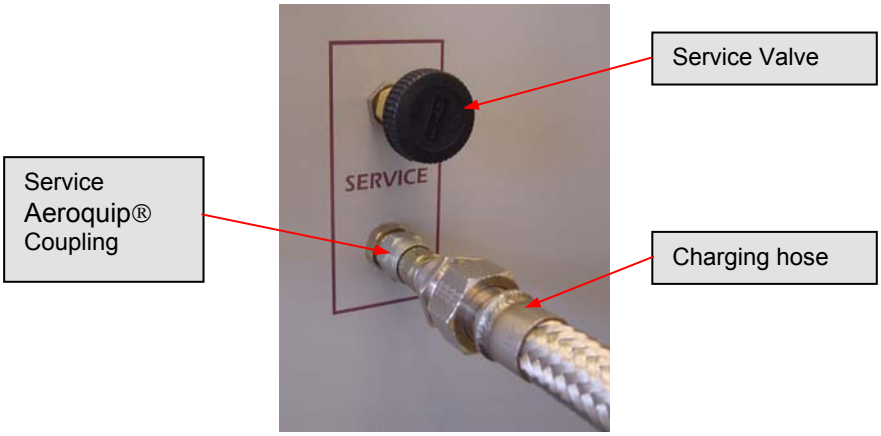


Figure 15: Service Valve and Access Port

6) Attach a charging line from the service Aeroquip® to a vacuum/charging station as shown in Figure 16 below.

Figure 16: Pumping Station

7) Evacuate to 50 microns.
8) Isolate the vacuum pump and add 50 PSIG (3.4 bar) of helium.
9) Vent the helium and repeat steps 8 to 10.
10) Final evacuation should be to 25 microns.
11) Pressurize the line to the service access with the desired amount of low pressure.
12) Slowly open the service valve to add helium to the system. Refer to Section 2.1.4 for the required helium charge.

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.

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

4.5 Cold head

The cold head contains no user serviceable parts. If cold head service is required it must be returned to Cryomech.

CAUTION

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

4.6 Cleaning

Compressor package and cold head

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

CAUTION

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

Aeroquip® couplings

CAUTION

Never remove an Aeroquip® coupling from the cold head, compressor or helium flex line.

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 are detached from the compressor package and/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 gets on the Aeroquip® coupling, contact Cryomech.

5 Section 5: Troubleshooting

5.1 System will not start

SYMPTOM	System will not start
POSSIBLE CAUSE	1) No power supplied to the compressor package. 2) Circuit breakers off. 3) "Compressor Error" message displayed on display screen.
REMEDY	1) Check the power supply to the system and verify that it meets the requirements outlined in Section 2.1.3. 2) Make certain both circuit breakers, located on the front panel of the compressor package, are on. 3) Refer to Section 3.3 for error message diagnostics.

5.2 System starts, no pressure fluctuation

SYMPTOM	System starts, no bounce in the pressure gauges, no refrigeration.
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. 4) Failure in the cold head motor circuit. 5) Defective cold head motor cord. 6) Failure of the cold head motor.
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 compressor package to the high pressure port on the cold head and that the other helium flex line connects the low pressure ports. 4) See Section 5.4 for checking circuit. 5) Check continuity of all 4 conductors in the cold head motor cord. 6) Check motor resistance between pins A – B and C – D. The resistance should be approximately 1.4 ohms. The resistance readings between all other pin combinations should be infinite.

5.3 System has shut itself down.

SYMPTOM	System has shut itself down.
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 compressor package. 2) Check the power supply to the system and verify that it meets the requirements outlined in Section 2.1.3. 3) Refer to Section 3.3 for error message diagnostics.

5.4 Checking cold head motor circuit

If the cold head motor is not functioning, the following steps should be taken to check the cold head motor circuitry.

1) Remove the left side panel from the compressor package.
2) Locate the power supply and the motor driver attached to the electrical panel. See Figure 17.

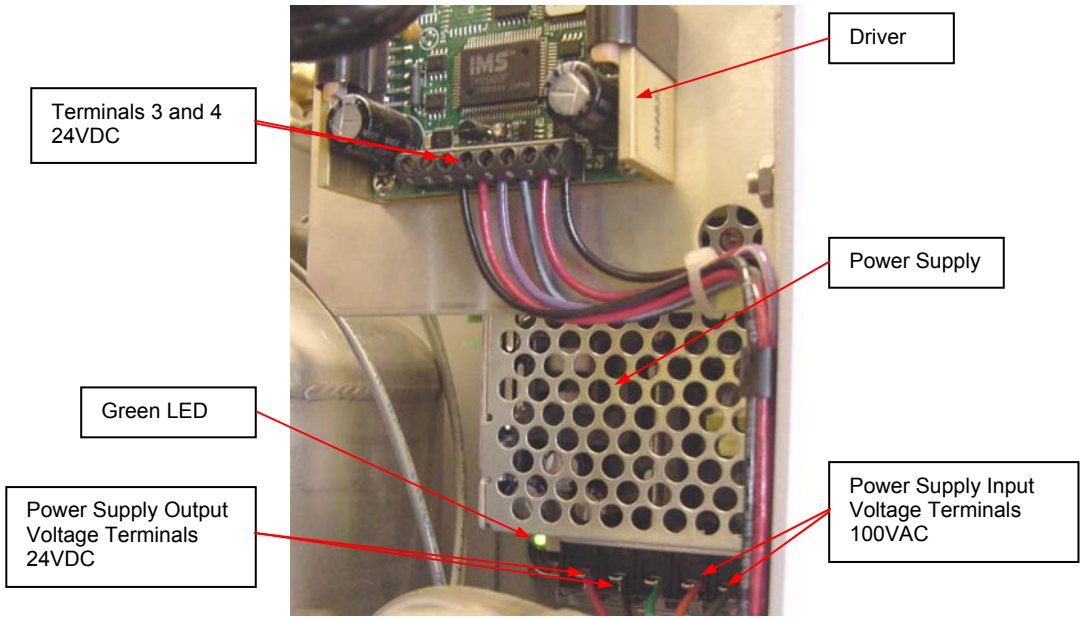


Figure 17: Cold Head Motor Power Supply and Driver

3) When the compressor is running, the power supply's green LED should be lit.
4) If the LED is not lit, check the input power to the power supply. There should be a voltage of 100VAC (±10%) between the orange (L) and gray (N) wires.
5) If the input power is good, the power supply is defective.
6) If the input power is bad, contact Cryomech.

7) Check the power supply's output voltage. There should be 24VDC across terminals +V (red wire) and –V (black wire). If not, the power supply is defective.

8) Check for an input voltage of 24VDC across terminals 3 (black wire) and 4 (red wire) on the driver.

9) If the input voltage is bad, check the wiring between the power supply and the driver.

10) If the input voltage is good, the driver may be defective. Check the cold head motor cord and cold head motor as per Section 5.2.