Polycold® MaxCool Cryochiller Installation and Operation Manual

Including Models:
MaxCool 4000H
MaxCool 2500L

Cool°Solutions

214072 Revision B

Information provided within this document is subject to change without notice, and although believed to be accurate, Brooks Automation assumes no responsibility for any errors, omissions, or inaccuracies.

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June 26, 2014 Part Number 214072 Revision B

Original manual written in English - Printed in the U.S.A.

Contents

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1 Introduction

Using This Manual

⚠ WARNING

The Polycold Cryochiller contains high voltages and other hazards which, if not properly handled, may result in death or serious injury.

Only trained and qualified personnel should work on the Polycold Cryochiller.

Do not perform installation, operation, or maintenance procedures on the Polycold Cryochiller unless you have read and understand the information in the Safety chapter of this manual.

This product is intended for use by industrial customers and should be serviced only by Brooks or Brooks trained representatives. The manuals and related materials are provided in English at no charge and are intended for use by experienced technicians. It is the responsibility of the user to obtain and assure the accuracy of any needed translations of manuals. If you require assistance please contact Brooks service department. Contact information can be found at: www.brooks.com.

This manual provides information for a wide variety of Polycold Cryochiller configurations. Some of the features that are shown are optional and may not be installed on your system. Refer to Brooks Automation sales literature to determine what items are optional.

There may be additional installation, maintenance, troubleshooting, and repair information in other manuals which may affect the settings or operation of the Polycold Cryochiller. When integrated in a system, the Polycold Cryochiller may be set to system specifications. Before adjusting or changing settings, consult the appropriate system documentation.

All documents that are referenced in this manual refer to documents of the latest revision as of the publication date of this manual. Brooks Automation Technical Support issues Technical Support Bulletins (TSBs) to notify the owners of record of any field retrofits.

Pressures are stated as gauge (i.e., psig) not absolute. Psig is pounds per square inch gauge and kPa is Kilopascals gauge. kPa = 6.895 x Psig. bar = Psig ÷ 14.5

System Illustration

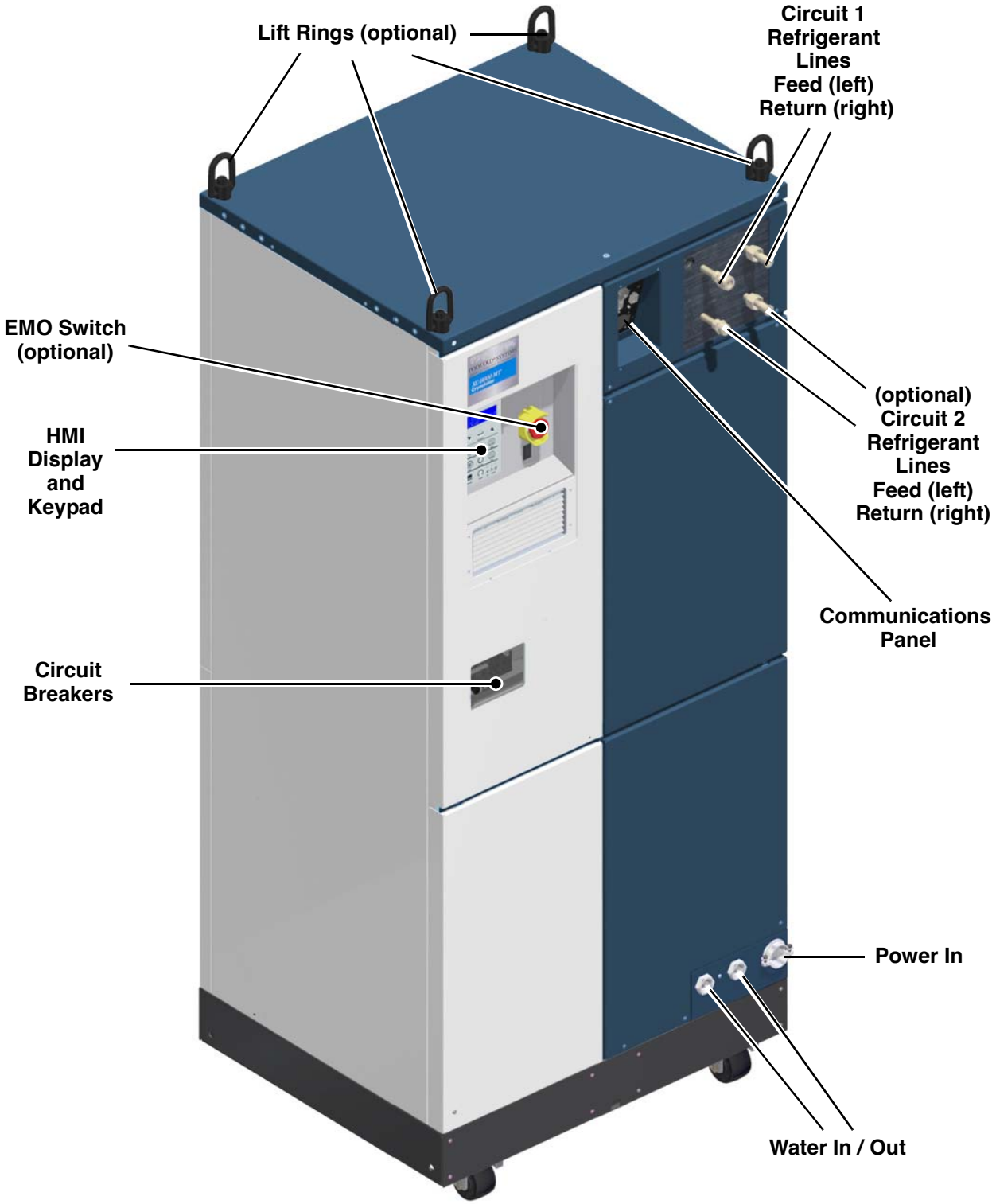


Figure 1-1: Illustration of MaxCool Cryochiller

System Summary

Definitions:

Refrigeration Unit: The device that compresses, cools, and pumps the refrigerant through the refrigerant line and cryosurface.

Refrigerant Line: Typically an insulated bundle that contains feed and return hoses that transfer refrigerant between the Polycold Cryochiller refrigeration unit and the cryosurface.

Cryosurface: The cold element that is installed in the customer's vacuum chamber. Cryosurfaces are usually shaped as a coil to capture water vapor or as a baffle to capture backstreaming oil.

About the Polycold MaxCool Cryochiller

The MaxCool Cryochiller is a closed loop cryogenic refrigeration system with many applications. It is frequently used to capture water vapor and other condensable substances by freezing them onto a cold surface such as a cryocoil (Meissner trap) or chevron baffle. This Cryochiller is also used to cool and heat objects such as electrostatic chucks used in semiconductor wafer processing.

The Polycold MaxCool Cryochiller consists of a refrigeration unit, refrigerant line set, and a cryosurface with cryogenic feedthrough. The refrigeration unit can pump cold or hot refrigerant in a continuous loop through the refrigerant lines and cryosurface. The innovative cryogenic refrigeration process in the Polycold Cryochiller uses patented refrigerant mixtures and patented control processes developed by Brooks Automation Polycold Systems.

Some configurations include advanced controls that reduce power consumption. Models are available that control two independent circuits, providing greater design flexibility for vacuum systems such as two cryocoils or one cryocoil and one cryobaffle. All models include both local and remote operation.

Optional features can be selected to add advanced performance and remote communications features that enhance productivity and add convenience. Some of these optional features include:

- Additional sound attenuation
- Compliance with SEMI S2 and F-47 standards
- Process heating
- Ethernet, Profibus, DeviceNet, or 24V DI/DO remote interfaces

Polycold Cryochiller Versions

The Polycold Cryochiller is manufactured in different models and configurations to fit a variety of applications. Table 1-1 shows the currently manufactured Cryochiller model numbers and their description. Contact Brooks Sales for optional configurations.

Table 1-1: Polycold Cryochiller Models and Descriptions

Configuration	Description
MaxCool 4000H	Optimized for maximum water vapor cryopumping speed and maximum vacuum process throughput (formerly XC-8800 HC)
MaxCool 2500L	Optimized for minimum water vapor partial pressure and maximum vacuum process quality (formerly XC-8800 MT)

Theory of Operation

The Polycold MaxCool Cryochiller employs a patented non-flammable HCFC-free refrigerant mixture in an auto-refrigerating cycle (ARC) cooling process to provide operating temperatures from -80°C to -150°C.

This process, which is thermodynamically more efficient than a multistage cascade process, combines all of its refrigerants into a single multi-component stream circulated by one compressor.

The advantages of the mixed refrigerant ARC cooling process are reduced system complexity, more favorable operating conditions, lower maintenance, and greater reliability.

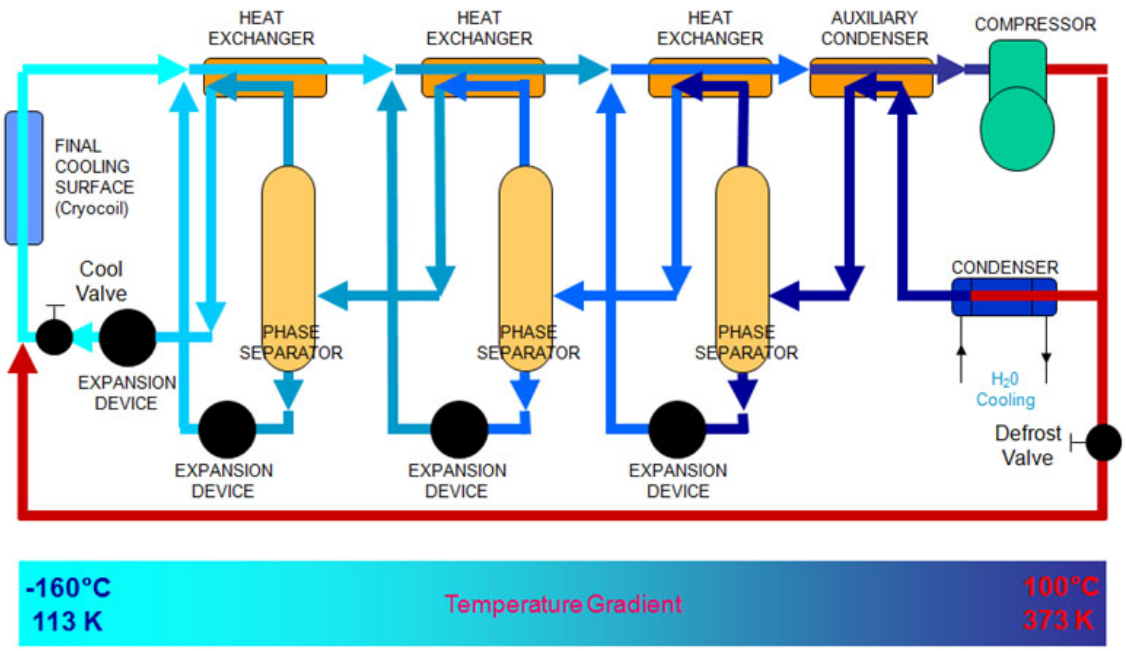


Figure 1-2: Refrigeration Flow Diagram

Water Vapor Capturing in High Vacuum Systems

Water vapor can be up to 95% of the residual gas in high-vacuum chambers and is typically the most reactive contaminant in such systems. The exceptionally high water vapor pumping speed provided by the Cryochiller greatly increases product throughput and produces higher film quality, better adhesion, and more reproducible deposition.

When capturing water vapor in high vacuum systems, the cryosurface is normally a coil. A rapid interchange between the cold and defrost states frees up valuable cycle time and increases product throughput.

As the vacuum chamber begins the pump down sequence, the pre-programmed Polycold Cryochiller can exit the Standby mode and quickly cool the cryocoil, providing much higher pumping speeds than traditional vacuum pumps and significantly reducing chamber pump down time.

During the deposition process, the Polycold Cryochiller remains in the Cool mode to greatly reduce water vapor contamination and increase product yield. During chamber venting, the Polycold Cryochiller quickly heats the cryocoil to defrost and sublime the captured water vapor.

In this application, the cryocoil can be mounted directly in the vacuum chamber so conductance is not limited by ports, manifolds, valves and baffles. The cryocoil is easy to install and can be adapted to fit any system. It does not need a high vacuum valve. See Figure 1-3 on page 1-6.

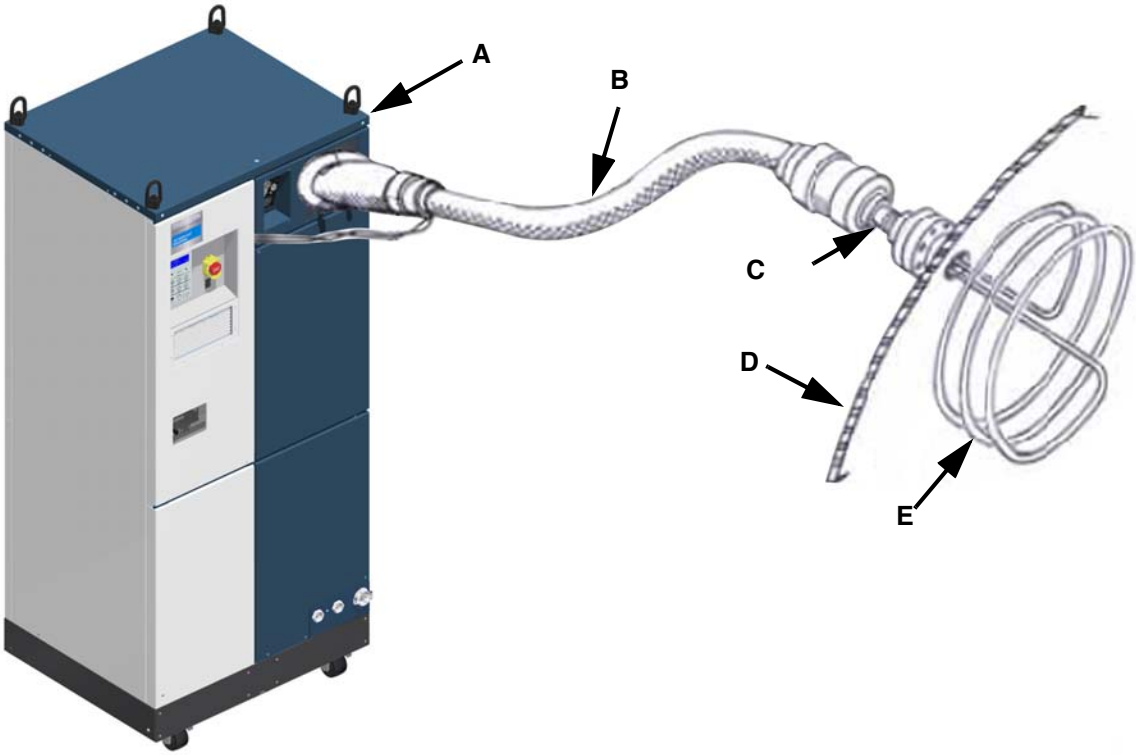


Figure 1-3: Polycold Cryochiller Used for Water Vapor Capture

Legend:

A. Polycold Cryochiller Refrigeration Unit

B. Refrigerant line

C. Cryogenic feedthrough

D. Vacuum chamber wall

E. Cryosurface

Minimizing Oil Backstreaming From Diffusion Pumps

Backstreaming can occur any time oil diffusion pumps are used in high vacuum systems. Hot oil vapor from a diffusion pump can migrate into the vacuum chamber and contaminate the system.

An optically-opaque cryogenic chevron baffle that is cooled by the Polycold Cryochiller is placed over the diffusion pump to greatly reduce oil contamination due to backstreaming. This baffle also provides additional water vapor pumping speed to the vacuum tool. This greatly improves vacuum system cleanliness and leads to greater product quality and yield. Quick cooling and defrosting is not typically required for such an application because the cold cryobaffle remains isolated behind a high vacuum valve whenever the chamber is vented to atmosphere. See Figure 1-4 on page 1-7.

Optically transparent cryobaffles are also available from Brooks Automation Polycold. These baffles are appropriate for increased water vapor pumping speed in turbomolecular pump applications.

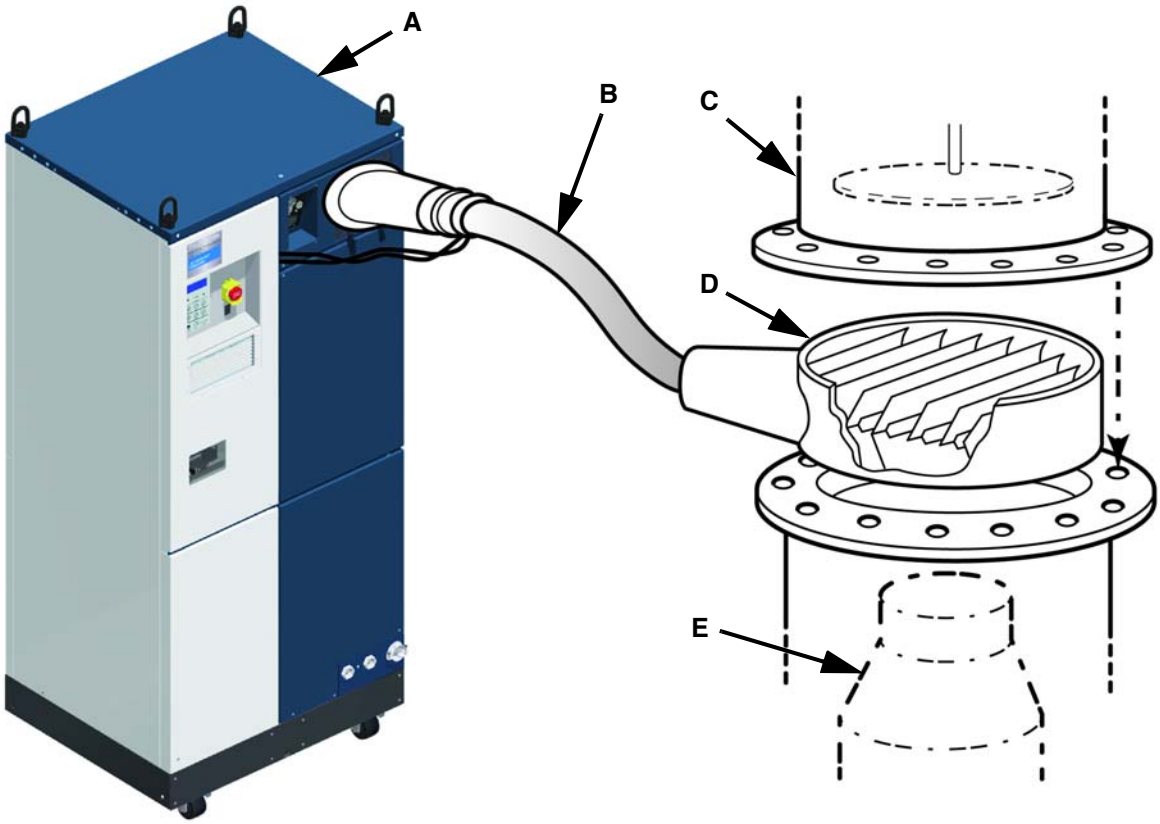


Figure 1-4: Polycold Cryochiller Used with Optically Opaque Baffle to Minimize Oil Backstreaming

Legend:

A. Polycold Cryochiller Refrigeration Unit

B. Refrigerant line

C. High vacuum valve

D. Cryobaffle

E. Oil diffusion pump

Heat Removal

The Polycold MaxCool Cryochiller is also used in applications requiring high power cooling to temperature as low as -150°C.

There are a wide variety of heat removal applications, but two notable examples include the cooling of external heat exchangers that chill a gas or a liquid and the cooling of refrigerant-cooled chucks that control the temperature of semiconductor wafers and other substrates during a manufacturing process in vacuum. See Figure 1-5.

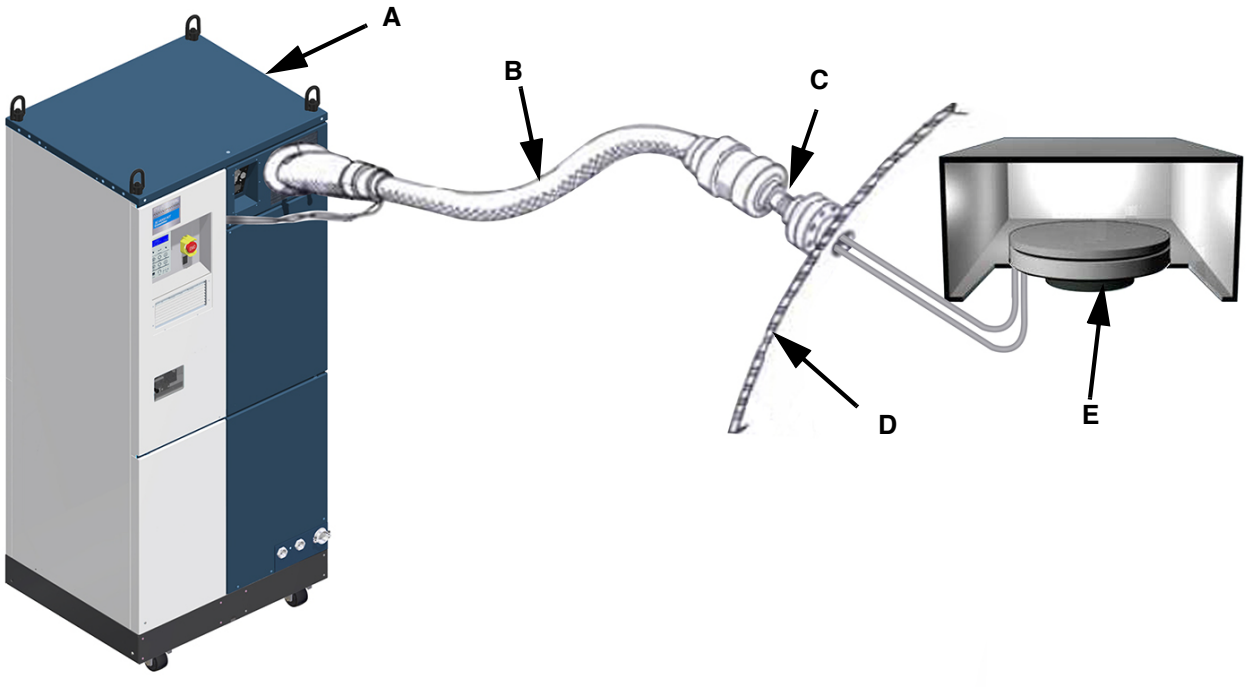


Figure 1-5: Polycold Cryochiller used for Heat Removal

Legend:

A. Polycold Cryochiller Refrigeration Unit

B. Refrigerant line

C. Feedthrough

D. Chamber Wall

E. Cool Plate

Polycold Cryochiller System Components

Polycold Cryochiller components are shown along with all optional components. Optional components must be selected when the system is ordered.

Polycold Cryochiller Component List

See figures 1-2, 1-3, and 1-4.

1. Human Machine Interface - HMI - Area
2. Fan Filter Access

3. High Voltage Box Cover and Circuit Breaker Access
4. Seismic Anchor Points (4 Places)
5. Warm Valves (for recharging and service only)
6. Compressor Shipping Hold Down Nuts (4 Places)
7. Removable Kick Plate for Pallet Jack Access
8. Water Supply and Return Connections
9. Casters (4 Places) (Optional) (not shown)
10. Power Inlet
11. Suction Service Valve
12. Compressor
13. Water Cooled Condenser
14. Discharge / Recharge Valve
15. Cold Valve Box
16. Feed / Return Lines (Optional Second Circuit Shown)
17. Lifting Rings (4 Places) (Optional)
18. Remote Interface Terminals
19. Thermocouple Access Panel
20. Discharge Service Valve
21. Compressor
22. Expansion Tank (s)
23. Pressure Gauge
24. Profibus Connection (Optional)
25. Thermocouple Terminal Block

Polycold Cryochiller Views

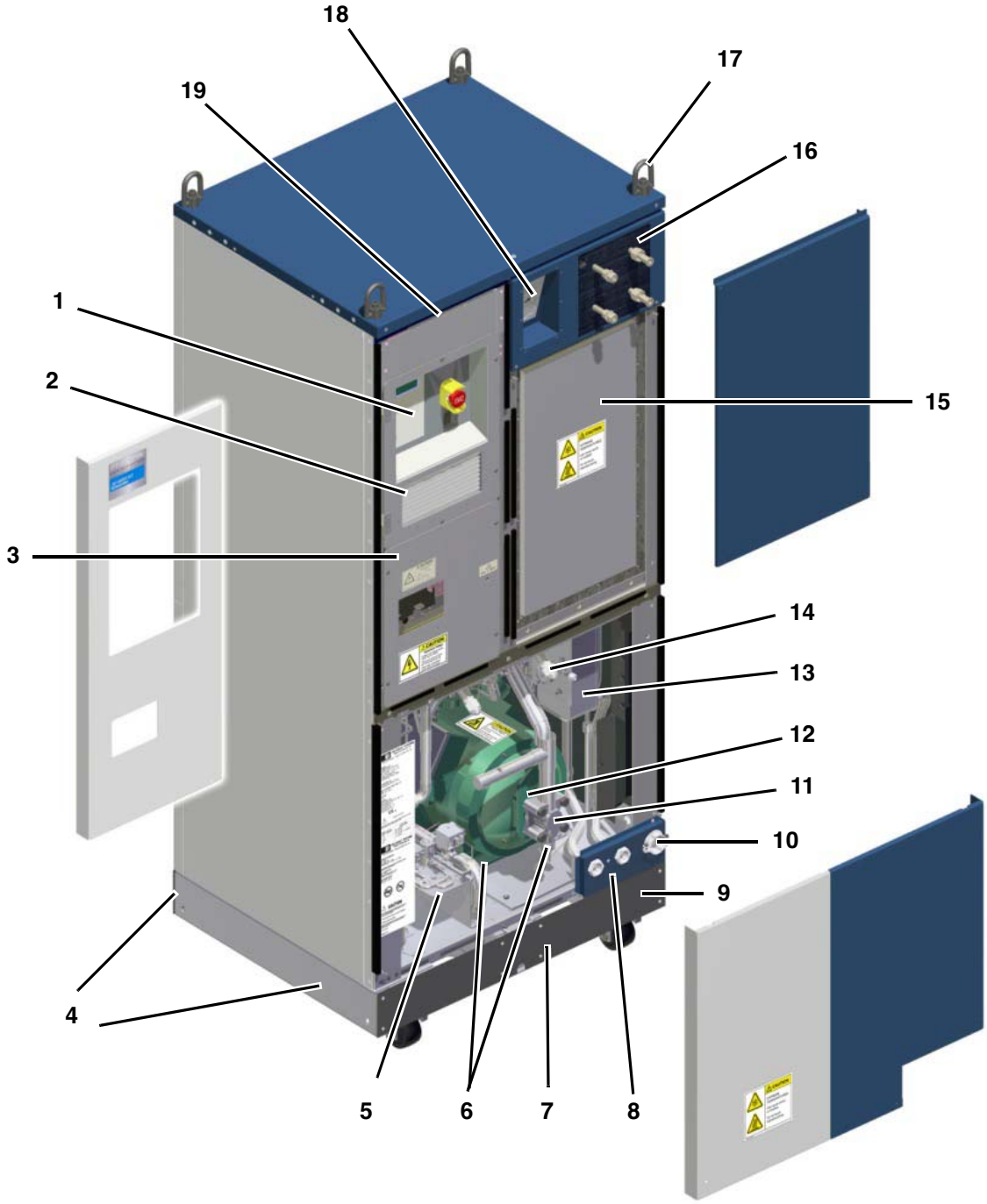


Figure 1-6: Polycold MaxCool Cryochiller System Exploded View

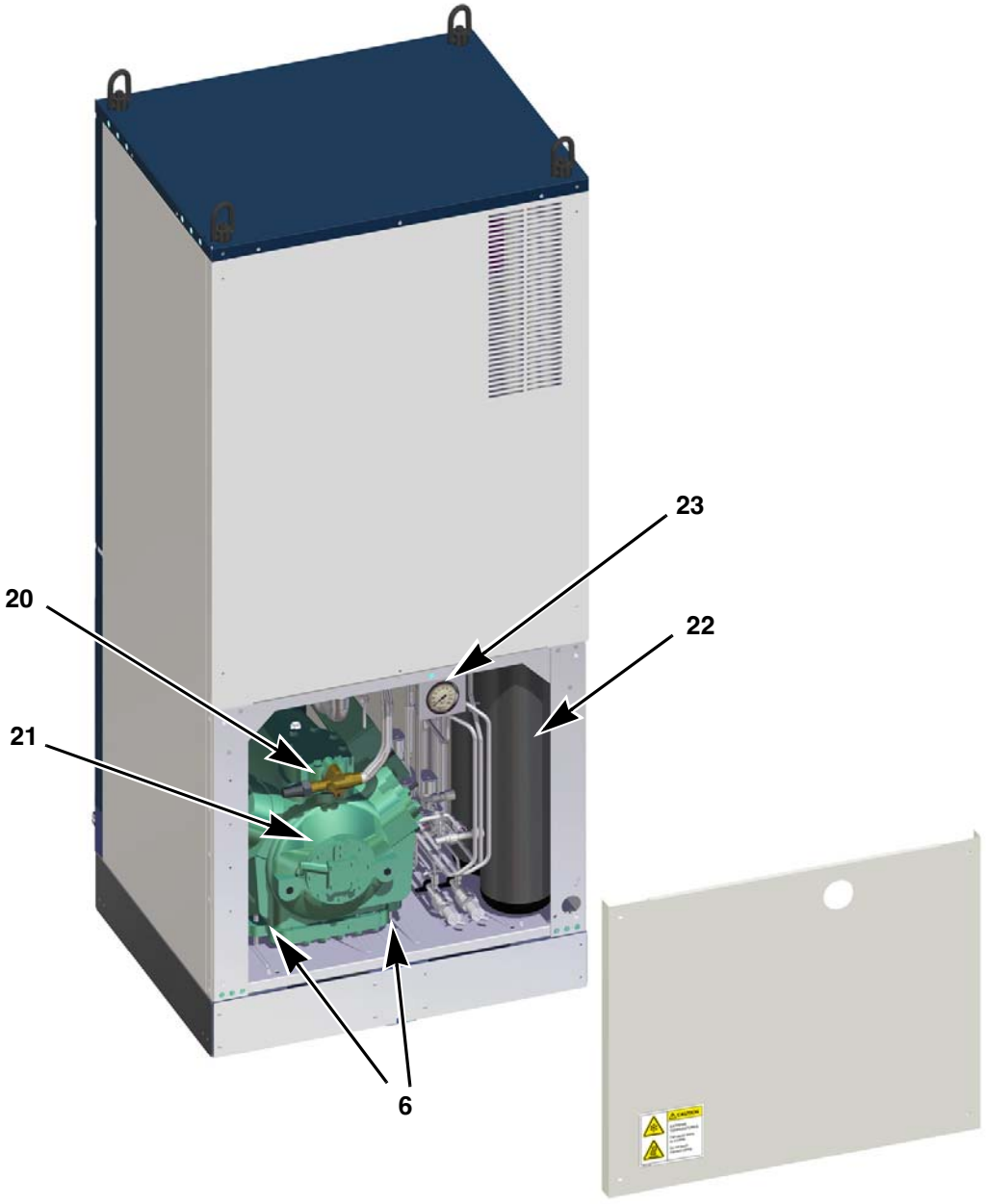


Figure 1-7: Polycold MaxCool Cryochiller Compressor View

Figure 1-8: Low Voltage Section

Limitations

This product is intended for use by industrial customers and should be serviced only by Brooks or Brooks trained representatives.

The Installation and Operation manual and related materials are provided in English at no charge and are intended for use by experienced technicians. It is the responsibility of the user to obtain and assure the accuracy of any needed translations of manuals.

If you require assistance, please contact Brooks service department. Contact information can be found at www.brooks.com.

Regulatory Compliance

Declaration of Conformity (DOC)

The Polycold Cryochiller meets the requirements of the European Union's Machinery Directive (2006/42/EC), the Low Voltage Directive (2006/95/EC), and the EMC Directive (2004/108/EC).

Brooks Automation has issued a Declaration of Conformity for units that are used independently from a system, and the Polycold Cryochiller has a CE mark affixed.

Brooks	**Declaration of Conformity** **Pressure Equipment Directive**	**Document #:**

CE 0036

We Brooks Automation Inc., 15 Elizabeth Drive, Chelmsford, MA, USA 01824

declare under our sole responsibility that the products shown below carrying the CE Marking:

Description : Polycold® Cryogenic Refrigeration Unit
Models: 8800 MT, 8800 HC, MaxCool 4000H, MaxCool 2500L
Serial Number:
Function: Closed loop cryogenic refrigeration water vapor recovery system

are in conformity with the provisions of the Pressure Equipment Directive (97/23/EC) of the European Communities.

- PED Category: II
- Conformity Assessment: Module A1
- Standards: EN 378, EN 60204-1, EN ISO 12100-1, -2
- Notified Body: TÜV SÜD Industrie Service GMBH (NB #0036) WestendStrasse, 80686, Munchen, Germany

Declaration of Incorporation (DOI)

When the Polycold Cryochiller is supplied for integration into a system, the final integrator is overall responsible for conformity to the applicable directives and safety systems. When the system has the CE mark, the Cryochiller becomes an incorporated component and the attached Declaration of Incorporation applies.

Brooks	**Declaration of Incorporation of Partly Completed Machinery For the European Union**	**Document #:** **Rev**

Description: Polycold® Cryogenic Refrigeration Unit,
Function: Closed loop cryogenic refrigeration water vapor recovery system
Models: XC8800 MT, XC8800 HC, MaxCool 4000H, MaxCool 2500L.
Part Number:
Serial Number:

Business name and full address of the manufacturer of the partly completed machinery:
Brooks Automation Inc., 15 Elizabeth Drive, Chelmsford, MA, USA 01824

Name and address of the person, established in the Community, authorized to compile the relevant technical documentation:
Brooks Automation (Germany) GmbH, Ernst-Ruska-Ring 11, 07745 Jena, Germany

The manufacturer declares:

- That the following essential requirements of Machinery Directive 2006/42/EC are applied and fulfilled and that the relevant technical documentation is compiled in accordance with part B of Annex VII:
  Annex I sections: 1.1.2, 1.1.3, 1.1.5, 1.1.6, 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.3.1, 1.3.2, 1.3.4, 1.5.1, 1.5.2, 1.5.3, 1.5.4, 1.5.5, 1.5.6, 1.5.7, 1.5.8, 1.5.9, 1.5.11, 1.6.1, 1.6.3, 1.6.4, 1.7.1, 1.7.2, 1.7.3
  - EN 60204-1
- That the safety objectives set out in directive 2006/95/EC (LVD) have been applied to the partly completed machinery.
- That this partly completed machinery conforms with the provisions of Electromagnetic Compatibility Directive 2004/108/EC.
  - *EN 61000-6-4*
  - *EN 61000-6-2*
- That this partly completed machinery fulfills all the relevant provisions of Directive 97/23/EC (Pressure Equipment Directive).
  - PED Category: II
  - Conformity Assessment: Module A1
  - Notified Body: TÜV SÜD Industrie Service GMBH (NB #0036) WestendStrasse, 80686, Munchen, Germany
  - Standards: EN 378, EN 60204-1, EN ISO 12100-1, -2
- We will transmit, in response to a reasoned request by a national authority, relevant information on the partly completed machinery, on paper or in electronic form, without prejudice to our intellectual property rights.

The partly completed machinery must not be put into service until the final machinery into which it is incorporated has been declared in conformity with the provisions of Directive 2006/42/EC

Signature

Name of signatory date of declaration
Title of signatory place of declaration

Brooks	Disclosure Table, EIP, Polycold Cryochiller	Part Number 192189	Revision B

Control of Pollution Caused by Electronic Information Products, China

Disclosure Table

February 5, 2013

表 1 有毒有害物质或元素名称及含量标识格式

部件名称	Polycold Cryochiller	有毒有害物质或元素					
		铅 Lead (Pb)	汞 Mercury (Hg)	镉 Cadmium (Cd)	六价铬 Hexavalent Chromium (Cr(VI))	多溴联苯 Polybrominated Biphenyls (PBB)	多溴二苯醚 Polybrominated Diphenyl Ethers (PBDE)
电控箱	ELECTRICAL ASSY	X	X	X	O	O	O
换热器及阀门	HEAT EXCHANGER/VALVE ASSY	X	O	O	O	O	O
压缩机室	COMPRESSOR COMPARTMENT ASSY	X	O	O	O	O	O
通讯及遥控接口	CUSTOMER COMMUNICATION ASSY	X	X	X	O	O	O
包装及附件	PACKAGING/ACCESSORY ASSY	X	O	O	O	O	O
制冷剂	REFRIGERANT	O	O	O	O	O	O

O:表示该有毒有害物质在该部件所有均匀材料中的含量均在 SJ/T11363-2006 规定的限量要求以下。

X:表示该有毒有害物质至少在该部件的某一均匀材料中的含量超出 SJ/T11363-2006 规定的限量要求。

以上所有部件中的有毒有害物质在该部件所有均匀材料中的含量均在《电子信息产品污染控制重点管理目录(第一批)》规定的限量要求以下。

All assemblies listed above comply with China RoHS temporarily allowed exemptions limit from The Key Catalog for Controlling Pollution by Electronic Information Products (Batch 1)

Brooks Automation
15 Elizabeth Drive
Chelmsford, MA 01824 USA

REVISION HISTORY:

Revision A:	5/15/2012	Initial Release per EC # 57074 L. Case
Revision B:	2/5/2013	Updated product names per EC# 63451 L. Case

Form #: FM-HW-SAC-018 Rev A DCO Q00724

Limited Warranty

Brooks

Limited Warranty

Polycold® Systems Cooling Products, CryoTiger®,AquaTrap®, Polycold Compact Cooler, Repair Services and Certified Refurbished Products

Polycold® Systems cryogenic cooling products, including water vapor cryopumps (XC, MaxCool, PFC, PCT, FLC, FI), chillers (PGC, PGCL), cyrocoolers (P), CryoTiger, AquaTrap, Polycold Compact Cooler (PCC) and accessories, Certified Refurbished products (the "Products") and Repair Service (i.e.- repairs other than warranty repairs) are warranted to be free from defects in materials and/or workmanship under normal service for the time period as set forth in Table A below from date of shipment from Brooks Automation, Inc. ("Brooks"). The warranty for Repair Service and Products is limited to the component parts replaced or repair performed by Brooks at Brooks' facility. Customer is responsible for all charges and expenses for Brooks Services provided at Customer's location by Brooks technicians as set forth in a quotation. Certified Refurbished Products and warranty exchange Products are remanufactured to like-new condition and contain used parts and materials.

Table A

Product	New Product Warranty	Repair Service Warranty	Certified Refurbished Cryogenic Cooling Products Warranty
Cryotiger® Products and Systems AquaTrap® Products and Systems Polycold® Compact Cooler (PCC)	15 Months	12 Months	N/A
Cryogenic cooling products, including: Water vapor cryopumps (XC, MaxCool, PFC, PCT, FLC, FI), chillers (PGC, PGCL), cryocoolers (P), and accessories	24 Months	12 Months	12 months

BROOKS MAKES NO OTHER REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO PRODUCTS OR SERVICES. UNLESS EXPRESSLY IDENTIFIED AS A WARRANTY, SPECIFICATIONS IN ANY PRODUCT DATASHEET CONSTITUTE PERFORMANCE GOALS ONLY, AND NOT WARRANTIES. BROOKS MAKES NO WARRANTY RESPECTING THE MERCHANTABILITY OF PRODUCTS OR THEIR SUITABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE, OR RESPECTING INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. **BROOKS DISCLAIMS ANY WARRANTY WITH RESPECT TO PRODUCTS MODIFIED WITHOUT BROOKS' WRITTEN CONSENT, REPAIRS MADE OUTSIDE OF OUR FACTORY, PRODUCTS RENDERED DEFECTIVE BY CUSTOMER MISUSE, NEGLIGENCE, CORROSIVE ATMOSPHERES, ATTACK BY FREE CHEMICALS WITHIN THE SYSTEM, ACCIDENT, DAMAGE BY CUSTOMER OR CUSTOMER'S AGENT, OPERATION CONTRARY TO OUR RECOMMENDATION, IF THE SERIAL NUMBER HAS BEEN ALTERED, DEFACED OR REMOVED, THE USE OF SERVICE REPLACEMENT REFRIGERANTS FROM ANY THIRD PARTY NOT LICENSED BY BROOKS, OR THE PRODUCT IS OTHERWISE COMPROMISED BY USE OF UNAUTHORIZED PARTS OR SERVICE, ALL AS DETERMINED BY BROOKS IN ITS SOLE DISCRETION.**

IN NO EVENT WILL CUSTOMER BE ENTITLED TO, NOR WILL BROOKS BE LIABLE FOR INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE OR CONSEQUENTIAL DAMAGES OF ANY NATURE, INCLUDING WITHOUT LIMITATION NEGLIGENCE, STRICT LIABILITY, OR OTHERWISE, ARISING AT ANY TIME, FROM ANY CAUSE WHATSOEVER, INCLUDING, WITHOUT LIMITATION, DOWN-TIME COSTS, DATA LOSS, DAMAGE TO ASSOCIATED EQUIPMENT, REMOVAL AND/OR REINSTALLATION COSTS, REPROCUREMENT COSTS, OR LOST PROFITS, EVEN IF BROOKS HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, AND EVEN IF THE LIMITED REMEDIES OF REPAIR OR REPLACEMENT FAIL OF THEIR ESSENTIAL PURPOSE. THIS WAIVER OF LIABILITY DOES NOT APPLY TO EITHER BROOKS' LIABILITY UNDER A STATUTE, ACT OR LAW PERTAINING TO BODILY INJURY, OR TO ANY LIABILITY INCURING OUT OF DAMAGE TO THE BODY, HEALTH OR LIFE OF A PERSON.

The exclusive remedies for breach of warranty will be either repair or replacement of the nonconforming parts or Products during the warranty period at the sole discretion of Brooks, shipped ExWorks (Incoterms 2000) Brooks factory. Customer's recovery from Brooks for any claim shall not exceed the amount paid by customer to Brooks for the Product or Service giving rise to such claim, irrespective of the nature of the claim, whether in contract, tort, warranty, or otherwise. Customer must inspect the Products within a reasonable time upon receipt, and must notify Brooks within 30 days of discovering a defect. Every claim on account of defective material or workmanship shall be deemed waived unless made in writing within the warranty period specified above. Brooks does not assume, or authorize any other person to assume, any other obligations or liabilities in connection with the sale of the Products.

All Polycold Products are also subject to the Brooks Automation, Inc. General Terms and Conditions, Polycold® Products, an excerpt of which is set forth above.

September 16, 2011
Doc# PS-02 Rev E
Polycold® is a registered trademark of Brooks Automation, Inc.

3800 Lakeville Hwy • Petaluma, California 94954 U.S.A. • 707.769.7000 • Toll Free: 888.4.Polycold • Fax 707.769.1380
E-mail petaluma.sales@brooks.com • www.brooks.com

2 Safety

WARNING

Failure to review the Safety chapter and follow the safety warnings can result in death or serious injury.

- Do not perform installation, operation, or maintenance procedures until you have read and understand the safety information.
- Follow all applicable facility safety codes
- Read and understand each procedure before performing it.

If additional safety related upgrades or newly identified hazards associated with the Polycold Cryochiller are identified, Brooks Automation Technical Support notifies the owner of record with a Technical Support Bulletin (TSB).

Explanation of Hazard Alerts

This manual and this product use industry standard hazard alerts to notify the user about personal or equipment safety hazards. Hazard alerts contain Safety Text, Safety Icons, and Signal Words and Color.

Safety Text

Hazard alert text follows a standard, fixed-order, three-part format.

- Identify the hazard,
- State the consequences if the hazard is not avoided,
- State how to avoid the hazard.

Safety Icons

- Hazard alerts contain Safety Icons that graphically identify the hazard.
- The safety icons in this manual conform to ISO 3864 and ANSI Z535 standards.

Signal Words and Color

Signal Words inform of the level of hazard.

DANGER	Danger indicates a hazardous situation which, if not avoided, **will result in death or serious injury**. Danger signal word is white on a red background with an iconic exclamation point inside a yellow triangle with black border.
WARNING	Warning indicates a hazardous situation which, if not avoided, **could result in death or serious injury**. Warning signal word is black on an orange background with an iconic exclamation point inside a yellow triangle with black border.
CAUTION	Caution indicates a hazardous situation or unsafe practice which, if not avoided, **may result in minor or moderate personal injury**. Caution signal word is black on a yellow background with an iconic exclamation point inside a yellow triangle with black border.
NOTICE	Indicates a situation or unsafe practice which, if not avoided, **may result in equipment damage**. Notice signal word is white on blue background with no icon.

Alert Example

The following is an example of a WARNING hazard alert.

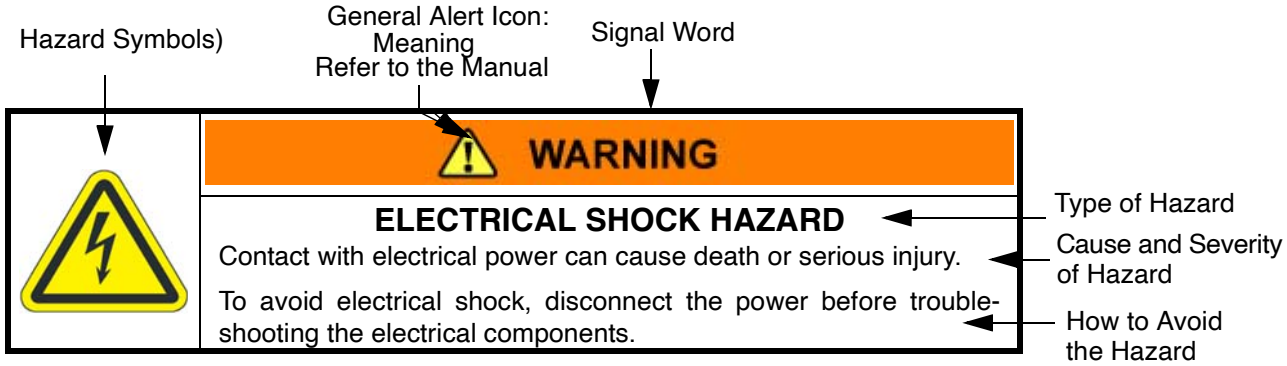


Figure 2-1: Components of a Safety Alert

Use of Notes

This manual uses notes to make the reader aware of additional information. Information in notes is not related to human or equipment safety. A note does not use icons. The following is an example of a Note.

NOTE: *Save all shipping materials for future use. If the Polycold Cryochiller is shipped, the original shipping crate must be used.*

General Guidelines

⚠ CAUTION

Unauthorized Service

Operation or service by untrained or unauthorized personnel may result in personal harm or damage to equipment.

- Only qualified personnel who have received certified training and have the proper qualifications for their jobs are allowed to transport, assemble, operate, or maintain the Product.
- Only Brooks parts are authorized to be used when configuring or repairing this system.

⚠ CAUTION

Proper Operation

Improper use of the Polycold Cryochiller may cause personal injury.

- Do not operate the Polycold Cryochiller before it is properly installed.
- Do not modify connectors or cables.
- Do not operate the unit without all guards and safety devices in place.
- Do not install or operate the Polycold Cryochiller if it has been dropped, damaged, or is malfunctioning.
- Do not use the Polycold Cryochiller for any purpose other than as a cryochiller or damage to the Cryochiller or the equipment to which it is connected may occur.

⚠ CAUTION

Seismic Restraint

The use of the Polycold Cryochiller in an earthquake prone environment may cause equipment damage or personal harm.

- The user is responsible for determining whether the product is used in an earthquake prone environment
- The user is responsible for providing appropriate seismic restraint in accordance with local regulations.

Safety Labels and Safety Label Identification

Safety labels are placed on the Polycold Cryochiller to identify hazards. Identification labels provide information about the product. This section describes each label and identifies its location.

NOTICE

Do not change or remove the safety labels or equipment identification labels.

Label Identification and Location

Table 2-1 lists the labels that are affixed to the Polycold Cryochiller. These labels alert personnel to hazards on or within the product and provide information about the product.

Figure 2-2 shows the location of each label. To replace a lost or damaged label call Brooks Automation Technical Support.

Table 2-1: Labels Used on the Polycold Cryochiller

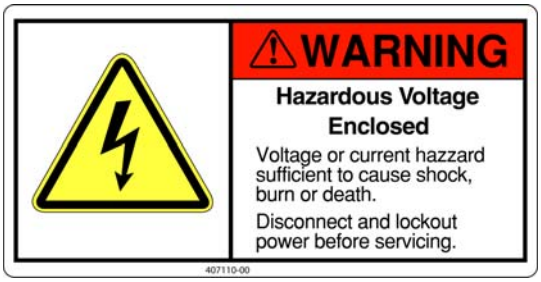
	Hazard: Hazardous Voltage Part Number: 407110-00 Qty: 2 Location: (1) On inside and (1) on outside of inner control unit cover below circuit breaker view port. Possible injuries: Electrical Shock or burn How to avoid the hazard: Turn off power and lock out before servicing.
	Hazard: Heavy Object Part Number: 407112-00 Qty: 1 Location: On compressor body Possible injuries: Muscle strain or back injury How to avoid the hazard: Use lifting aids and proper lifting techniques

Table 2-1: Labels Used on the Polycold Cryochiller

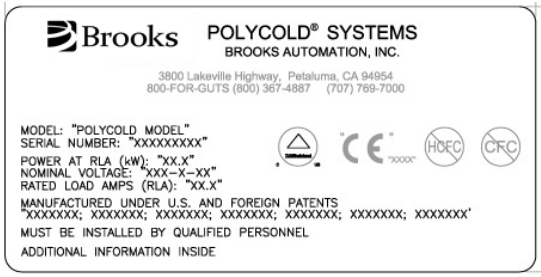
	Hazard: Tip (On units with Caster option installed) Part Number: 184193 Qty: 2 Location: Front and back lower panels. Only on units with caster option Possible injuries: Crush How to avoid the hazard: Push from below the midpoint of the height. Lock casters when not moving. Move only on level surfaces. Do not use casters to move up and down ramps. Move at slow speed with slow acceleration/deceleration Move on smooth floors free of gaps, grooves, or debris
	Hazard: Extreme Temperatures (Hot and Cold) Part Number: 407114-00 Qty: 3 Locations: (1) Lower right front cover. (1) Lower rear cover, (1) Inner valve cover panel on inside of unit. Possible injuries: Burns or Frost Bite injuries How to avoid the hazard: Do not touch exposed piping. Allow to come to ambient temperature before servicing.
	Unit Nameplate Label, Abbreviated Part Number: 179924 Qty: 1 Location: Outside Lower Right Front Cover Contains part number, serial number

Table 2-1: Labels Used on the Polycold Cryochiller

Nameplate Label

Part Number: 407168-00 (left or top section)

Qty: 1 (2 label set)

Location: Inside on lower left frame of compressor area

Contains part number, serial number, and specification information.

Table 2-1: Labels Used on the Polycold Cryochiller

Nameplate Label

Part Number: 407168-00 (right or bottom section)

Qty: 1 (2 label set)

Location: Inside on lower left frame of compressor area

Contains specification information

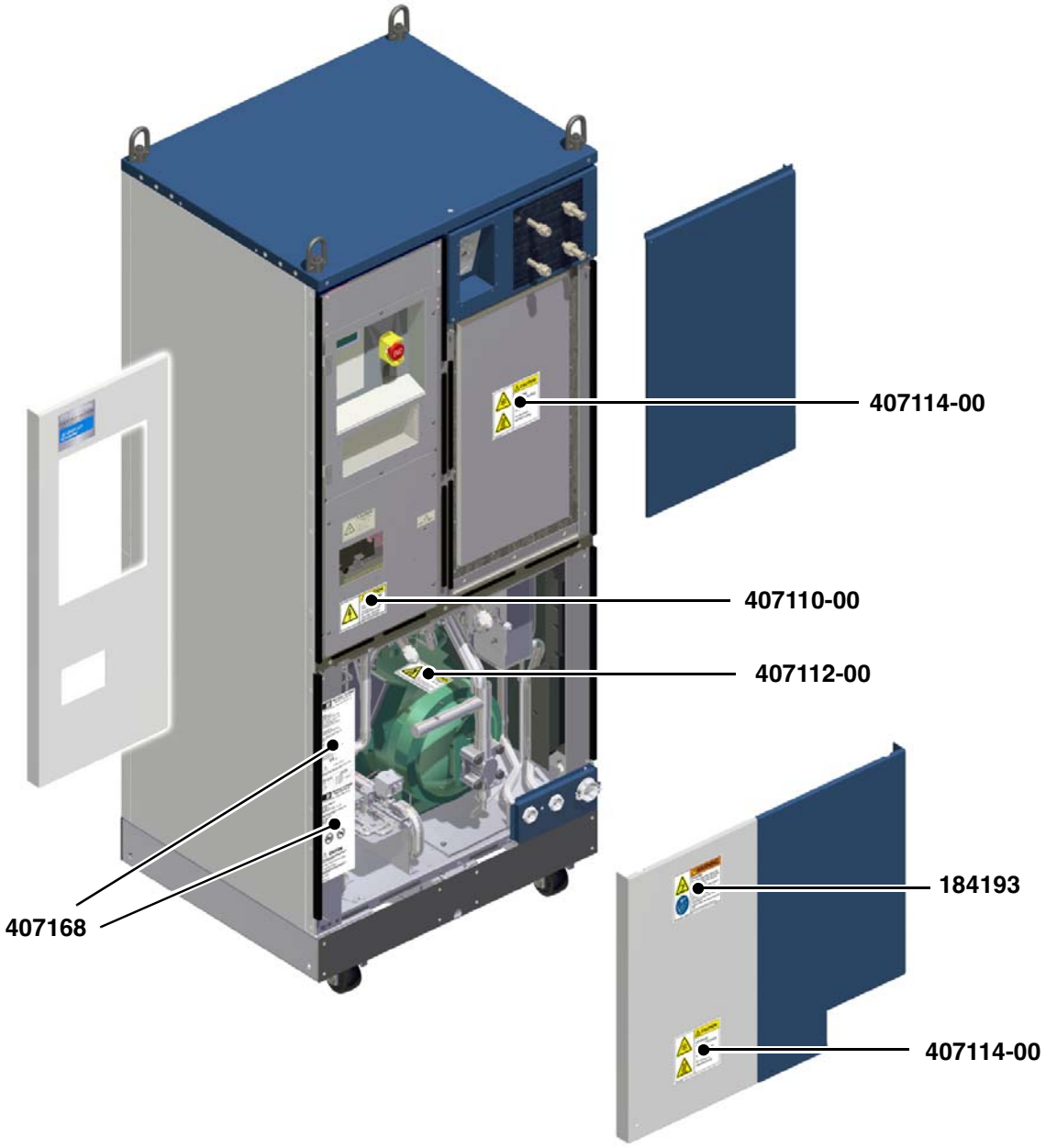


Figure 2-2: Locations of Labels on the front side of the Polycold Cryochiller

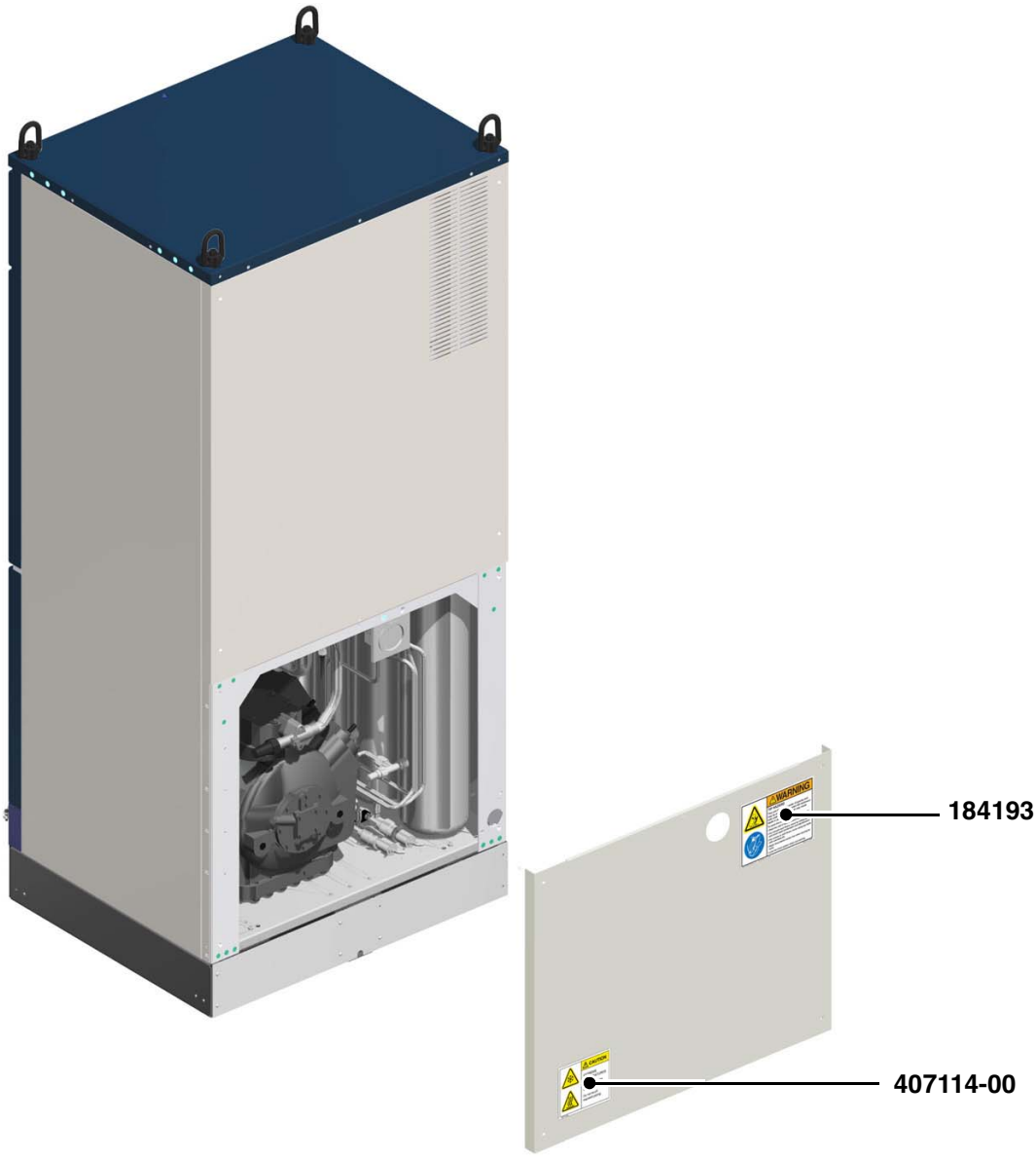


Figure 2-3: Locations of Labels on the back side of the Polycold Cryochiller

Safety and Operational Interlocks

Safety interlocks protect personal safety. Operational interlocks protect the Polycold Cryochiller. Additional interlocks may be added to the Cryochiller by the user. For additional information, see Compressor Safety Chain on page 6-7.

The Cryochiller contains the interlocks listed in Table 2-2 and shown in Figure 2-4.

Table 2-2: Interlocks on the Polycold Cryochiller

Interlock	Function
Circuit Breakers	Protective devices that prevent current overload of the compressor motor or control system. Circuit breakers require manual reset.
High Voltage Interlock	The Lockout/Tagout slide bar must be moved to the lockout/tagout position with the primary circuit breaker in the OFF position in order to remove the cover to the high voltage box and access the interior of the high voltage assembly.
Over Pressure Relief Valve	A pressure relief valve vents refrigerant gas when the refrigerant circuit pressure exceeds the set point of the valve. Causes a controlled-release of excess pressure for the refrigerant in a manner that avoids an over pressure event. Valve closes when pressure is reduced to the valve set point.
Compressor Motor Thermostat	Detects when the temperature of the compressor on the Polycold Cryochiller exceeds a safe temperature and shuts off power to the compressor motor. The thermostat automatically resets when the temperature of the compressor motor thermostat falls to a safe level.

DANGER

Hazardous Voltage

Overriding interlocks can cause electrical hazards. Direct contact with hazardous voltage will cause death or serious injury.

- Do not defeat, modify, or disable any of the unit's safety interlocks.

NOTICE

The user may choose to add an Emergency Off (EMO) circuit to the Polycold Cryochiller and is accountable for that EMO circuit.

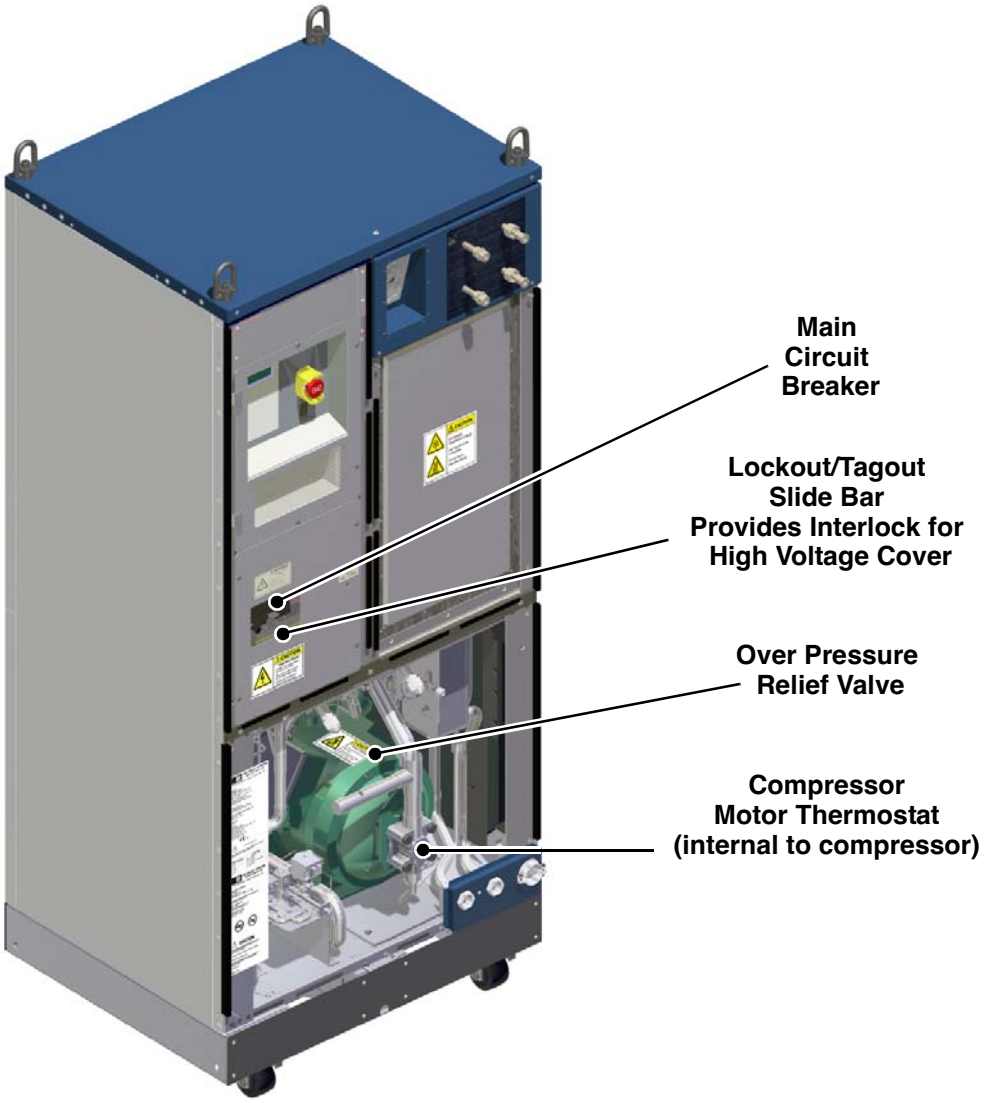


Figure 2-4: Location of Safety Interlocks on the Polycold Cryochiller

⚠ WARNING

Lockout / Tagout

Working with energized equipment may cause electrical shock or burn and may result in death or serious harm.

- All energy must be removed from the equipment per the system's or the facility's Lockout/Tagout procedure before servicing.
- If local procedures are not available, follow the procedure for Lockout/Tagout in **OSHA Standard 29CFR 1910.147**.

Cryochiller Lockout/Tagout

A slide bar that is attached to the high voltage box cover is provided as the Lockout/Tagout device.

When the high voltage box cover is removed, the Lockout/Tagout device is also removed, and Lockout/Tagout procedures must be performed on the input power to the Polycold Cryochiller.

To use the Lockout/Tagout device:

1. Turn off the main circuit breaker.
2. Slide the Lockout/Tagout bar across the circuit breaker to prohibit the circuit breaker from being turned on.
3. Apply the Lockout/Tagout device to hold the slide bar in place.

To remove the high voltage box cover:

1. Apply Lockout/Tagout procedures at the source of the input power.
2. Turn off the main circuit breaker and move the Lockout/Tagout slide bar to the Lockout/Tagout position.
3. Remove the high voltage box cover.

Mechanical Hazards

WARNING

Tip Hazard

This unit has a high center of gravity and may tip when moved improperly or when left stationary with casters unlocked which may cause death or personal injury.

To avoid this hazard, follow these precautions:

- Read the user's manual before moving.
- For smooth hard floors, move by rolling slowly and avoid rapid acceleration and deceleration.
- Move only on smooth level surfaces that are free of gaps, grooves, or debris.
- For uneven or soft floors, move using optional hoist rings with overhead lift
- Do not use casters to move up and down ramps.
- Apply force below center line when moving by hand.
- Lock two front casters when not moving.

WARNING

Lifting Ring Hazard

This unit is equipped with lift rings that when used improperly may fail and cause death or serious personal injury.

To avoid this hazard, follow these precautions:

- Lift with 4 straps that each have a minimum strength as required by local regulations but not less than the weight of the lifted item.
- Length for each strap between the lift ring bolt and the lifting point must be greater than 736mm (29 inches).
- The angle between the sling strap and horizontal at each lift ring must be greater than 45°
- Strength of lift device must be greater than 4 times weight of unit being lifted.

CAUTION

Trip Hazard

Trip hazard which may cause personal injury exists if the facilities connections such as power and communications cables, gas and vacuum lines, for the compressor are not properly routed.

- Route facilities connections and communication cables out of the way where there is no travel and they do not cause trip hazards

CAUTION

Heavy Object

The Polycold Cryochiller weighs a minimum of 533 kg (1175 lb) up to a maximum of 544 kg (1200 lb).
Failure to take the proper precautions before moving this unit could result in personal injury.

- Follow appropriate methods for moving heavy equipment.

Electrical Hazards

The Brooks Automation Polycold Cryochiller is a hazardous voltage device. It requires a user installed slow blow circuit breaker that meets, or exceeds, the minimum SCCR rating specified by SEMI S2. See Electrical on page 3-4.

The proper precautions for operating and servicing electrical equipment must be observed.

WARNING

Electrical Installation Hazard

Improper electrical connection or improper handling of the power can cause electrical shock resulting in death or serious injury and can cause fire and damage to the equipment.

- Ensure that a proper ground is provided from the power connection and confirm the equipment is properly grounded.
- Use proper power and proper electrical connections in accordance with the appropriate electrical code.
- Do not allow cables to be walked on or become wet.
- Turn off power before connecting or disconnecting cables.
- Allow only a qualified electrical installer to perform electrical work on the Polycold Cryochiller in accordance with local codes.

WARNING

Electrical Hazard

Contact with energized equipment can cause electric shock and result in death or serious injury.

- All electrical energy supplied to the Polycold Cryochiller must be disconnected from the system according to the facility's lockout/tagout procedure before performing service or maintenance.
- Lockout/Tagout device is provided for use when high voltage box cover is in place.
- Lockout/Tagout must be provided at the input power source if high voltage box cover is removed,
- Only a qualified electrician or electrical technician is allowed to open the Polycold Cryochiller and troubleshoot electrical problems.

Thermal Hazards

The condenser and compressor inside the Polycold Cryochiller present thermal hazards.

WARNING

Extreme Temperature Hazard

Contact with hot or cold surfaces can cause death or serious injury. from burns or frost bite.

- Do not operate the Polycold Cryochiller without all covers in place.
- Wait 90 minutes after performing appropriate Lockout/Tagout procedures before removing covers.
- Allow cryocoil, cold chuck, or cryobaffle to come to +10° C (50° F).
- Wait until signs of frost have gone before servicing.
- Use appropriate Personal Protective Equipment if handling cold devices.
- Do not touch any uninsulated part of the refrigerant circuit when the unit is operating. This includes the:
  - Solenoid
  - Hand valves
  - Uninsulated parts of the refrigerant line
  - Uninsulated parts of the feedthrough
  - Cryosurface

CAUTION

Cold Thermal Hazard

Moving or repositioning the refrigerant line when cold may result in crimping of the gas lines and insulation may crack and cause minor or moderate injury along with hazardous refrigerant discharge.

- Do not attempt to move or position the refrigerant line.

Chemical Hazards

The Polycold Cryochiller is supplied with two Overpressure Relief Valves. In the unlikely event that the relief valves release refrigerant gas, the gas must vent to atmosphere in a well vented area that meets the minimum room size requirements as specified in ASHRAE-15 and EN-378.

WARNING

Asphyxiation Hazard

The blend of refrigerant used in the Polycold Cryochiller is non flammable and non toxic. However, as with any gas, asphyxiation could occur if concentrated refrigerant gas is inhaled which may cause death or serious injury.

- Service the Polycold Cryochiller in a well ventilated area as specified by ASHRAE-15 and EN-378.

CAUTION

Chemical Hazard

Opening the refrigerant circuit or changing valve settings without following the instructions in this manual could result in release of refrigerant gas which is considered a green house gas.

- Avoid releasing refrigerant gas to the atmosphere.
- Keep the gas line couplings aligned when making or breaking coupling connections to prevent leaks due to a sharp bends.
- Review this manual before performing any procedure including routine operation.

NOTICE

United States and other federal laws require a certified refrigeration technician (Type 2, High Pressure) perform any procedure that could release refrigerant to the atmosphere.

This includes:

- Installing the Polycold Cryochiller
- Inspecting procedures
- Disconnecting the refrigerant lines
- Troubleshooting procedures
- Repairing
- Disposing of the unit or charged components

High Pressure Gas Hazard

CAUTION

High Pressure Gas

The use of high pressure gas or compressed air during cleaning may cause flying debris.

- Wear personal protection equipment such as safety glasses if using high pressure gas for cleaning,
- Follow safety guidelines for cleaning with high pressure gas as specified by the facility.

Fire and Explosion Hazard

The Polycold Cryochiller does not have any direct fire or explosion hazard.

WARNING

Fire Hazard

Cleaning fluids such as isopropyl alcohol may cause fire if used on hot parts.

- Allow the Polycold Cryochiller to cool before using cleaning fluids.

CAUTION

High Pressure Refrigerant

In the unlikely event that the Polycold Cryochiller develops a refrigerant leak inside an enclosed chamber, it is possible that a high pressure event could occur which may result in equipment damage or personal injury.

- The vacuum chamber must have a pressure-relief valve to avoid an over-pressure condition.

Environmental Information

NOTICE

The Polycold Cryochiller contains fluorinated green house gases covered by the Kyoto Protocol.

Refrigerant Gas Recycling and Disposal

CAUTION

Refrigerant Gas

A qualified refrigeration technician is required to remove the refrigerant from the Polycold Cryochiller.

- When working with refrigerant gas, follow all facility and local regulatory environmental procedures regarding the storage, handling, and disposal of the gases.
- Refer to the refrigerant Material Safety Data Sheets, MSDS.

Hazardous Materials

Ensure the product has been properly decontaminated before performing any service. Follow the facility's decontamination procedures.

Follow all facility and local regulatory procedures for the disposal of hazardous materials. If the components are charged with refrigerant, refer to the Material Safety Data Sheets, MSDS, for each refrigerant.

Material Safety Data Sheets - MSDS

The Polycold Cryochiller contains refrigerants that are a proprietary mixture of different gasses. The actual blend may vary depending on the application. All of the blends of refrigerant gases are non-flammable and non-toxic.

A single Material Safety Data Sheet set for the different blends of gasses is located in Appendix J: Material Safety Data Sheets - MSDS on page 12-21.

The compressor in the Polycold Cryochiller contains lubrication oil which may be considered a hazardous substance. The MSDS for the POE Solest LT-32 oil is included in Appendix J: Material Safety Data Sheets - MSDS on page 12-21

3 Specifications and Site Preparation

Physical Specifications

Table 3-1: Physical Specifications

Parameter	MaxCool 4000H	MaxCool 2500L
Width - mm (inch)	813 (32)	813 (32)
Depth - mm (inch)	663 (26.1)	663 (26.1)
Height - mm (inch) (without castors or lifting hooks)	1791 (70.5)	1791 (70.5)
Min. room volume, m^3 (ft^3) (per ASHRAE 15 and EN 378-1)	33.98 (1200)	39.64 (1400)
Weight kg (lb)	533 (1175)	544 (1200)
Shipping Weight kg (lb)	567 (1250)	578 (1275)
Cooling Water Connection	3/4 NPT Female	3/4 NPT Female
Max. operating sound level, dB(A)	78	78
Max. operating sound level with sound attenuation option dB (A)	69	69

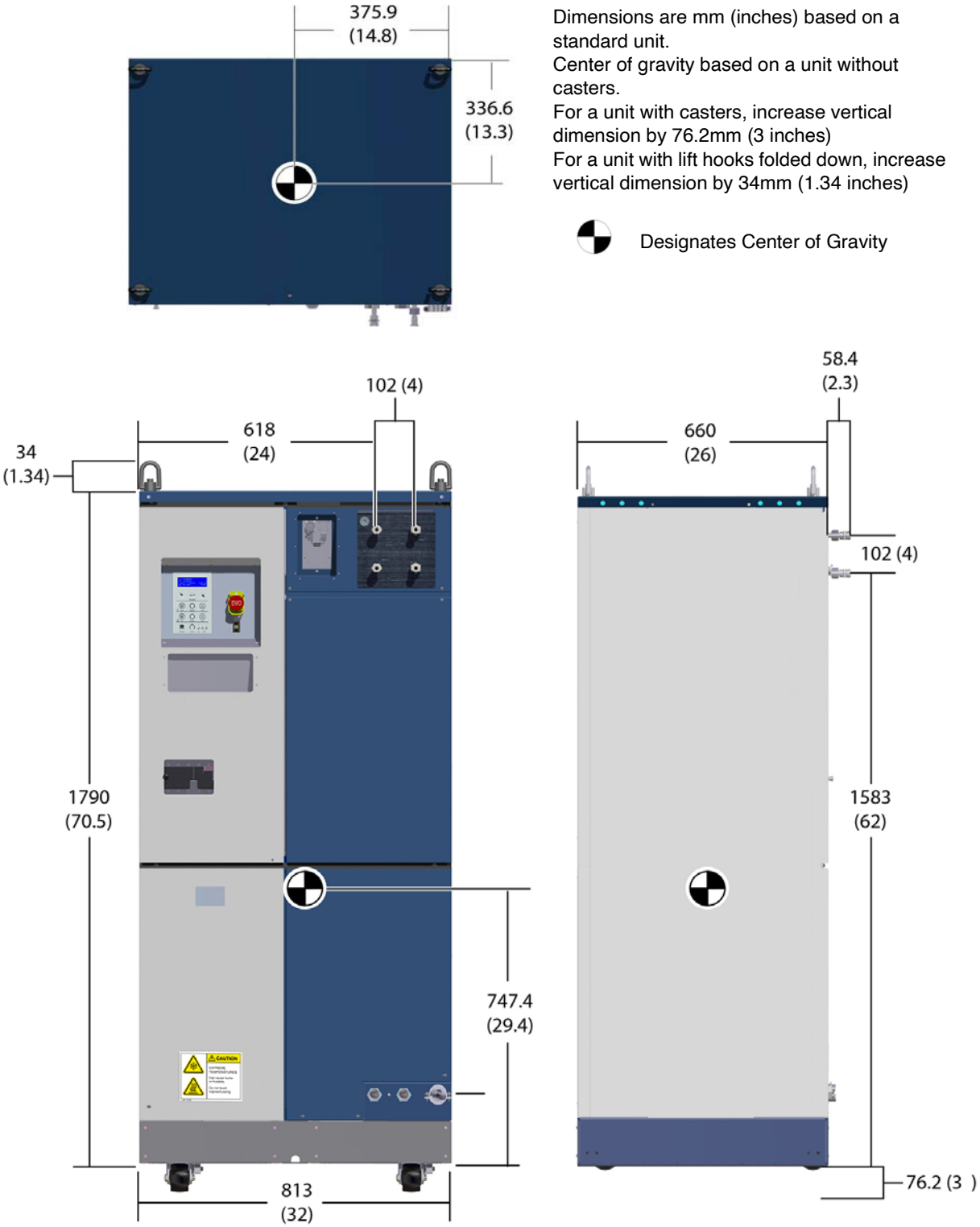
NOTE: *All units have cold elements that may be decoupled from the refrigerant lines.*

NOTE: *Maximum angle of inclination for shipping or handling all units is forty-five degrees (45°). When moving units using pallet jack or optional casters must be moved on level floors only.*

NOTE: *All specifications are for the standard product configuration. Specifications can vary for customized configurations*

NOTE: *Sound measurements were made on each side of the unit at a distance of 1.0m (39 in) and at a height of 1.6m (63 in). Measurements taken from each side of the unit did not vary significantly. Measurements will vary with the acoustics of the environment.*

Dimensions



Dimensions are mm (inches) based on a standard unit.
Center of gravity based on a unit without casters.
For a unit with casters, increase vertical dimension by 76.2mm (3 inches)
For a unit with lift hooks folded down, increase vertical dimension by 34mm (1.34 inches)

Designates Center of Gravity

Figure 3-1: Polycold Cryochiller Refrigeration Unit Dimensions

Site Preparation

The refrigeration unit should be installed in an environment that meets the following conditions:

- Indoors
- Above ground
- Well ventilated area. Room size must meet minimum requirements of ASHRAE-15 and EN-378. See Installing a Refrigeration Unit to Meet ASHRAE Requirements on page 4-3.
- Room temperature of 4-38° C (40-100° F)
- Relative humidity of 20-80%, non-condensing

The Polycold Cryochiller must remain vertical while operating. The refrigeration unit is not gravity sensitive and may be placed at any elevation relative to the cryosurface.

Access

During operation, the Polycold Cryochiller requires 51mm (2 inches) of clear area at the back of the system and 914mm (36 inches) at the front.
See Figure 3-2.

This clearance is required for access to switches, settings, air circulation, and safety reasons.

For service and maintenance, it is recommended that the unit is installed with as much clear service access as the facility will allow.

Routine service is performed from the front.

Major compressor service requires a minimum of 36 inches of rear clearance.

Units that are seismic anchored require a minimum of 914mm (36 inches) of rear service access.

Units that have the caster option require 51 mm (2 inches) of side clearance for gripping the unit.

Multiple units may be placed side by side as long as the rear clearance is provided.

Multiple units placed facing each other require 914mm (36 inches) front service access.

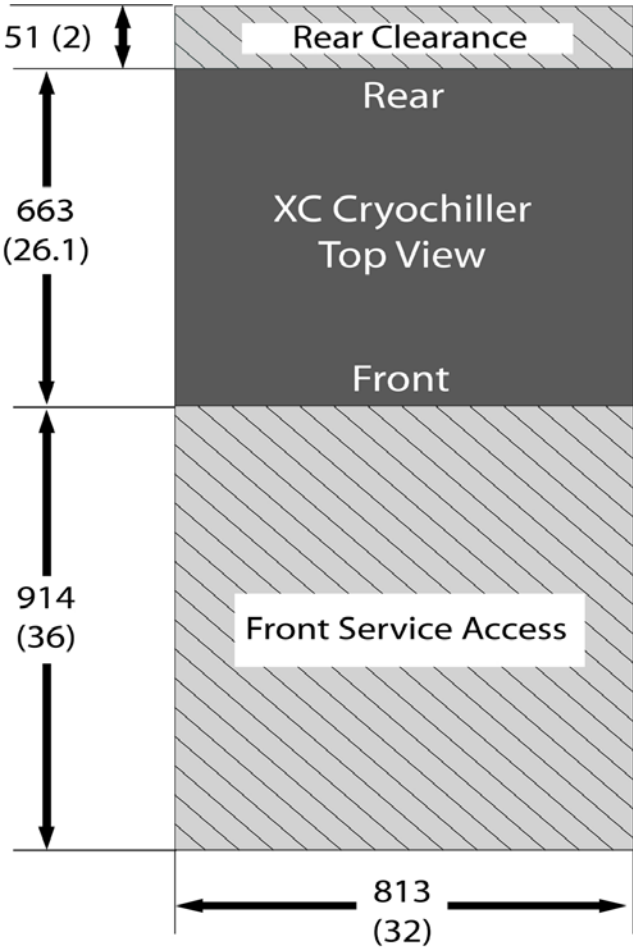


Figure 3-2: Polycold Cryochiller Service Access
Units are mm (inches) (not to scale)

Electrical

Table 3-2: Nominal and Maximum Power

Parameter	MaxCool 4000H	MaxCool 2500L
Power Input at Max Rated Load	19.2 kW @ 4000 watts	19.2 kW @ 2500 watts
Power Input with Cool and Low Load	12.4 kW @ 0 to 300 watts	13.9 kW @ 0 to 300 watts
Standby Power	12 kW	11.4 kW

Table 3-3: For units with Power Management Option Enabled

Parameter	MaxCool 4000H	MaxCool 2500L
Power Management Cool at 2/3 Max Rated Load	14 kW	14.9 kW
Power Management Cool with No Load	9.2 kW	12.4 kW
Power Management in Standby	10.1 kW	9.9 kW

Electrical Characteristics - MaxCool 4000H and MaxCool 2500L

Table 3-4: MaxCool 4000H and 2500L Cryochiller Electrical Characteristics

Compressor Voltage Range	Transformer Tap Setting	Common Nominal Voltages Worldwide (Voltage-Phase-Frequency)	Voltage Range
200-230 VAC	200-3-50/60	200-3-50 202-3-60 208-3-60	180-222 @ 50 Hz 182-229 @ 60 Hz
	230-3-60	230-3-60	207-230 @ 50 Hz 207-253 @ 60 Hz
380-480 VAC	380-3-50	380-3-50	342-418 @ 50 Hz
	400-3-50	400-3-50 415-3-50	360-440 @ 50 Hz
	460-3-60	440-3-60 460-3-60	414-506 @ 60 Hz
	480-3-60	480-3-60	432-528 @ 60 Hz
575 VAC	575-3-60	575-3-60	518-632 @ 60 Hz

Electrical Protection Requirements - MaxCool 4000H and 2500L

Table 3-5: MaxCool 4000H and 2500L Cryochiller Electrical Protection Requirements

Transformer Tap Setting and ID Label	RLA Amps	MCC Amps	LRA Amps	Fuse Size Amps	Power Input kVA
200-3-50/60	55.4	75	160	80	19.2
230-3-50/60	48.3	75	160	80	19.2
380-3-50	27.2	39	80	35 (see Note 1) 45 (see Note 2)	17.9
400-3-50	25.8	39	80	35	17.9
460-3-50/60	25.4	39	80	35	20.2
480-3-60	21.5	39	80	35	17.9
575-3-60	17.9	31.2	64	35	17.8

All voltages are nominal +10%/-10%, unless otherwise stated.

Note 1: 35Amp breaker is allowable for 380-3-50 setting when nominal voltage is 380V +10% / -5%.

Note 2: 45Amp breaker is required for 380-3-50 setting when nominal voltage is 380V +10% / -10%.

Electrical Specification Notes

- The Cryochiller is shipped with transformer tap settings for the voltage specified on the system label. If voltage is outside of the specified range, the transformer taps must be changed.
- 24 volt transformers on systems capable of 230 to 480 Volt power input may be configured in the field to the actual voltage. Refer to *Change Transformer Tap Settings on page 4-16*.
- RLA = Rated Load Amps is the current drawn by the compressor at rated load. It may also be referred to as the maximum full load amps.
- A Bussman FRS-R dual element, current limiting fuse or equivalent is recommended to protect the Polycold Cryochiller power circuit.
- Actual protection must comply with local codes.
- “Worst Case low Volts” refers to the lowest amount of voltage available. Power fluctuates by 10%, so the lowest voltage amount would be 90% of the nominal voltage.
- MCC = Maximum Continuous Current of the compressor motor.
- LRA = Locked Rotor Amps. This refers to the current that the compressor motor uses when the compressor is not able to rotate because the rotors are locked.
- Gould TRS, Littelfuse FLSR, MCA, minimum circuit ampacity, should be at least 125% RLA. This value is to assist the site electrician in determining the dimensions of the electrical system.
- Compressors are provided with over current and over temperature protection which comply with UL and NEC definitions of inherent thermal protection.

kVA = (Test Volts) X (RLA) X (1.732/1000)
kW = (kVA) X Power Factor (Power Factor is 90% in this case.)

Cooling Water

The cooling water supplied to the Cryochiller must meet temperature, flow, and purity requirements.

- Cooling water temperature must be between 13 – 38° C (55 – 100° F).
- Minimum flow rates and water temperatures are shown in Table 3-6.
- Purity requirements are shown in Table 3-7.

Minimum water flow rates are based on requirements to effectively remove heat from the cryochiller and to reduce risk for scale and corrosion of the condenser. Flow rates below the published minimum required flow rate can result in scale and corrosion since the risk for these conditions increases with lower water flow rates and higher outlet water temperatures.

Condenser failures or unit performance issues that occur on units operating at water flow rates that are lower than the minimum required flow rate in Table 3-6 are not covered by warranty.

Allow for cooling water temperature rise during the summer months.

User is advised to add a filter to the cooling water to remove dirt and abrasives. 100 micron filter is recommended. Chemical impurities in the cooling water must be compatible with copper. See Table 3-7.

Cooling water recommendations:

- Install a user-supplied filter that can be quickly purged of accumulated sediment by purging water from the filter, or install two parallel redundant user-supplied water filters with individual input and output shut off valves to allow for continuous operation during maintenance by diverting water to the opposite filter.
- Install a water flow rate meter in the input water line to monitor water flow.

Table 3-6: Water Flow and Inlet Water Temperature

Refrigeration Unit	Water Inlet Temperature °C (°F)	Minimum Required Flow Rate L/min (gpm)	Maximum Allowable Flow Rate L/min (gpm)	Internal Pressure Drop kPa (Psi)	Pressure Drop in Supply Line[1] kPa/m (Psi/ft)	Heat Rejection kW (Btu/Hour)
MaxCool 4000H	13 (55) – Min.	13.6 (3.6)	145 (38.3)	6.9 (1)	No data	23.2 (79,232)
	18 (65)	18.2 (4.8)	145 (38.3)	10.3 (1.5)	No data	23.2 (79,232)
	24 (75)	27.3 (7.2)	145 (38.3)	20.7 (3)	No data	23.2 (79,232)
	29 (85)	54.1 (14.3)	145 (38.3)	77.2 (11.2)	3.4 (0.15)	23.2 (79,232)
	38 (100) – Max.	54.1 (14.3)	145 (38.3)	77.2 (11.2)	3.4 (0.15)	23.2 (79,232)
MaxCool 2500L	13 (55) – Min.	13.6 (3.6)	145 (38.3)	6.9 (1)	No data	21.7 (74,109)
	18 (65)	18.2 (4.8)	145 (38.3)	10.3 (1.5)	No data	21.7 (74,109)
	24 (75)	27.3 (7.2)	145 (38.3)	20.7 (3)	No data	21.7 (74,109)
	29 (85)	54.1 (14.3)	145 (38.3)	77.2 (11.2)	3.4 (0.15)	21.7 (74,109)
	38 (100) – Max.	54.1 (14.3)	145 (38.3)	77.2 (11.2)	3.4 (0.15)	21.7 (74,109)

NOTE: *[1]Pressure Drop values assume a 3/4-inch (20 mm) standard pipe size.*
Maximum working pressure of the unit's cooling water circuit is 1380 kPa (200 psig).

Cooling Water Purity

The chemistry of water typically used to cool equipment can vary widely. Multiple different elements, compounds and ions may be present at the same time. Depending on which chemicals are present, their amount, and the cooling water temperature, there may or may not be a risk for scaling.

The guidelines listed here are provided to reduce the potential for scale and scale related corrosion. Whereas scale reduces heat exchanger effectiveness and cause the cryochiller performance to degrade, scale deposits can result in corrosion that can occur beneath the scale layer. The presence of excessive amounts of chlorine or chloride can accelerate this type of corrosion.

In addition to scale, the accumulation of micro organisms on heat exchanger surfaces can lead to corrosion. Even after microbes have been killed by heat of chemical agents, they remain on the surface and have the same effect as scale.

The specific elements of water quality which are important depend upon your local area and the minerals and chemicals dissolved in your cooling water. Although your local water supply was used to fill water into your cooling loop, it is the chemistry of the water circulating through your cooling loop which is important. In many cases, this is significantly different from the make up of the water originally filled into the cooling loop.

Best practice for cooling loop maintenance call for periodic sampling (i.e. monthly) and analysis of the water quality circulating in the cooling loop. When parameters are beyond the limits listed in Table 3-7, then corrective action is needed to bring them within the limits.

In cases where the cooling water is consistently at risk for scale, a periodic descaling process should be put in place, such as monthly or quarterly depending on scaling risk. Scale risk typically increases with water outlet temperature. This risk increases significantly when the compressor is allowed to operate without any water flow. While such events are expected, if a unit is repeatedly operated without cooling water, the condenser should be descaled.

Water quality may vary by location. The most common chemical properties and their recommended levels are identified in **bold** in Table 3-7. Additional properties which may be present in your cooling water are listed without bold.

Water Purity Properties

The following table provides general water purity guidelines.

Table 3-7: Water Purity Properties

Water Property	Recommended Level	Explanation
Microbiological Control	**<10,000 CFU (Colony Forming Units)**	**Higher microbiological levels can result in buildup of biofilm, which causes poor heat transfer and copper pitting corrosion.**
Particle Size	**< 100 microns**	**Larger particles can clog heat exchanger passages.**
pH	**7.5 - 9.0**	**Lower levels increase corrosion risk** **Higher levels increase scale formation and precipitation.** **Some references recommend keeping the pH level in the range 7.5 – 8.5**

Table 3-7: Water Purity Properties

Total hardness (°dH)	**3.9 – 8.4 °dH (70 - 150 ppm)**	**Maintain recommended levels to reduce scaling Scaling affects heat transfer and can lead to crevice corrosion.** **Values below 100 ppm are strongly recommended as there is a higher risk for scale above 5.6 °dH (100 ppm).** **(Note: This assumes the majority of hardness is due to calcium carbonate, $CaCO_3$)**
Alkalinity (HCO_3)	**70 - 250 ppm**	**Low levels cause copper corrosion, dissolution and release into water.** **High levels can cause increased chance of scaling.** **Note: The alkalinity of interest is "methyl orange" alkalinity or "m alkalinity"**
Electrical Conductivity	**10 - 600 µS/cm**	**Conductivity above the recommended level indicates a high concentration of ionic substances which results in high dissolved solids and potential for particles and scale.**
Chlorides (Cl^-)	**< 100 ppm**	**Higher levels can cause pitting corrosion.**
Free Chlorine (Cl_2)	**< 0.5 ppm**	**Higher levels accelerates copper leaching by oxidation and dissolution of the metal surface.**
Sulphate (SO_4^{2-})	< 100 ppm	Levels higher than 100 ppm increase the risk of copper pitting corrosion.
Electrical Resistivity	2,000 - 100,000 Ω-cm	Resistivity is the inverse of Conductivity. Higher resistivity above 100,000 Ω-cm can result in copper corrosion.
Hydrogen Sulfide (H_2S)	< 0.05 ppm	Higher levels can lead to corrosion, pitting, and copper fatigue.
Free (aggressive) Carbon Dioxide (CO_2)	< 5 ppm	Higher levels can indicate oxidation of metals.
Nitrate (NO_3^-)	< 100 ppm	Nitrate ions help to inhibit corrosion, similar to Sulphate (SO_4^{2-}) Higher levels increase the risk of copper pitting corrosion.
Iron (Fe)	< 0.3 ppm	Higher levels can increase the risk of galvanic corrosion.
Aluminum (Al)	< 0.2 ppm	Higher levels can increase the risk of galvanic corrosion.
Manganese	< 0.5 ppm	Higher levels can increase the risk of galvanic corrosion.
Silica	< 50 ppm	
Total Copper (Cu)	< 0.3 ppm	Higher levels can increase the risk of galvanic corrosion.
HCO_3^- / SO_4^{2-}	> 1 ppm	Lower levels below 1 ppm add risk of copper pitting
Turbidity	< 5 FTU	Higher turbidity levels are signs of high levels of microorganisms. Clean water is less likely to form deposits.
Ammonium (NH_4^+)	< 2 ppm	Higher levels increase the risk of copper corrosion.

Performance Specifications

Table 3-8 lists the performance specifications for the Polycold Cryochiller product family. For additional information, contact Brooks Automation Polycold Systems.

Table 3-8: Typical Performance Specifications

Performance	MaxCool 4000H	MaxCool 2500L
Maximum load (watts at warmest average temperature)	4000 W at -98 C	2500 W at -120 C
Theoretical maximum pumping speed (l/sec) (See footnote 2)	327,800	208,600
Conservative pumping speed, in chamber (l/sec) (See footnote 2)	220,000	140,000
Ultimate operating pressure, torr (mbar) (See footnote 3)	$5x10^{-8}$ ($7x10^{-8}$)	$8x10^{-10}$ ($1x10^{-9}$)
Maximum pump start pressure, (atm) (See footnote 4)	1.0	1.0
Time to defrost, (minutes) (See footnote 5)	2.2 m^2 = 6min 1 m^2 = 3 min	1.4 m^2 = 3 min
Standard cryocoil surface area m^2 (ft^2)	2.2 (23.7)	1.4 (15.1)

Notes:

1. Standard conditions for performance testing:
   - Cryocoil environment at 25°C
   - Recommend cryocoils and line lengths
   - Cooling water temperature between 25° and 28°C
   - Operation at 60 Hz
2. Larger cryocoils may give greater pumping speeds and can be used in some applications. Contact your Sales Representative or a Polycold Applications Engineer for details.
3. Standard cryocoil at 25% of maximum pumping speed
4. Recommended cryopump start pressure is near normal crossover. Mechanical roughing pumps and blowers are generally more effective for moisture above 1 torr.
5. Estimated time depending upon cryocoil mass and refrigerant line.
6. Units were tested in a manufacturing environment while under maximum load in the Cool mode.
7. Operation at 50Hz results in warming of the cryocoil temperatures by 3 to 5°C.
8. Operation of warmer cooling water temperatures results in a reduction of maximum load rating and warms cryocoil temperatures by about 4°C for a 10°C increase in cooling water temperature.

Cryocoils and Refrigerant Lines

Refrigerant lines should be kept to a minimum length. Any line over 6m (20 ft) should be reviewed by a Brooks Automation Polycold Applications Engineer. Longer refrigerant lines delay the start of cryopumping and the time to complete the defrost cycle. They also add to the total heat load on the cryochiller and impact the coldest achievable temperatures at the cryocoil. The heat gain through the insulation on the combined feed and return refrigerant line set is 8 Watts/ft (25 Watts/m).

The cryocoil(s) must be specified and sized for the process. Contact Brooks Automation Polycold for assistance in selecting the proper cryocoil.

Total cryocoil surface area for dual circuit models must be divided between the two circuits. Larger cryocoils may give faster pumping speeds and can be used in some applications. However, if the heat load is too great, the cryopump becomes less efficient and may be shut off by a protective device

Table 3-9: Typical Cryocoils and Refrigerant Lines for MaxCool

Cryocoils and Refrigerant Lines	Single Circuit		Dual Circuit	
	MaxCool 4000H	**MaxCool 2500L**	**MaxCool 4000H**	**MaxCool 2500L**
Design Pressure, bar (psig)	31 (450)	31 (450)	31 (450)	31 (450)
Test Pressure, bar (psig)	44.4 (644)	44.4 (644)	44.4 (644)	44.4 (644)
Temperature Range	+150C to -160C	+150C to -160C	+150C to -160C	+150C to -160C
Standard Cryocoil Surface Area m^2 (ft^2) - per circuit	2.2 (23.7)	1.4 (15.1)	1.1 (11.8)	0.7 (7.5)
Standard Cryocoil Tube Length - m (ft) - per circuit	43.8 (144.7)	27.9 (92.1)	21.9 (72.4)	18.6 (57.6)
Standard Cryocoil Tube OD - mm (in)	16 (5/8)	16 (5/8)	16 (5/8)	12 (1/2)
Refrigerant Line Length -m (ft) - per circuit (note 1)	2.4 (8)	2.4 (8)	2.4 (8)	2.4 (8)
Feed Line Tube OD - mm (in)	10 (3/8)	10 (3/8)	10 (3/8)	8 (5/16)
Return Line Tube OD - mm (in)	16 (5/8)	16 (5/8)	16 (5/8)	12 (1/2)

Note 1 Other refrigerant line lengths and cryocoils may be possible, depending upon performance requirements.

NOTICE

The tubing for the refrigerant lines and cryocoil must be dried prior to installation.

- Perform strength test with dry compressed nitrogen using the appropriate safety precautions
- After testing, backfill with dry nitrogen and cap the assembly.
- Hydrostatic pressure testing is NOT recommended because it introduces significant amounts of water and will void the warranty.
- Lines or coils that are hydrostatically tested must be drained of water and then baking out at 80 C for at least 12 hours under a dry nitrogen purge.
- A calibrated hygrometer should be used to verify that water vapor concentration is less than 50 ppm at the end of the bake out process.

Balance Pressure

Table 3-10: .Balance Pressures for Polycold Cryochiller Refrigeration Units[1]

Refrigeration Unit	Balance Pressure kPa (psig)
MaxCool 4000H	1241-1586 (180-230)
MaxCool 2500L	1448-1724 (210-250)

NOTE: [1] *These pressures are for the refrigeration units only. The balance pressure may drop 5-20 psig (35-70 kPa) after installing the refrigerant line and cryosurface and opening the isolation valves.*

NOTE: [2] *Balance Pressure refers to the pressure of the unit when it is turned off and warmed up to room temperature. It is the balance of pressure on both sides, the suction side and the discharge side, of the compressor. When the compressor is running, the unit creates a pressure difference between the suction and discharge sides of the compressor.*

Refrigerants in the MaxCool Unit

This product does not contain R-22 or any CFC's or HCFC's and is in accordance with U.S. EPA law and EC2037/2000 and EC1005/2009.

All refrigerant used in Polycold's MaxCool Cryochiller products have significant GWP values. Users and service providers should ensure that refrigerant is not released to the environment at any time. The refrigerant should be reclaimed and either recycled or destroyed in accordance with international regulations and the current best industry practices.

Calculations of the GWP for the Polycold Cryochiller refrigerant blends, as shown in Figure 3-11, were calculated in accordance with the **European Union's EC Regulation No 842/2006** on Certain Fluorinated Greenhouse Gases.

Table 3-11: GWP Values for Polycold Cryochiller Refrigerants

Model	**Refrigerants used in the Blend** (see product I.D. Label for amounts)	**Total Refrigerant Weight - kg (lb)**	**Blend GWP**
MaxCool 4000H	R-245fa, R-125, R-23, R-14, Argon	8.5 (18.74)	5310
MaxCool 2500L	R-245fa, R-125, R-23, R-14, Argon	9.0 (19.9)	5200

4 Installation

WARNING

General Hazard

Failure to review the Safety section and follow the safety warnings can result in death or serious injury.

- Do not attempt to perform installation, operation, or maintenance procedures on the Polycold Cryochiller until you have read and understand the information in the Safety chapter.
- Read and understand each procedure before performing the procedure.

This chapter assumes that the user has completed the specification, design, and component selection process. Refer to the Introduction and Specification chapters for design and specification information.

When using this chapter. follow the recommendations below.

- Read and become familiar with the Safety chapter.
- Read the Specifications chapter and ensure the site and system components are suitable for the installation location.
- Read this chapter and be familiar with the steps required to install the unit.
- Be aware of all Safety issues associated with the materials and refrigerants contained in the Polycold Cryochiller.
- Read the section titled “Installation Considerations” and decide on how each of these issues will be handled.
- Confirm the availability of certified refrigeration specialists that may be required for some procedures.
- Arrange for a qualified electrician or electrical installer to perform electrical power installation.
- Follow the Installation Checklist to guide you through the installation.

Installation Checklist

Use the checklist in Table 4-1 when installing the Polycold Cryochiller. Perform the procedures in the order shown. Initial and date each procedure as you complete it.

NOTE: *Before installing the Polycold Cryochiller, check the specifications and site requirements in this manual.*

Table 4-1: Installation Checklist

	Name	Completion	Page
1.	Installation Overview		4-3
2.	Inspect and Unpack the Polycold Cryochiller	Balance Pressure:_____	4-4
3.	Move to Location		4-7
4.	Remove Compressor Hold-Down Nuts		4-9
5.	Connect Cooling Water		4-10
6.	Connect Electrical Power		4-13
7.	Install the Cryosurface		4-17
8.	Install the Refrigerant Lines		4-19
9.	Install the Condensate Drain Tube		4-26
10.	Check the Refrigerant Lines and Cryosurface for Leaks		4-27
11.	Evacuate the Refrigerant Lines and Cryosurface		4-32
12.	Connect the Refrigerant Line Thermocouples		4-36
13.	Preliminary Check of the Polycold Cryochiller		4-39
14.	Insulate Exposed Refrigerant Tubes and Couplings		4-41
15.	Startup and Test		4-46
16.	Evaluate the Polycold Cryochiller / Place Into Service		4-48
17.	Install Seismic Restraints (as required)		4-51

Installation Overview

Before starting installation, review the items in this section to confirm that the installation location meets the requirements of the Cryochiller and that the proper components have been selected and are available to perform the installation.

Component Description

Confirm that each of the main components of the Polycold Cryochiller are available for installation.

- Refrigeration Unit
- Refrigerant Line
- Cryosurface; one of two types:
  - Coil - for water vapor cryotrapping
  - Baffle - usually used to minimize oil back streaming
- Cryogenic feedthrough, which routes the refrigerant lines through the vacuum chamber wall

Installing a Refrigeration Unit to Meet ASHRAE Requirements

The following information helps to comply with ANSI / ASHRAE 15-1994 “Safety Code for Mechanical Refrigeration.”

- ANSI is for the American National Standards Institute.
- ASHRAE is for the American Society of Heating, Refrigeration, and Air Conditioning Engineers.

Normally, the manufacturer provides the type and amount of refrigerant used in the refrigeration unit. However, Polycold considers their mixtures of refrigerants to be proprietary. Therefore, the following information complies with the above standards.

- The amount of refrigerant mixture, the minimum room size, and the refrigerant safety group classification are included next to the refrigeration unit's nameplate.The nameplate is located on the frame under the lower left front panel or above the water connection panel, lower right front panel.
- Brooks determined the refrigerant safety group classification of the refrigerant mixture by evaluating the safety group classifications of the individual components. This evaluation used ANSI / ASHRAE-34 and EN 378.1 as a guide.
- The Polycold Cryochiller is a “direct (refrigeration) system”. It is only intended to be installed above ground in an industrial environment.
- To comply with the Safety Code for Mechanical Refrigeration, ANSI/ASHRAE-115-2007, the units should be located in a room no smaller than listed.
- If the minimum room size indicated on the nameplate is not obtainable, the refrigeration unit must be installed in a “refrigerating machinery room”. Consult local or national building codes for machinery room requirements.
- See section 9.7.8 of ANSI / ASHRAE 15- 1994 for location requirements.
- Only A1 refrigerants are used on MaxCool systems. According to ASHRAE 15 and EN 378, it is permissible for the pressure relief valves to vent into the equipment cabinet. This assumes the unit is installed above ground and in a room that meets the minimum room volume.

Table 4-2: Pressure Relief Venting Requirements

Refrigeration Unit	Recommended Discharge Capacity (lb-air / min) [1]	
	ANSI / ASHRAE 15	EN 378
MaxCool 4000H	2.58	1.58
MaxCool 2500L	2.37	1.47

[1]The discharge capacity recommended by Polycold is based on actual relief requirements from the refrigeration system as assessed by these standards. The pressure relief devices on the refrigeration unit are oversized. Discharge capacities based on the pressure relief devices are 23.9 pounds of air per minute.

Inspect and Unpack the Polycold Cryochiller

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	Standard tool kit and unpacking tools Overhead crane or forklift truck capable of lifting the Cryochiller

WARNING

General Hazards

The Polycold Cryochiller presents hazards that may cause death or personal injury.

- Review this manual before performing any procedure. This includes routine operation of the Polycold Cryochiller.
- Know the information in the Safety Chapter.
- Review the MSDSs that are associated with this tool.

WARNING

High Pressure Rupture

If a high pressure circuit is ruptured, such as a refrigerant circuit, equipment damage could occur. Cuts and eye injury from flying objects could result in death or serious injury.

- Inspect the refrigerant circuit and entire unit before performing any installation procedures.

WARNING

Heavy Object - Lift / Tip Over

Polycold Cryochiller refrigeration unit weighs a minimum of 533kg (1175 lb) and up to 544kg (1200 lb). Failure to properly lift or move this device may result in death or serious injury.

- Use proper lifting devices and techniques when moving the Polycold Cryochiller.

1. Carefully inspect all surfaces of the shipping containers for signs of damage or stress. Note that there may be more than one shipping container.

2. If the container has signs of damage:
   - Record the damage and notify the carrier immediately.
   - Assess the damage to the shipping container with the carrier.
   - Determine if the Polycold Cryochiller is damaged.
   - If the Polycold Cryochiller is damaged, STOP THIS PROCEDURE!
     Do NOT install a damaged unit.
     Notify Brooks Automation of the damage to the unit.
   - Arrange with the carrier and Brooks Automation to repair the damage or replace the unit.
     Refer to the Brooks Automation contact information in the Appendix of this manual.
   - If there is no damage, continue this procedure

3. Remove strapping and fasteners that hold the cardboard enclosure to the palette.

   Examine the contents for damage.

   Report any damage that is discovered.

4. Remove the lower braces from the palette that block the base frame of the Cryochiller.

5. Remove the front and rear bottom panels from the Cryochiller.

6. Locate and remove the bolts that hold the cryochiller to the palette.

7. Save the bolts, palette, shipping materials, and the shipping containers that are in re-usable condition to ship the Polycold Cryochiller to another location, as required.

8. If a spare parts kit was shipped with the unit, remove the front panel of the refrigeration unit to retrieve the spare parts kit and the manual. Verify that all of the parts were shipped with the unit.

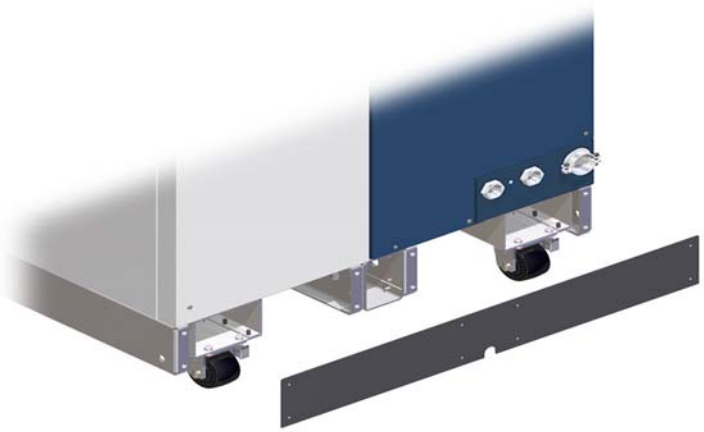


Figure 4-1: Bottom Panels

9. Record the balance pressure by performing the following steps:
    a. Locate the pressure gauge on the rear of the refrigeration unit. When the compressor is turned off and at room temperature, the pressure gauge reading is the balance pressure.
    b. Read the balance pressure on the pressure gauge. The pressure should be within the ranges shown on the Balance Pressure Table, Table 3-10 on page 3-11.
    c. Record the balance pressure in the space in Task 1 on Table 4-1 on page 4-2.
    d. If the equipment has recently been moved from an area where the temperature differs greatly from the installation area, allow the components 24 hours to stabilize to the new room temperature before reading the balance pressure and verifying correct charge pressure.
    e. If the pressure is not within the listed range, contact the nearest Brooks Automation Polycold Service Center.

NOTE: *If the system is exposed to extreme cold during shipping, the balance pressure is reduced due to the increased condensation of the refrigerant mixture. Refrigerant may take up to 48 hours at room temperature to achieve normal balance pressure and for the pressure gauge to display the proper reading.*

10. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Move to Location

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	Lift Device to lift, move, and place the unit -See Warning - Heavy Object below # 2 Phillips screwdriver (2) 9/16-inch wrenches

NOTE: *If the unit includes the Lifting Ring option, refer to* Appendix B: Lifting Rings (Optional) on page 12-3
If the unit includes casters, refer to 185304, Install Procedure, Caster Option.

WARNING

Heavy Object

The refrigeration unit weighs more than 522 kg (1150 lb). Failure to properly lift this device may result in death or serious injury.

- Use a fork lift or crane when lifting or moving the compressor unit.
- If using **lift ring option**, refer to Appendix B: Lifting Rings (Optional) on page 12-3

WARNING

High Pressure Rupture

If a high pressure circuit is ruptured, equipment damage could occur and cuts and eye injury from flying objects could cause death or serious injury.

- Wear gloves and goggles when working around the Polycold Cryochiller.

1. Check the location where the Cryochiller is to be placed.

   Refer to Figure 3-1 on page 3-2 and Figure 3-2 on page 3-3 for placement and spacing requirements.

2. Follow the placement recommendations below.
   - Place the unit in an area where routing and connecting the water and electrical power will not pose a personnel or equipment hazard.
   - Place the refrigeration unit as close as possible to where the cryosurface will be installed.
   - Orient the refrigeration unit for ease of maintenance and connection of facilities and refrigerant lines.
   - Place the refrigeration unit indoors and above ground.
   - Place the refrigeration unit in a well-ventilated area.
   - Place the refrigeration unit in an environment where the temperature is between 40° - 100° F (4° - 38° C).
   - Placement of the unit may be at any elevation relative to the cryosurface. The cryopumping system is not gravity-sensitive.

NOTICE

If using a fork lift or pallet jack, make sure the forks extend fully through the frame of the Polycold Cryochiller and completely support both sides of the frame.

Lifting the unit with a forklift or pallet jack without having the forks or jack fully extended through the Cryochiller frame will damage the frame and void the warranty.

3. Use a forklift or pallet jack or an appropriate lift device to lift the refrigeration unit.

   When using a forklift or pallet jack, remove both the front and back bottom panels to access the slots for the forks. See Figure 4-2.

   Place the forks of the forklift or pallet jack fully through the frame of the Cryochiller so that they extend out the back side of the unit and are in position to lift the Cryochiller by both sides.

   Carefully lift the unit and confirm that it is being lifted by both sides.

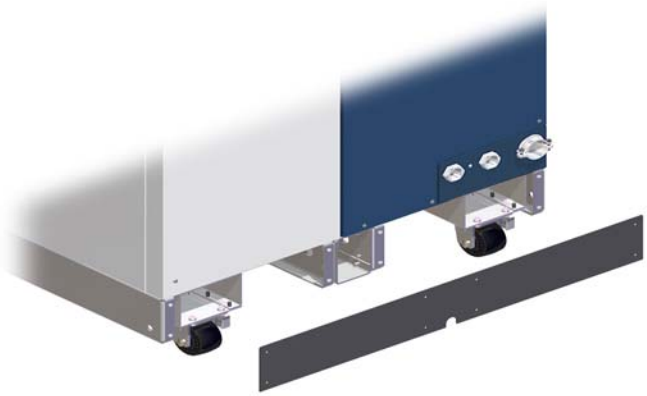


Figure 4-2: Bottom Panels for Fork Lift Access

4. Keep the Cryochiller vertical while it is being moved.

5. Place the refrigeration unit at the desired location.

6. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next checklist task.

Remove the Compressor Hold-Down Nuts

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	# 2 Phillips screwdriver (2) 9/16-inch wrenches

1. Use a Phillips-head screwdriver to remove the (4) screws that attach the front lower panel on the system and remove the panel.

2. Use a Phillips head screw driver to remove the (5) screws that attach the rear lower panel on the system and remove the panels.
   See Figure 4-4.

3. If an optional spare parts kit was ordered, it will be behind the lower front panel of the unit.

   Remove the spare parts kit and verify that all of the parts were shipped with the unit.

4. Locate the compressor in the bottom of the refrigeration unit. See Figure 4-3 and Figure 4-5.

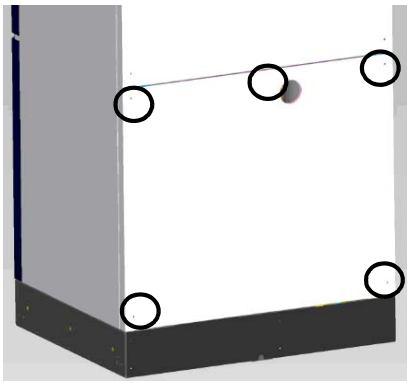


Figure 4-4: Rear Lower Panel Access Screws

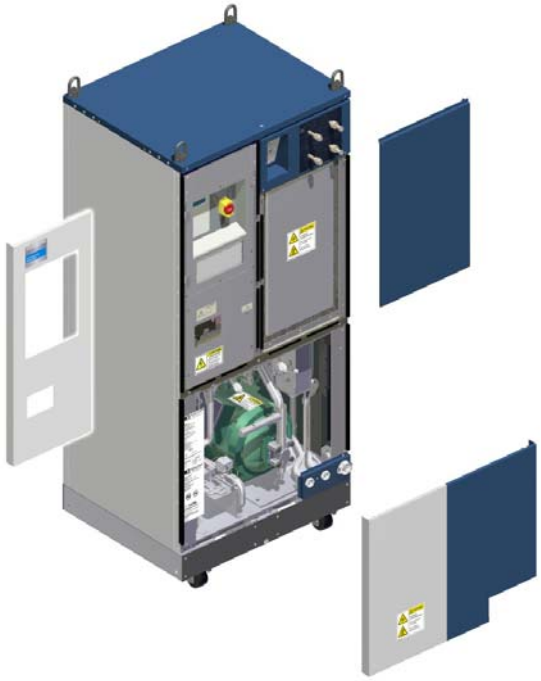


Figure 4-3: Polycold Cryochiller with panels removed showing compressor location

5. Locate the four hold-down nut locations on the compressor. See Figure 4-5.

6. Use two 9/16-inch wrenches to remove the two hold down nuts on each corner of the compressor.
   - Place one wrench on the lower nut and the other wrench on the upper nut.
   - Hold the lower nut and loosen and remove the upper nut from the bolt.
   - Loosen and remove the lower nut.

7. Repeat the procedure to remove the remaining three sets of hold-down nuts.

8. Save the hold-down nuts for future use when moving or shipping the refrigeration unit.
   Recommended: Place nuts on cable tie and secure to compressor.

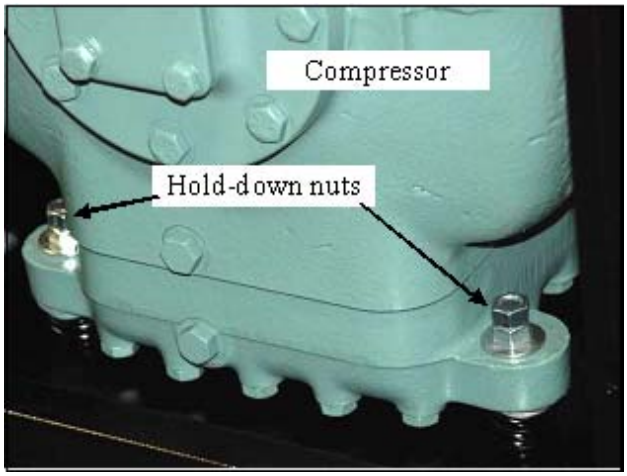


Figure 4-5: Hold-down Nuts
(2 of 4 shown)

9. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Connect the Cooling Water

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	Pipe wrenches
Materials	Fabricated water lines from 3/4-inch (20 mm) standard pipe or equivalent with compatible fittings. 3/4-inch female NPT fittings. Thread sealant such as Teflon tape

NOTICE

Water should be filtered for contaminants and copper reducing microbes.

Brooks recommends filtration to 100 microns and microbiological controls be put in place in order to supply clean and safe cooling water to your Polycold product.

Failure to provide water of proper specification may void the system warranty.

NOTICE

If the system is turned on before cooling water has been connected, damage to the equipment can result.

Verify that cooling water has been connected before turning on power to the unit.

1. Ensure that the water supply for the Polycold Cryochiller refrigeration unit meets the specifications in Cooling Water on page 3-6

   Optional:
   Install pressure gauges on the water lines at the refrigeration unit in order to measure the pressure drop within the refrigeration unit. This will help you adjust the water flow for optimum operation of the Polycold Cryochiller. It will also aid you in troubleshooting if there are water cooling problems. See Figure 4-6

   It is also recommended to install two parallel input water lines including valves, water filters, and flow meters. This allows switching water lines and avoiding equipment shutdown during scheduled maintenance. See Figure 4-6

NOTICE

If using rotameter-type flow meters, their inherent restriction may reduce the actual flow rate delivered to the refrigeration unit.

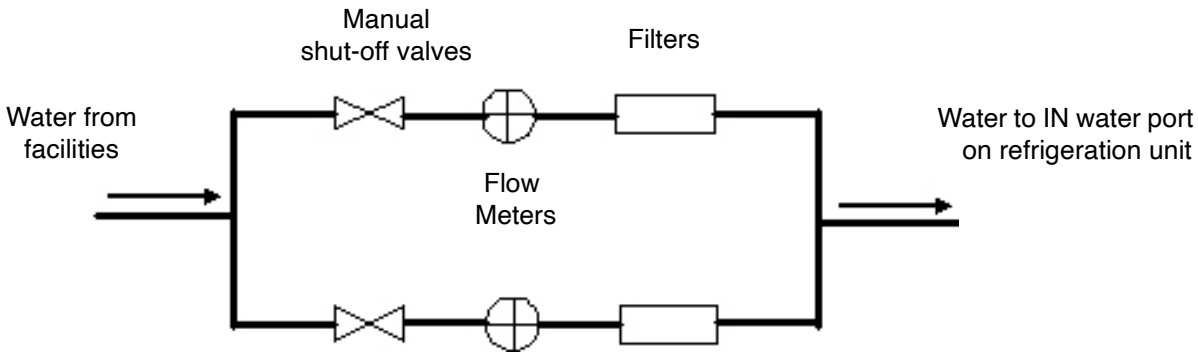


Figure 4-6: Redundant Water Circuits in Supply Line, Optional

2. Route the supply and drain water lines to the In and Out water fittings on the lower right side of the Polycold Cryochiller.

   IN water port is on the **right**.

   OUT water port is on the **left**

   See Figure 4-7.

3. Apply two wraps of water-grade Teflon tape or apply water sealant paste to the threads of all of the male fittings that connect to the In and Out water ports on the refrigeration unit.

4. Connect the supply water line to the IN water port on the right side.

   Connect the drain water line to the OUT water port on the left side.

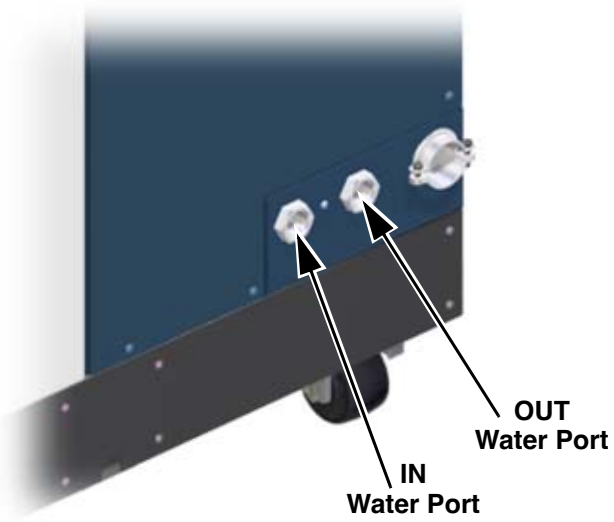


Figure 4-7: Location of Water Ports

5. Tighten each water line finger tight until the water line gasket contacts the fitting and then tighten 2 to 3 additional full turns. The number of turns required to tighten the fittings is affected by the thickness of the tape or sealant that has been applied to the threads.

6. Turn the supply and return water lines on. Check for leaks. If water leakage is found, tighten the leaking fitting an additional 1/4 turn. If water continues to leak at the connection, turn off the supply and return water lines, disconnect the fittings and check for the cause of the leak.

7. When the water connections are installed, test, and do not leak, go to the Installation Checklist Table 4-1 on page 4-2. Initial and date this task. Go to the next task on the checklist.

Connect Electrical Power

Electrical power connections must be performed by a qualified electrician or electrical installer and must meet local electrical codes.

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	Torque Wrench for 3.9 to 4.5 N-m (35 to 40 lb-in) range ... or equivalent for electrical terminal connections
Materials	4-Conductor power cable that meets local electrical code for the voltage and amperage of the unit See Table 3-5 on page 3-5. Connector for power cord to facilities power connection Cable Strain Relief or Conduit Connector for 49.2mm (1.94 inch) power access hole 1/4 inch ring lugs

WARNING

Hazardous Voltage

Contact with energized equipment may cause electric shock and result in death or serious injury.

- Only a qualified electrician or electrical installer is allowed to install the power to the Polycold Cryochiller.

1. The location of power input to the Polycold Cryochiller is on the lower right corner of the front of the unit. There is a 49.2mm (1.94 inch) clearance hole in the outer skin and a 42.1mm (1.656 inch) mounting hole on the frame for mounting an appropriate sized strain relief or conduit connector.

   Strain Relief Example: “OZ-Gedney KC-125T Flexible Conduit Connector”

2. Route the 4 conductor cable or individual wires through the connection, up the right front leg, above the cable tray that is attached to the bottom of the shelf that separates the compressor area from the valve area, and then up to the circuit breaker area.

3. Confirm that the protective grommet or strain relief is in place in the opening below CB1.

4. When using larger cables, the (3) screws that hold the front edge of the upper cable track may be removed and the track lowered to provide greater access. When completed, replace the (3) screws.

5. If the input power cable is too large to route through the cable tracks or existing cable is too short, use Terminal Block Accessory and Wiring Kt, p/n 181500.

   If using 4-conductor cable that is too stiff to bend in the cable tracks, remove the outer jacket from the cable after it passes through the strain relief. Optionally, use Terminal Block Accessory and Wiring Kt, p/n 181500.

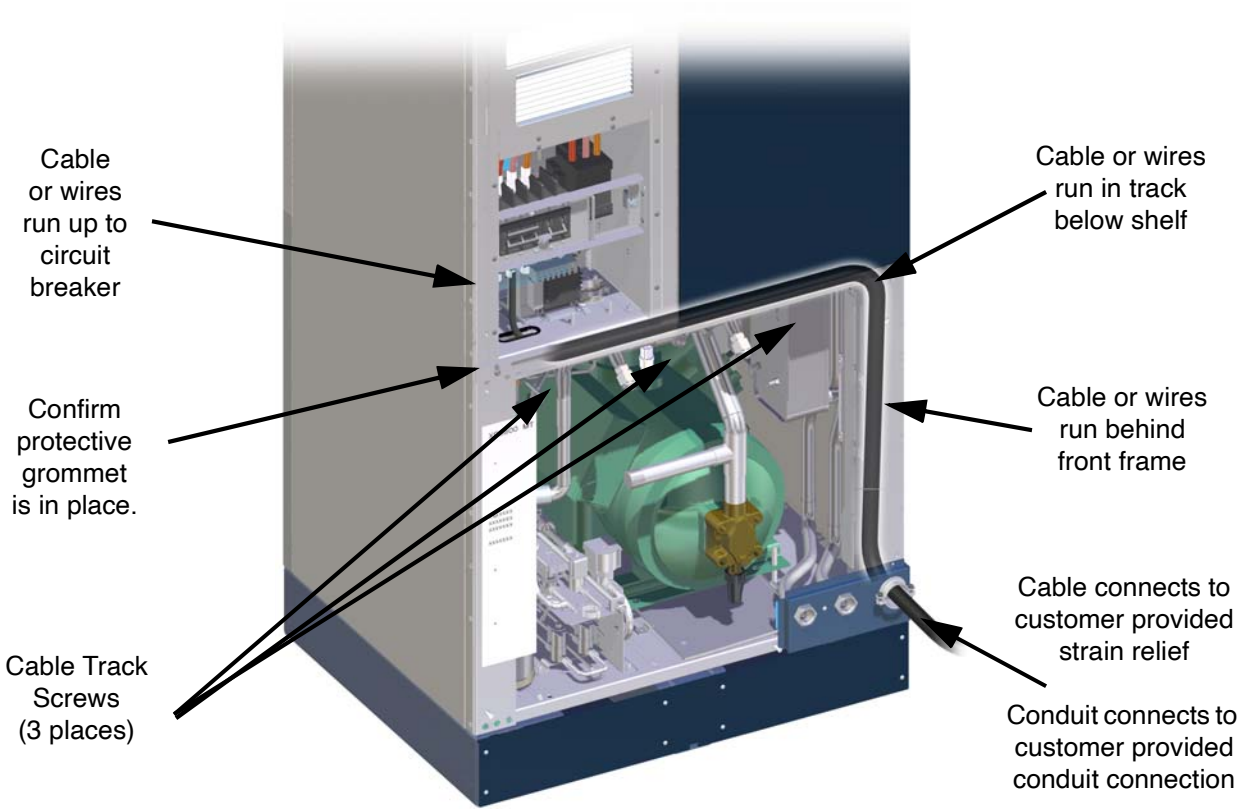


Figure 4-8: Power Cable Routing

6. Attach 1/4 inch ring lugs to each conductor on the input power cable.

7. Remove the finger guard from CB1 and CB2 as required.

8. Connect the three phase lines of the input power cable to the lower terminals / input side of CB1 using the provided screws and washers (optional) in the stack sequence shown in Figure 4-10.

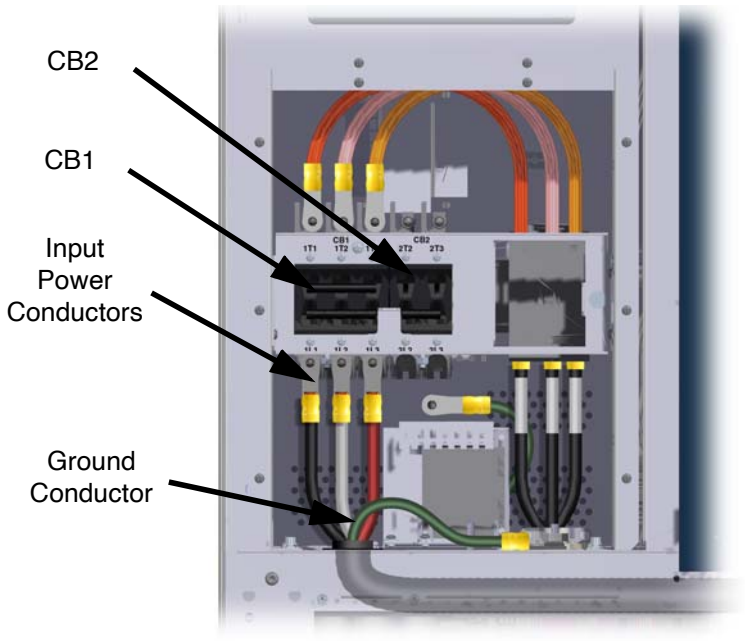


Figure 4-9: Input Power Connections to CB1

9. Tighten each 1/4-20 (M6) terminal screw to 3.9 to 4.5 N-m (35 to 40 lb-in).

10. Connect the ground line of the power cable to the **ground stud** using the hardware provided in the fastener sequence. Follow the stack sequence below and shown in Figure 4-11.
    - External star washer
    - Terminal lug
    - Flat washer - (optional)
    - Lock washer - (optional)
    - 1/4-20 (M6) Nut

11. Tighten the 1/4-20 (M6) ground nut to 4.5 to 5.1 N-m (40 to 45 lb-in).

12. After the power cable is fully connected, secure the power cable to the track using cable ties. Holes are provided in the cable track for inserting the cable ties.

13. If the Polycold Cryochiller is operating at maximum load and the power rating is lower than 93% of the power setting selected for the transformer tap setting, then it is recommended that the input power to CB2 be wired in accordance to the “Excepted Wiring Method” as found in Appendix C: CB2 Excepted Wiring on page 12-5 or contact Brooks as required.

14. Check the input voltage and compare to the voltage specified on the system label. Adjust the tap settings, if required, to accommodate the actual input voltage. See Input Power Transformers on page 4-16.

Figure 4-10: Terminal Washer Stack Sequence

Figure 4-11: Ground Washer Stack Sequence

Input Power Transformers

The Polycold Cryochiller has one of three different transformers installed based on the input power requested when the unit was ordered. The system is set to a specific input voltage at the factory by transformer tap settings. These tap settings must be adjusted in the field as required to accommodate the actual voltage at the installation site.

- Available tap settings are: 200V, 230V, 380V, 400V, 430V 460V and 480V.
- All transformers use the same numbering scheme for tap settings but the taps may be in different physical locations on the transformer depending on the transformer that is used.

Change Transformer Tap Settings

1. Check the input voltage.

2. Check the transformer tap settings. Refer to the tap setting sticker on the transformer or Figure 4-12.

3. Rewire the transformer tap settings as required. Refer to Table 3-4 on page 3-4 for tap settings for your compressor and voltage.
   - Remove the protective cover
   - Change the input wiring and jumper settings as required
   - Replace the protective cover

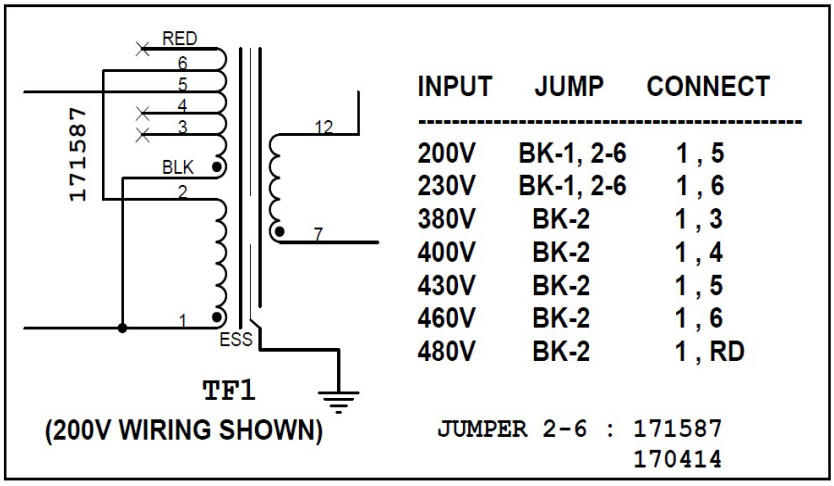


Figure 4-12: Tap Settings for 230 and 480 Volt Transformers

4. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to next task on the checklist.

Install the Cryosurface

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	2.5 inch Spanner wrench, p/n 810030-07, for the nut on feedthrough connection
Materials	High-vacuum grease - must have an appropriate low vapor pressure (for optional use on the feed-through's) O-ring, as required

This section describes how to install the cryocoil or cryobaffle, and refrigerant lines. If these items are not already selected, then follow the recommendations below.

- Refer to System Summary on page 1-3 and Cryocoils and Refrigerant Lines on page 3-10 for cryosurface information.
- Refer to Appendix F: Feedthroughs on page 12-10 for feedthrough selection information.
- Contact Brooks Automation Polycold Systems for more information.

NOTE: *This task assumes that both a cryosurface and a standard 50mm (2-inch) feed-through from Brooks Automation Polycold Systems are being installed.*
If a cryobaffle or cryocoil and feed-through has been custom-fabricated by a source other than Brooks Polycold, verify that the part meets the specifications in the section Specifications and Site Requirements, Cryocoils and Refrigerant Lines on page 3-10*.*

The feed-through on the Brooks Polycold Systems Cryocoil is designed to be installed from the inside of a vacuum chamber. This allows removal of the cryosurface when cleaning or servicing the vacuum chamber.

CAUTION

High Working Pressure

The refrigeration unit's working pressure may exceed the cryosurface's working pressure which may damage the vacuum system components and may result in equipment damage and personal injury.

- Do not use reservoir type cryosurfaces.
- Do not connect the refrigeration unit to a cryosurface without first verifying that the cryosurface meets specifications.

Install the Feed-Through and Cryocoil

1. Inspect the feed-through port thickness, hole diameter, and sealing surface. Ensure that the feed-through port is compatible with the feed-through.

2. Clean the inner and outer surfaces of the feed-through port on the vacuum chamber wall where the cryosurface feed-through is to be installed.

3. Inspect and clean the O-ring groove and O-ring in the inner flange of the feed-through.

4. Insert the O-ring into the groove in the inner flange.

5. From the inside of the vacuum chamber, insert the feed-through into the feed-through port.

6. Tighten the feed-through nut finger-tight and position the cryosurface. If the cryosurface has fasteners, secure them at this time. See Figure 4-13.

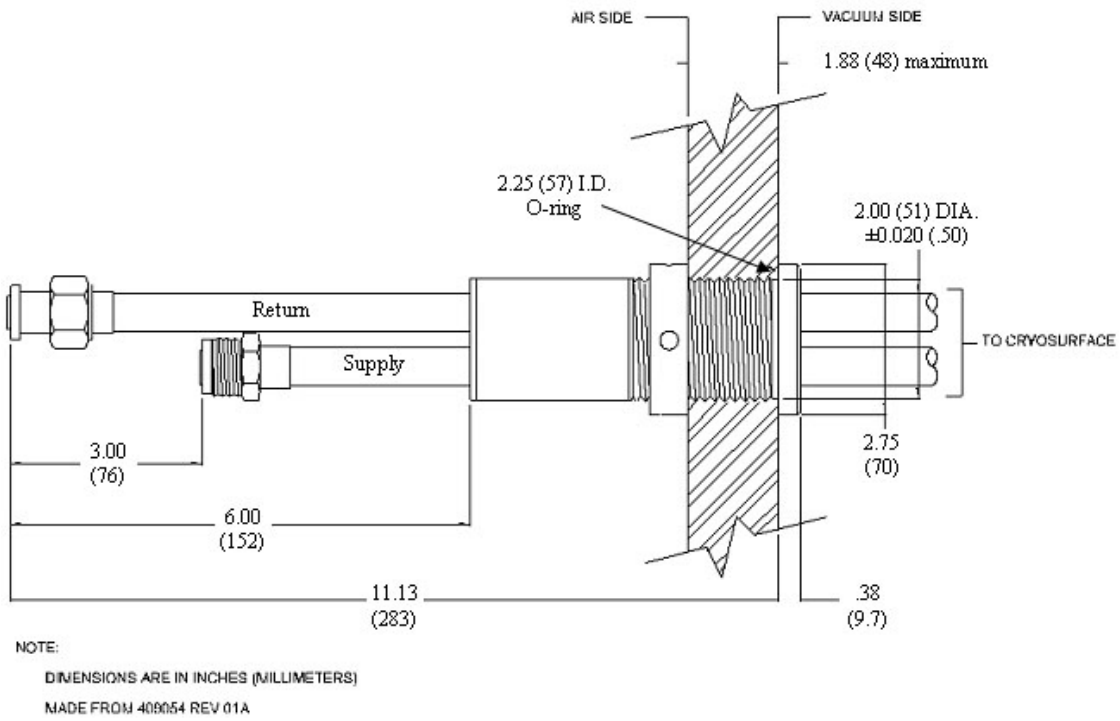


Figure 4-13: Typical Feedthrough

7. Verify that no moving parts will hit the cryosurface. Make sure the cryosurface does not touch the vacuum chamber wall or anything in the vacuum chamber. The cryosurface must be at least 16mm (5/8-inch) from the vacuum chamber wall to prevent ice bridging. Greater distances are better.

8. Hold the feed-through in place and tighten the nut with the spanner wrench included with the cryosurface assembly. Make certain the nut is tight. If the nut is loose, the O-ring will tend to lift from the vacuum chamber wall when under vacuum.

9. Install a heat radiation shield if the cryocoil is in direct view of a source of heat greater than 50°C. Position the shield between the cryocoil and the heat source. The shield should be as close as possible to the heat source and as far away as possible from the cryocoil. The cryocoil traps molecules best when it has maximum view of the vacuum chamber.

10. Check the vacuum chamber for leaks. If any leaks are found, correct them before proceeding.

11. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Install a Cryobaffle

1. If you are installing a Polycold “CB” type cryobaffle, carefully center it between the flange bolt holes to assure a good O-ring seal.

2. Verify that no moving parts will hit the cryosurface.

3. Make sure the cryosurface does not touch the vacuum chamber wall or anything else in the vacuum chamber. The cryosurface should be at least 16mm (5/8-inch) away from the vacuum chamber wall to prevent ice bridging. Note that greater distances are better.

4. Install a heat radiation shield if the cryobaffle is in direct view of a source of heat greater than 50°C. Position the shield between the cryobaffle and the heat source. The shield should be as close as possible to the heat source and as far away as possible from the cryobaffle. The cryobaffle traps molecules best when it has maximum view of the vacuum chamber.

5. Check the vacuum chamber for leaks. If any leaks are found, correct them before proceeding.

6. Go to Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Install the Refrigerant Lines

NOTICE

This procedure assumes that refrigerant lines from Brooks Automation, Inc. Polycold Systems are being installed.

- If installing a refrigerant lines not made by Polycold Systems, verify that the refrigerant lines meet the required specifications.
- Contact Brooks Polycold for assistance.

NOTICE

Dual-Circuit System

This section assumes both refrigerant circuits are connected at the same time.

It is possible to connect only one refrigerant circuit of a dual circuit system.

- When connecting the second refrigerant circuit, the refrigerant mixture must be fully drawn back into the unit.
- Contact Brooks Automation Customer Support for more information.

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	Torque wrench (optional)
For Parker UltraSeal Style Couplings (Standard)	Silver-plated stainless steel O-rings 1 inch open end wrench 15/16 inch open end wrench
For Cajon VCR Style Couplings (Optional)	Silver-plated stainless steel gaskets or unplated nickel gaskets 1-3/16 inch open end wrench 1-1/16 inch open end wrench

Guidelines for Refrigerant Lines

- Improper connection of the couplings is a common source of leaks. Internal leaks can damage the equipment.
- Use a new O-ring or gasket each time the coupling is assembled.
- Do not use grease when assembling the couplings. Grease can contaminate the cryopump and can mask a leak during the leak-checking procedures. Additionally, the coupling will leak when the grease gets brittle at cryogenic temperatures.
- Do not scratch or dent the sealing surfaces of the couplings.
- Always use the O-ring removal tool to remove an O-ring from the Parker UltraSeal compatible couplings. See Appendix G: Zero Line Loss Procedure on page 12-13.

NOTICE

Use of unauthorized or non-standard couplings voids your warranty.

Improper use of, incorrect installation of, over-tightening of, or use of damaged O-rings in couplings will void your warranty.

NOTICE

O-ring removal tool requires lubrication.

Always clean couplings after using the lubricated tool.

NOTICE

Refrigerant lines should only be bent once.

Re-bending a refrigerant line can cause “work hardening” and fractures and refrigerant line failure.

Route and Install the Refrigerant LIne

1. Use the following considerations to plan the route of the refrigerant line between the cryosurface and the top of the refrigeration unit:
   - The refrigerant line should not be a hindrance or hazard to the movement of personnel.
   - The refrigerant line should not hinder access to or maintenance of any equipment.
   - Provide at least 32mm (1-1/4 inches) wall thickness of insulation around the feed and return lines. If the insulation and system are not completely sealed and airtight, water vapor from the air will accumulate on some of the surfaces and create ice on the refrigerant lines.
   - Support the line at mid-length and at three-foot intervals.
     Ensure that the line supports do not crush the insulation covering the lines.
     Use supports that are at least 100mm (4 inches) wide.
   - Do not use supports that make direct contact with the exposed tubes or couplings.
   - Do not allow the lines to be vibrated by the application.
   - **Important**.
     The feed lines are made of soft refrigeration copper and have a minimum bend radius of 300mm (12 inches).

     Feed lines are only suitable to be bent once to fit the planned layout.
   - Bend the refrigerant line so that the couplings are even at the point of connection to the refrigeration unit.

     The feed and return lines should have the same bend radius.

     The brand or type of tape, hangers, clamps, or cradles depends on what is available and acceptable at the installation site.

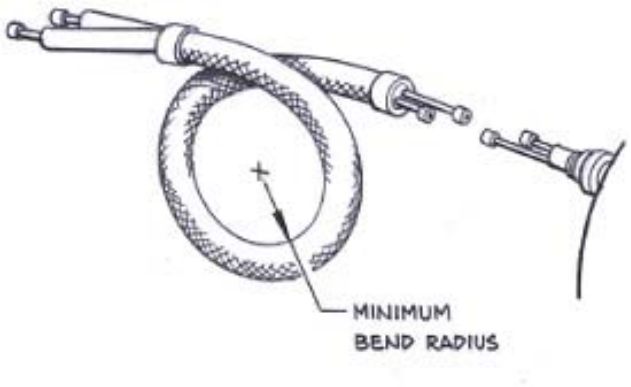


Figure 4-14: Minimum Refrigerant Line Bend Radius

Brooks Automation. Inc. Polycold Systems recommends using a continuous line length from the refrigerant unit to cryocoil feed-through. Polycold does not recommend or warranty the use of intermediate fittings.

If your line design has an intermediate set of fittings between the unit and chamber

feed-through, Polycold recommends eliminating these fittings and brazing the tubes together. If brazing the lines cannot be done, use only approved fittings and support the tubing within 300mm (12 inches) of each side of the intermediate fitting.

2. Inspect the sealing surfaces of the couplings for the following:
   - Dirt and foreign material
   - Scratches
   - Dents

3. Clean the sealing surfaces of the couplings.

   If the sealing surfaces are scratched or dented, contact the Brooks Automation Polycold Service Department.

NOTE: *Parker UltraSeal compatible couplings are standard on all Polycold Cryochillers.*

4. Connect the refrigerant line to the cryosurface first, if possible.

   Finger-tighten the refrigerant line couplings to the feed-through couplings.

5. Remove the upper-right front panel of the refrigeration unit.

6. Locate the isolation valve box which is the box just below the refrigerant line couplings.

7. Remove the upper right panel on the front of the Polycold Cryochiller to expose the valve box.

8. Locate the hand valves in the isolation valve box.

   Hand valves are the manually operated valve and have red handles.

   A unit may have up to 4 hand valves, depending on the configuration.

   See Figure 4-15 for valve locations.

9. Close each of the hand valves by turing them clockwise until they are firmly closed.

NOTE: *The isolation valves are used to hold the refrigerant mixture in the refrigeration unit during shipping or whenever the cryosurface or refrigerant line is dis-*

Figure 4-15: Cold Valve Box Showing Hand Valves with Red Handles

connected. These valves cannot be operated when they are at cryogenic temperatures.

10. Locate the refrigerant feed and return fittings on the upper right corner of the front of the refrigeration unit.

    Remove the brass blank-off fittings from the feed and return lines using the following procedure. See Figure 4-16.

    a. Use one wrench to hold the fitting on the refrigerant line steady.

    b. Use a second wrench to carefully loosen the blank-off fitting from the refrigerant line.

    c. **Slowly** remove the blank-off fittings from the feed and return couplings while listening for refrigerant leakage.

        – A brief hiss of refrigerant gas leakage is OK.

        – Continuous escape of refrigerant is NOT OK. Quickly reinstall the blank-off fittings and make certain the isolation valves are closed.

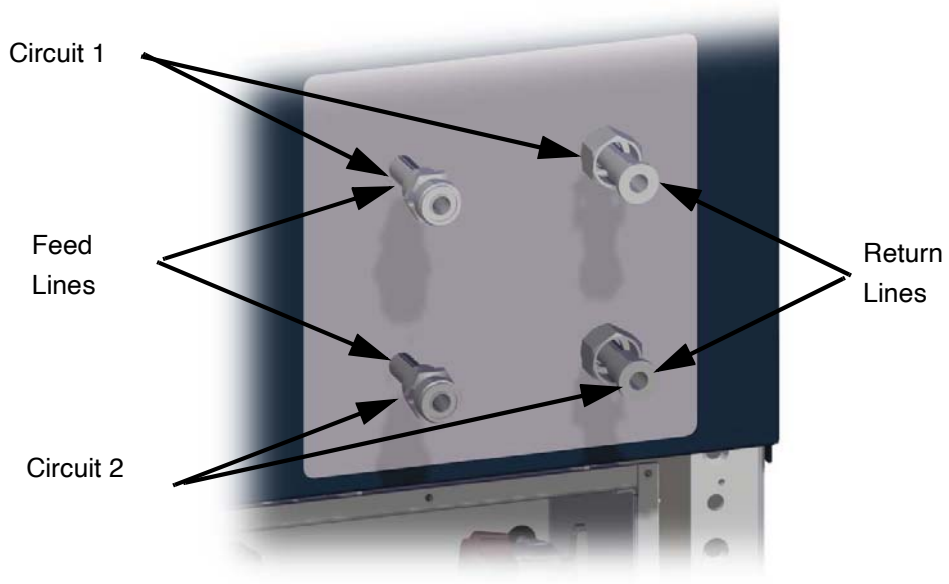


Figure 4-16: Polycold Cryochiller Refrigerant Lines with Standard Ultra Fittings

11. Save the blank-off fittings and store them with the unit for reinstallation if the refrigerant lines are disconnected.

12. Bend the refrigerant line so that the couplings are even when they get to the mating couplings on the refrigeration unit. Commonly, the feed and return lines should have the same bend radius.

13. Loosely fasten all couplings on the refrigerant line.

14. Check the line for stress or misalignment between couplings.

    Resolve line stress or misalignment before going to the next step.

15. Go to the installation procedures for either the Parker UltaSeal or Cajon VCR couplings.

Figure 4-17: Blank off Fittings

Install Parker UltraSeal Compatible Couplings (Standard Fitting)

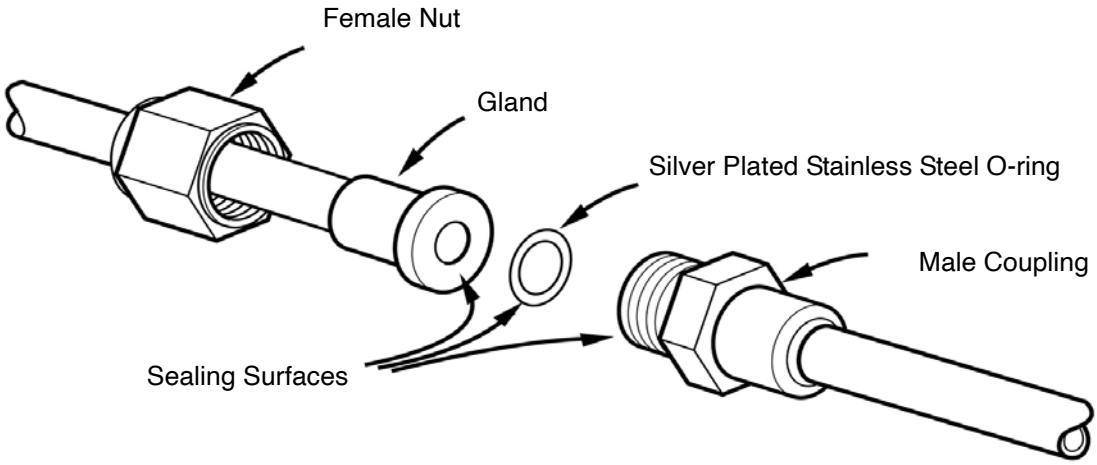


Figure 4-18: Parker Ultra Seal compatible Coupling (standard coupling)

1. Insert a new O-ring into the male coupling's groove

2. Place the gland against the O-ring and male coupling. Make certain the O-ring does not drop out of the groove

3. Slide the nut forward and finger-tighten the coupling.

4. Use two wrenches to tighten the coupling. Keep the male coupling stationary with the 15/16-inch wrench and tighten the nut with the 1-inch wrench. Each wrench must have a length of at least 12 inches (300 mm).

5. Tighten the nut no less than ¼ turn until resistance increases sharply and no further tightening occurs. The metal o-ring will be crushed into the o-ring groove. Tighten each coupling to 54-80 Nm (40-60 pound-foot).

NOTE: *The Parker fittings are coupled and sealed based on mechanical displacement of the threaded parts, which results in compression at the sealing surface. Torque values are provided for customers requiring a measurable value.*

6. Go to the Installation Checklist Table 4-1 on page 4-2. Initial and date this task. Go to the next task on the checklist.

Install Cajon VCR Couplings (Optional Fitting)

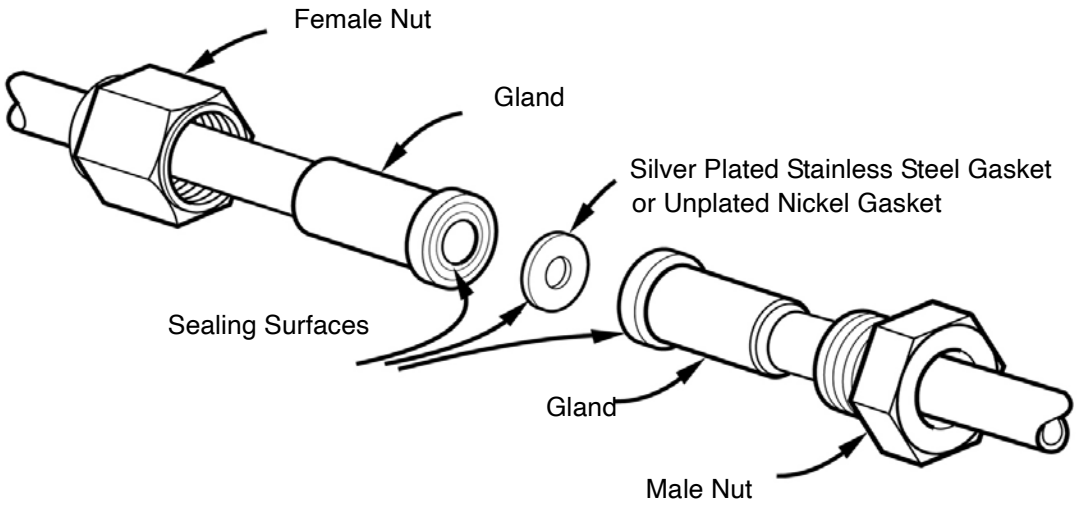


Figure 4-19: Cajon VCR Coupling (optional fitting)

1. Place a new gasket into the female nut.

2. Assemble the components and finger-tighten the coupling.

3. Use both wrenches to tighten each coupling no less than ¼ turn until resistance increases sharply and no further tightening occurs, approximately 54-80 Nm (40-60 pound-foot).

NOTE: *The Cajon fittings are coupled and sealed based on mechanical displacement of the threaded parts, which results in compression at the sealing surface. Torque values are provided for customers requiring a measurable value.*

4. Go to Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Route Condensate Drain Tube

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	Standard hand tools
Material	5/16 inch ID tubing Length is dependent on facility drain location Condensate Pump Kit (optional)

1. Locate the condensate drain tube. It is visible from the base of the unit and is visible when the front skirt and rear skirt are removed. See Figure 4-20.

2. Determine if the drain tube should be routed to the front or to the rear of the unit.

3. Be careful to not damage the fitting on the bottom of the drain pan while moving the hose to position.

   Support the drain pan fitting while carefully moving the drain hose to the desired side of the unit.

4. When the drain hose is in its final position, check the hose for kinks and adjust as required.

5. Route the tubing to a facility waste water drain or to the input line of a condensate pump.

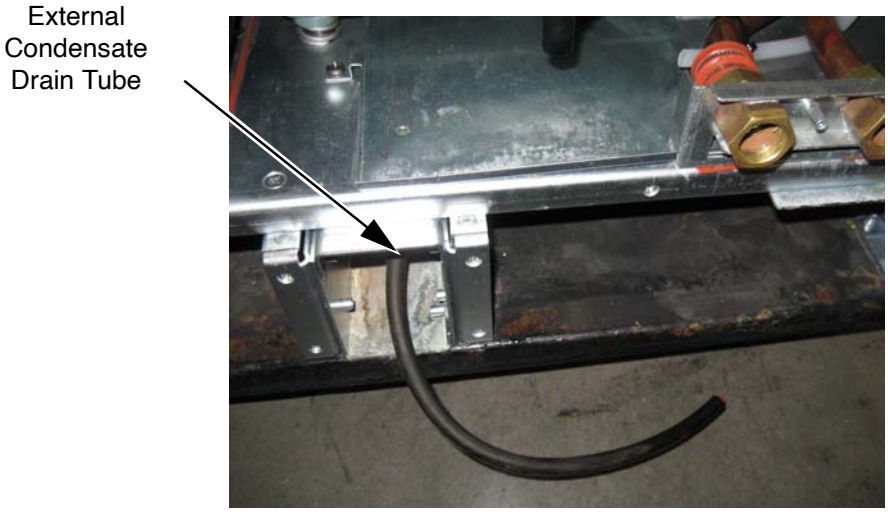


Figure 4-20: Condensate Drain Tube

6. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Check the Refrigerant Line and Cryosurface for Leaks

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tool or material	Cylinder of refrigerant gas R-134a Cylinder of dry nitrogen gas (very low dew point of -80 C) with a regulator Service manifold gauge set with three hoses (manifold) Electronic halogen leak detector with a leak sensitivity of at least 0.40 ounces (11 g) per year Leak detector soap Inspection mirror 1/4 inch ratchet valve wrench 7/16 inch open-end wrench 9/16 inch open-end wrench 5/8 inch open-end wrench 15/16 inch open-end wrench 1 inch deep socket or open end or crow foot wrench 1 1/16 inch deep socket or open end wrench 1 5/16 inch deep socket or open end wrench Adjustable wrenches as required
Reference Documents	Service Procedure, Zero Line Loss, p/n 185307 Service Procedure, Evacuation-Recovery, p/n 185308 Service Procedure, Brazing Specifications, p/n 185305

WARNING

Chemical Hazard

Failure to have a qualified refrigeration technician do all refrigeration work could result in system damage or personal injury.

- Contact a qualified refrigeration technician to perform all refrigerant work.

About Leak Check

The leak gas used must be dry with a dew point of -80 C or less.

Helium leak checking the refrigerant line and cryosurface is an acceptable alternative to the procedure specified below if helium leak check equipment and trained helium leak check operators are available.

If helium is used as a leak check medium, only use helium while the compressor is off and ensure that the pressure in the line and cryosurface during this test does not exceed the lowest refrigerant pres-

sure. This is important to assure that helium does not migrate into and contaminate the refrigerant system. When the system is off, the lowest pressure is the balance pressure.

During evacuation of the line and coil, after the leak check, it is recommended to purge the line with dry nitrogen or dry argon that has a dew point of -80 C or less since it can be difficult to pump out pure helium.

Be aware of false positives created by the armaflex insulation around the line set. The factory installed tube insulation and flat insulation can produce false positives with some leak check sensors.

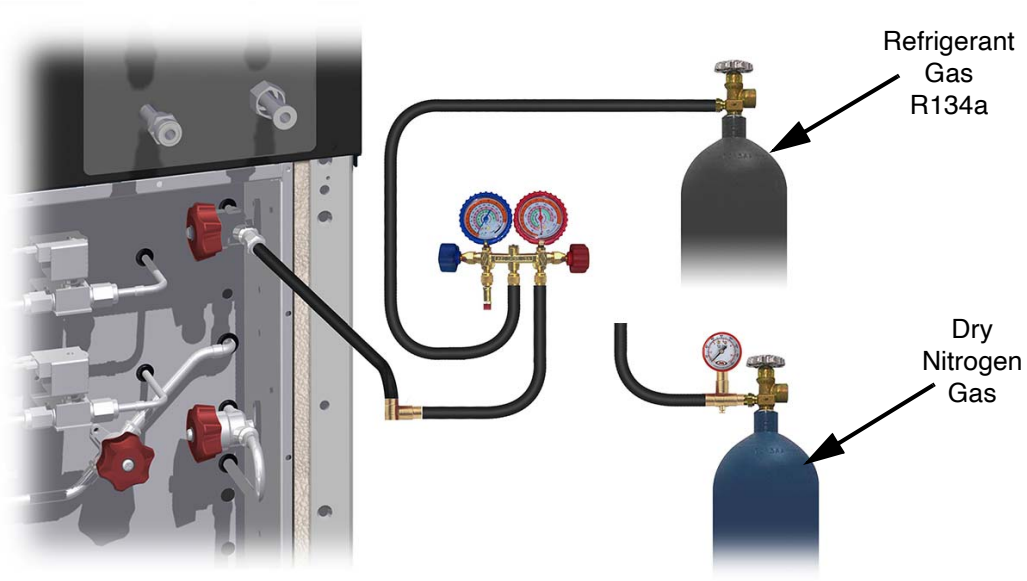


Figure 4-21: Leak Check - Add “Trace” Refrigerant

Leak Check Procedure

Refer to Figure 4-21 and Figure 4-22 for the following steps.

1. Make certain the valves on the manifold are closed.
2. Connect the manifold's suction (low pressure) hose to the evacuation valve inside the valve box. See Figure 4-21.
3. Open the evacuation valve.
4. Connect the refrigerant cylinder to the center port of the manifold.
5. Open the suction valve on the manifold and pressurize the refrigerant line and cryosurface to 70-140 kPa (10-20 psig). This adds refrigerant trace gas to the system.

6. When the refrigerant line is pressurized, close the suction valve and disconnect the refrigerant cylinder.

NOTICE

Improper pressurization can damage refrigerant lines or system components.

Do not pressurize the refrigerant line and cryosurface above 3100 kPa (450 psig) with the cryosurface attached to the system. The pressure relief valve may leak if it is activated.

7. Connect the nitrogen cylinder to the center port of the manifold. See Figure 4-21.

8. Open the suction valve and increase the pressure in the refrigerant line and cryosurface to 1030 kPa (150 psig).

9. Close the valve on the nitrogen cylinder.

Figure 4-22: Leak Check - Pressurize with Nitrogen

10. Use a halogen leak detector to check each connection in the refrigerant circuits. This includes the Parker UltraSeal compatible or Cajon VCR couplings, the Evacuation Valve, and all brazed joints.

    The couplings have two small access holes on each nut to help find leaks. Cover the lower access hole with a finger and put the sensor at the higher hole. See Figure 4-23.

NOTE: *If there is a large leak and the source cannot be pinpointed without activating the leak detector, open the manifold's suction valve until the pressure drops to about 345 kPa (50 psig). This should allow detection of the source of the leak.*

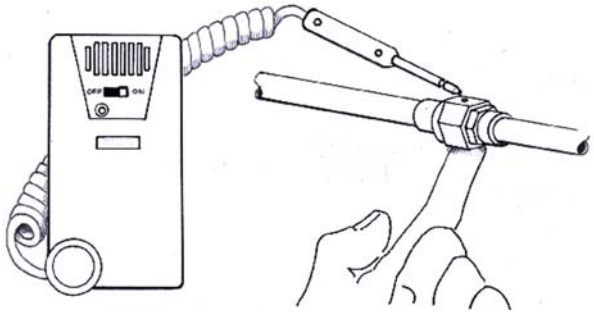


Figure 4-23: Leak-Checking Couplings

WARNING

Chemical Hazard

The blend of refrigerants used in the Polycold Cryochiller is non flammable and non toxic. However, as with any gas, asphyxiation could occur if concentrated refrigerant gas is inhaled.

- Service the Polycold Cryochiller in a well ventilated area.
- Never add refrigerant to a unit with a leak. Locate and repair any leaks prior to adding refrigerant or re-charging.

11. If the pressure in the manifold has decreased below 1030 kPa (150 psig), use leak detector soap and an inspection mirror to locate the source of the leak.

12. If a leak is found, correct the leak using one of the steps below and retest:
    - To correct a leak on a Parker UltraSeal compatible or Cajon VCR coupling, follow the steps in Correct a Leak in a Parker UltraSeal Compatible or Cajon VCR Coupling on page 4-31.
    - To correct a a leak on a brazed joint or a valve, contact Brooks Service for assistance.

13. If no leaks are found, verify the manifold pressure is still 1030kPa (150 psig).

14. If the pressure in the manifold stays at 1030 kPa (150 psig), follow these steps:
    a. Close the valves on the manifold.
    b. Disconnect the equipment from the manifold, but leave the manifold connected to the evacuation valve on the refrigeration unit.

15. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Correct a Leak in a Parker UltraSeal Compatible or Cajon VCR Coupling

1. Cover the lower access hole with a finger and apply leak detector soap to the higher access hole. Observe the higher access hole for at least 2 minutes.

   If a bubble forms, verify that the coupling is tightened to within specification.

2. Check for leak again.
   - If the leak is repaired, return to the previous procedure.
   - If the coupling still leaks, reassemble the coupling as follows:
     a. Open the discharge valve on the manifold to release the gas in the refrigerant line and cryosurface.
     b. Perform the Zero Line Loss Procedure and then disassemble the coupling. See Appendix G: Zero Line Loss Procedure on page 12-13.
     c. Check the coupling's sealing surfaces to make sure they are not scratched or damaged.
     d. Re-assemble the coupling using a new o-ring or gasket and following the instructions found at Install Parker UltraSeal Compatible Couplings (Standard Fitting) on page 4-24 or Install Cajon VCR Couplings (Optional Fitting) on page 4-25.
     e. Leak check the coupling again.
        - If the coupling still leaks, contact Brooks Automation Service.
        - If the leak is repaired, return to the previous procedure.

3. Return to the Check Refrigerant Lines procedure.

Evacuate the Refrigerant Line and Cryosurface

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	Vacuum pump with a 1/4-inch SAE male flare connection that is capable of pumping down to at least 0.05 torr (6.5 Pa) Thermistor or thermocouple type vacuum gauge (Granville-Phillips Convectron works well for this purpose) Service manifold gauge set with hoses (manifold) 1/4 inch ratchet valve wrench 7/16 inch open-end wrench 9/16 inch open-end wrench (important) 5/8 inch open-end wrench 15/16 inch open-end wrench Adjustable wrenches as required Coil Magnets (3) for single circuit, (6) for dual circuit
Materials	Cylinder of dry nitrogen gas with a regulator

WARNING

Chemical Hazard

Failure to have a qualified refrigeration technician do all refrigeration work could result in personal injury or system damage.

- Have a qualified refrigeration technician do all refrigerant work.

1. Connect the vacuum pump, vacuum gauge, and service manifold. See Figure 4-24.

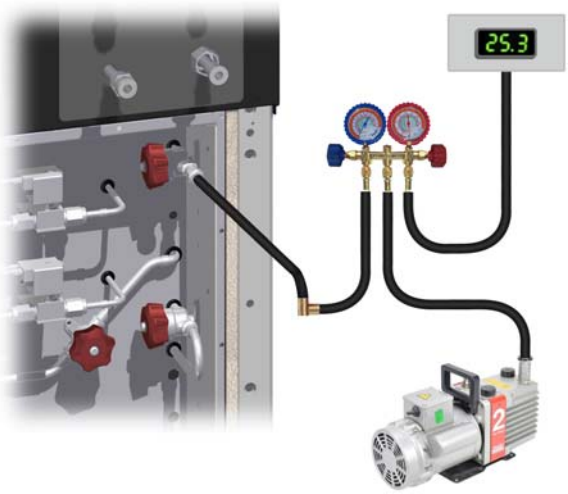


Figure 4-24: Cold Valve Box Setup to Evacuate Refrigerant Line and Cryosurface

2. Open both valves on the service manifold.

3. On the following valves, remove the solenoid coils and place coil magnets on the valve stems: See Figure 4-25, Figure 4-26, and Figure 4-27.
   - Single Circuit:
     VLV5 in the cold valve box
     VLV6 in the warm valve assembly.
   - Dual Circuit:
     VLV5, VLV11 in the cold valve box
     VLV6 and VLV12 in the warm valve assembly.

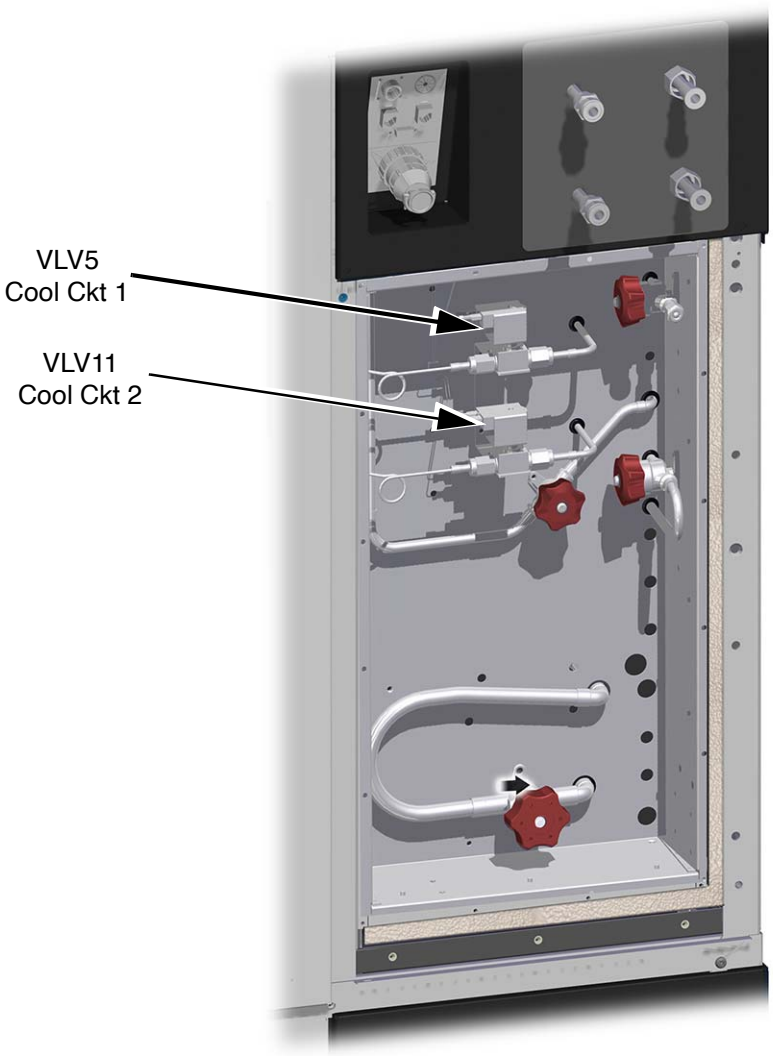


Figure 4-25: Cold Valve Box

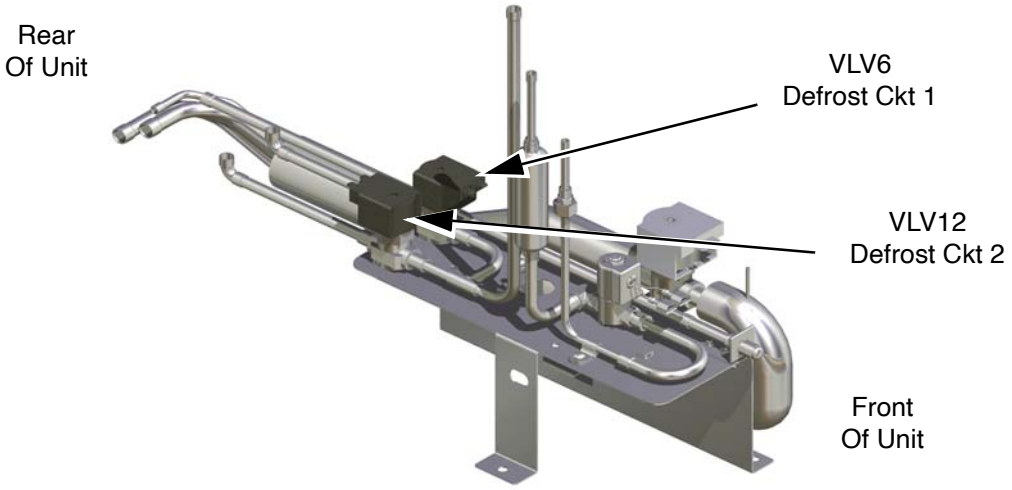


Figure 4-26: Warm Valve Assembly

Figure 4-27: Coil Magnet on Solenoid Valve

4. Turn on the vacuum pump and evacuate the refrigerant line and cryosurface to 13Pa (0.1 torr).

5. Allow the vacuum pump to continue pumping for at least 30 minutes.

NOTE: *The vacuum pump should evacuate the refrigerant line and cryosurface to 13Pa (0.1 torr) within 30 minutes.*
If not, there may be a leak which must be corrected.

6. Close the evacuation valve while the vacuum pump is still pumping.

   Turn off the vacuum pump.

   Carefully remove the hose from the evacuation valve.

   Recheck the tightness of the brass top nut on the evacuation valve to prevent leaking.

7. Reinstall the protective cap and flare nut with bonnet onto the output port of the evacuation valve. Torque to 13.6 to 20.3 Nm (10 - 15 lb-ft). See Figure 4-28.

8. Remove the magnets and reinstall the solenoid coils on the valves.

Figure 4-28: Install Cap and Flare Nut on Evacuation Valve

NOTICE

Improper tightening of the refrigerant lines or caps may cause damage or leaks.

Always use correct size wrench

Always use two wrenches when connecting to or installing the refrigerant lines or cap on the evacuation valve.

- Use one wrench to hold the valve nut.
- Use the other wrench to tighten the fitting or cap.

NOTICE

It is very important to re-install the protective cap and flare nut with bonnet onto the evacuation valve to prevent refrigerant leaks.

9. Go to the Installation Checklist Table 4-1 on page 4-2. Initial and date this task. Go to the next task.

Connect the Refrigerant Line Thermocouples (Type T)

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools and materials:	Torque wrench, 0.34Nm (3 lb-inch) range (optional) Phillips screwdriver Small straight blade screwdriver Wire stripper, a thermal wire stripper is preferred Small labels or tape

Each Polycold Cryochiller may have up to 20 type T thermocouples depending on configuration.

Table 4-3: Complete Thermocouple List for Unit with All Options

Thermo-couple	Customer-Installed	Description	Note
TC1		Compressor Discharge	
TC2		Refrigerant Liquid Line	
TC3		C1 Return	
TC4		Coldest Liquid	
TC5		C2 Return	Optional
TC6		Rapid Balance Pressure Check	
TC7	Yes	C1 Control (see note)	Optional
TC8	Yes	C2 Control (see note)	Optional
TC9	Yes	C1 Inlet	
TC10	Yes	C1 Outlet	
TC11	Yes	C2 Inlet	Optional
TC12	Yes	C2 Outlet	Optional
TC13		C1 Feed	
TC14		C2 Feed	Optional
TC 15		Not Used	
TC16		Buffer Line	
TC17	Yes	Custom 1 (customer use, no control functions)	Optional
TC18	Yes	Custom 2 (customer use, no control functions)	Optional
TC19	Yes	Custom 3 (customer use, no control functions)	Optional
TC20	Yes	Custom 4 (customer use, no control functions)	Optional

For all units:

- Several commands are available to get the individual thermocouple values by name.
- Each circuit has factory installed Thermocouples for the feed and return lines. Other Thermocouples may be added as desired by the user for monitoring their process. Each cold chuck should have a Thermocouple.
- Thermocouple junction must be either a commercially made junction or must be a soldered or welded junction.
- Thermocouple junction must NOT be a simple twisted wire junction.

Additional Options available on some units:

- TC7 and TC8 are available as customer-installed temperature control thermocouples for Cool and Defrost modes using Host command EXT_TC_ENABLE

NOTE: *If the refrigerant line was made by someone other than Polycold, make sure the thermocouples are properly installed. Refer to* Install the Refrigerant Lines on page 4-19*.*

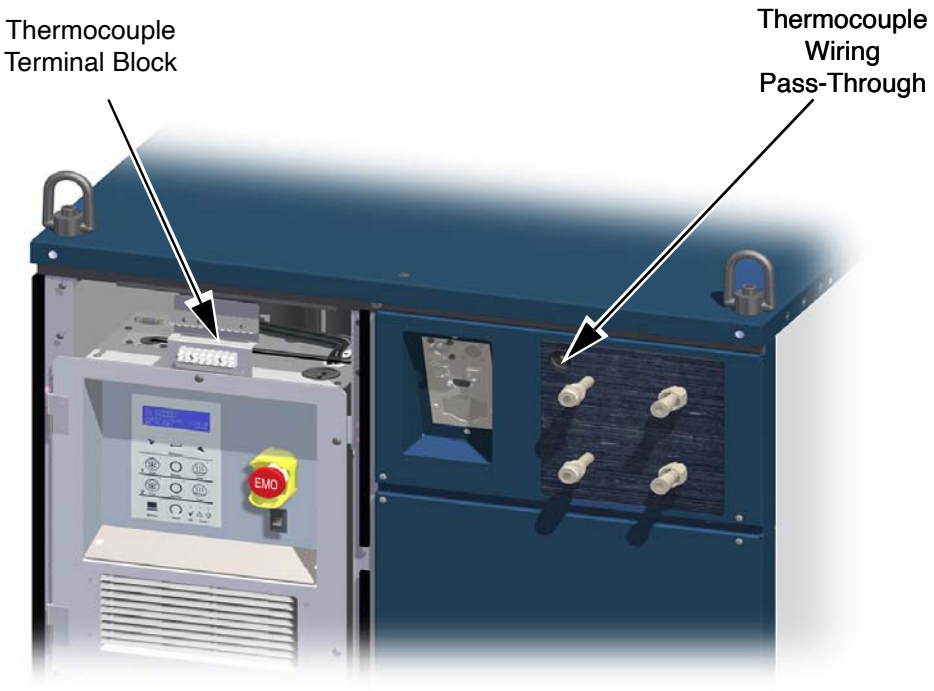


Figure 4-29: Location of Low Voltage Box and Thermocouple Terminals

1. Locate the low voltage box on the refrigeration unit and remove the terminal access cover. See Figure 4-29.

2. Pass the thermocouple wires through the thermocouple wire pass-through.

   To access the pass through, push in on the foam insulation at the left corner of the coolant supply-return connections and pass the wires behind the sheet metal front panel. Then, pass the wires behind the interface panel and to the thermocouple terminal block.

3. Locate the external thermocouple terminal block in the low voltage box. See Figure 4-29

4. On the refrigerant line, locate the thermocouple wires labeled COIL IN and COIL OUT.
   a. Fold a small piece of tape around each thermocouple wire next to its label.
   b. Label the tape "**Circuit 1**" on the COIL IN and COIL OUT thermocouple wires coming from the first refrigerant circuit.
   c. Label the tape "**Circuit 2**" on the COIL IN and COIL OUT thermocouple wires coming from the second refrigerant circuit.

5. Strip about 1/4 inch (6 mm) of insulation from the end of each thermocouple wire.

NOTICE

Do not nick the conductor. The wire may break at the nick from system vibration and can result in damage to the equipment.

6. Attach the thermocouple wires to their designated locations. See Figure 4-30 and Table 4-3
   - The blue-insulated copper wire must be attached to the positive (+) terminal.
   - The red-insulated constantan wire must be attached to the negative (-) terminal
   - Torque terminal screws to 0.34Nm (3 lb-in).
   - Refer to the System Wiring Diagram provided with your system

Figure 4-30: Thermocouple Terminal Block

7. Minimum recommended Thermocouple usage is Coil In and Coil Out for each refrigerant circuit. Cool plates should also have a Thermocouple.
   Additional Thermocouples can be added by the user as desired.

   If you are working on a single circuit Polycold Cryochiller, connect the Thermocouple wires as follows:
   - Position # 9: COIL IN
   - Position # 10: COIL OUT

If you are working on a dual circuit. Polycold Cryochiller, connect the Thermocouple wires as follows:

- Position # 9: #1 Line COIL IN
- Position # 10: #1 Line COIL OUT
- Position # 11: #2 Line COIL IN
- Position # 12: #2 Line COIL OUT

8. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Preliminary Check of the Polycold Cryochiller

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools and materials	No tools required

NOTICE

Do not open the isolation valves at this time or the unit may be damaged.

Follow the instructions that follow in proper sequence to avoid damage to the equipment.

1. Make sure you have performed all of the tasks up to this point on the installation checklist.

2. Perform the following tasks before opening the isolation valves on the refrigeration unit: Refer to Figure 4-31
    a. Check the Refrigerant Line and Cryosurface for Leaks
    b. Evacuate the Refrigerant Line and Cryosurface

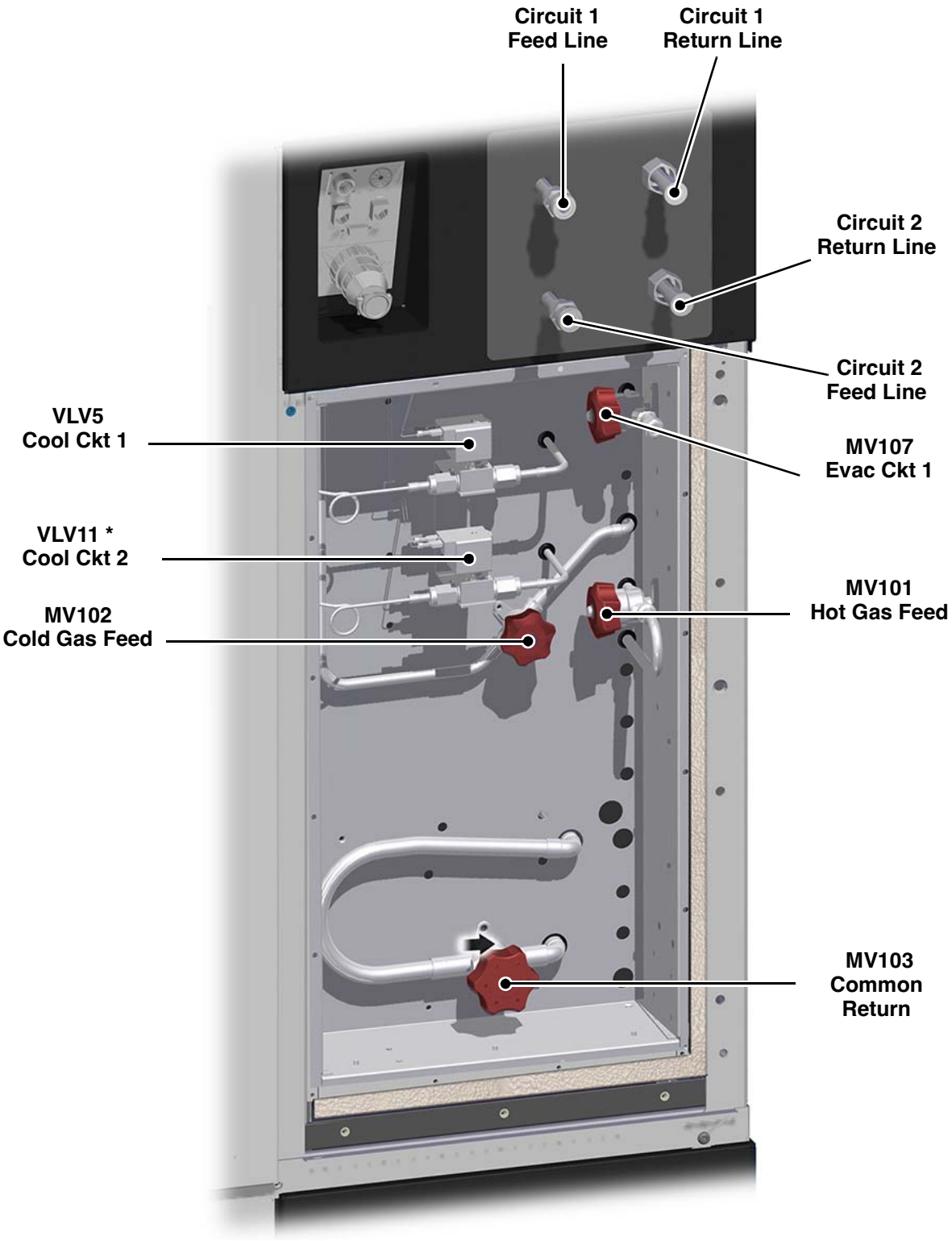


Figure 4-31: Illustration of Cold Valve Box with Valve Names
* asterisk denotes optional item

3. Open the cold box on the right top panel of the refrigeration unit and locate the red hand valves.

4. Locate the valves labeled as follows: See Figure 4-31.
   - MV101 - Hot Gas Feed
   - MV102 - Cold Gas Feed
   - MV103 - Common Return

5. Turn each of these hand valves completely counter-clockwise to fully open each valve.

6. Turn each hand valve clockwise 1/4 turn from full open.

7. Wait 10 minutes for the pressure to equalize in the system.

   The pressure may drop 35-70 kPa (5-10 psig) as the refrigerant mixture enters the refrigerant line and cryosurface.

8. If the back side of the system is not accessible, disregard this step.

   If the back side of the system is accessible, locate the pressure gauge and read the pressure value. This is the Static Pressure. See Figure 4-32

   Record the pressure reading in a maintenance log for future reference.

9. Inspect the valve box cover to make sure the rubber seals are intact.

10. Reinstall the valve box cover and securely screw it into place, covering the hand valves. The gasket should form a seal to keep out water vapor.

11. Start the cooling water.

12. Confirm the cooling water flow meets specifications found in Cooling Water on page 3-6.

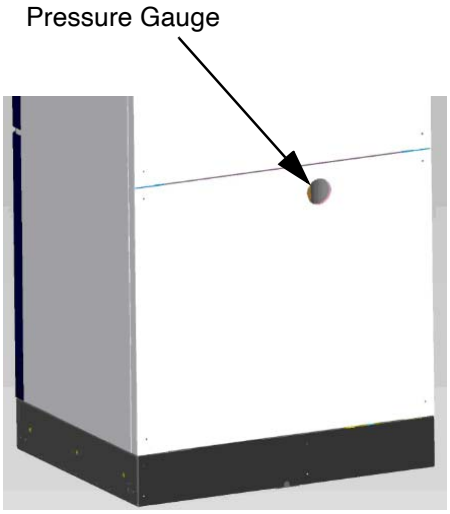


Figure 4-32: Pressure Gauge on Back of Refrigeration Unit

13. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Insulate Exposed Refrigerant Tubes and Couplings

Properly insulating the exposed tubes and couplings keeps them dry. Penetrating moisture adds heat load to the cryopump and can cause corrosion or leaks.

Item	Description
Electrical Category	Type 1 – Equipment is fully de-energized
Tools	Large pair of scissors or knife
Materials:	Insulation materials shipped with unit • Tubes of closed-cell pipe insulation • Sheet of closed-cell pipe insulation • Armaflex Insulation Tape • Armstrong 520 adhesive - See warning below

WARNING

Flammable Materials and Chemicals

Fumes from the adhesive Armstrong 520 are a source of ignition and suffocation and may cause fire and serious injury or death.

- Make sure there is adequate ventilation and no ignition source when using the Armstrong 520 adhesive.
- Read the label and follow the instructions on the container.

NOTICE

Armaflex tape is extremely difficult to remove and makes the feed-through nut bind when unscrewed and may result in damage to the equipment.

- Do not get Armaflex tape or Armstrong 520 adhesive in the threads of the feed-through.

Insulate exposed tubes between the refrigeration unit and the refrigerant line insulation:

Refer to Figure 4-33, Figure 4-34, and Figure 4-35

1. Cut the tubes of insulation so that they will fit snugly between the refrigeration unit and the refrigerant line's insulation. Cut each tube of insulation lengthwise.

2. Fit a smaller diameter tube of insulation around each exposed tube. Apply adhesive to the lengthwise slits in the insulation. Close the lengthwise slits to form an air-tight seal.

3. Fit the larger diameter tubes of insulation around the smaller diameter tubes of insulation. Seal each lengthwise slit shut with adhesive. (It is best to stagger the lengthwise seams.)

4. Cover the insulated refrigerant line bundle with a spiral wrap of Armaflex Insulation Tape. Overlap the previous wrap of insulation tape by at least 1 inch to ensure there are no gaps.

   Alternately, cut sheet insulation the same length as the tubes of insulation and wrap the sheet once

around the refrigerant line bundle, allowing the sheet to overlap 2-3 inches (50-75 mm). Put adhesive on the last 1-1.5 inches (25-40 mm) of the overlapping sheet to secure it in place.

5. Seal both ends of the refrigerant line bundle with tape or insulation tape. Secure the insulation around the refrigerant line bundle to the refrigerant line's insulation and to the unit's panel. Flare the tape so that it connects the insulation directly to the Polycold Cryochiller panel.

6. Use the tape or sheet Insulation to insulate all remaining exposed tubes and refrigerant components between the refrigerant line insulation and the feed-through.

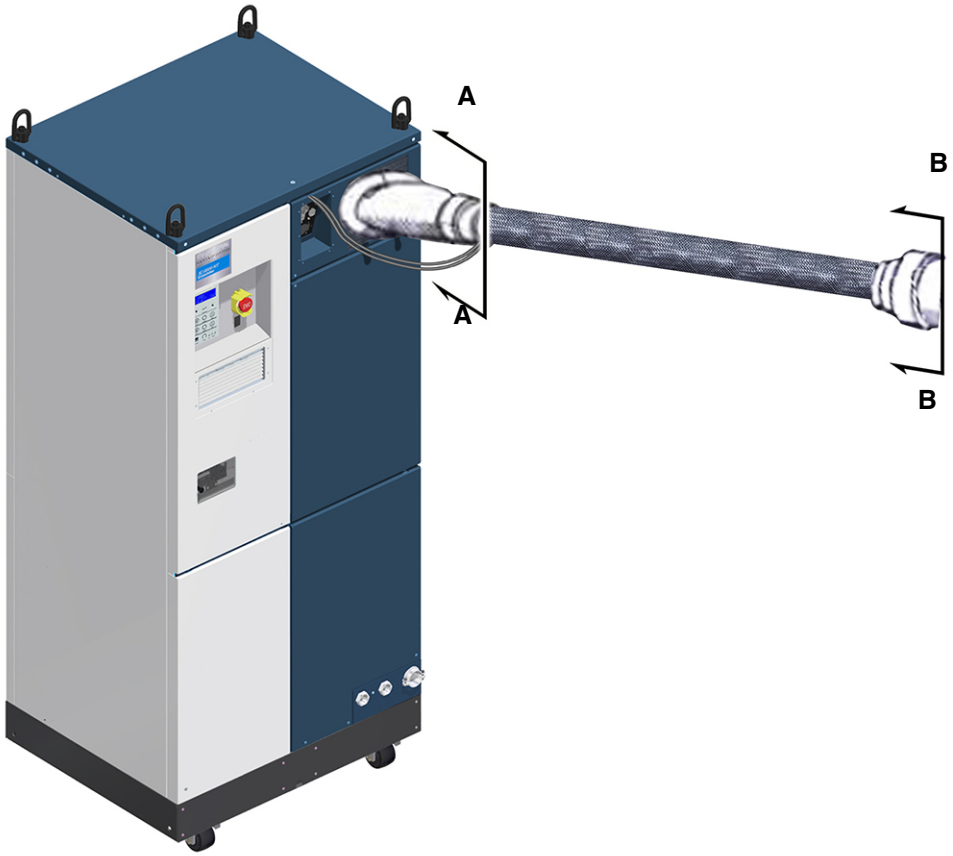


Figure 4-33: Insulating Exposed Tubes and Couplings

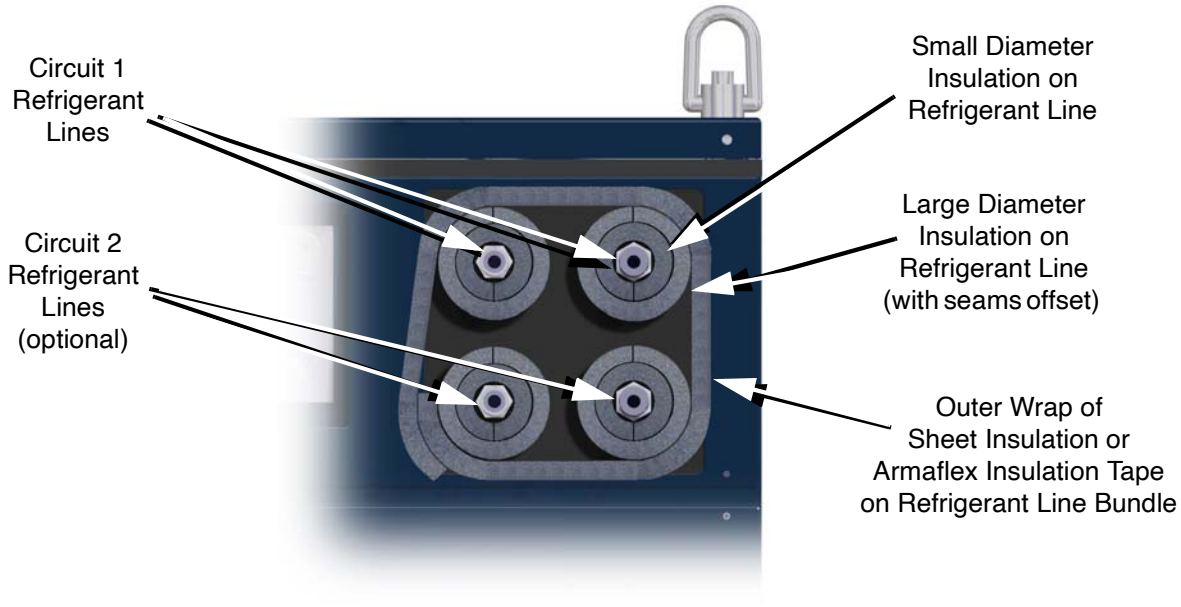


Figure 4-34: Cutaway View A-A Showing Sheet Insulation on Refrigerant Lines at Polycold Cryochiller

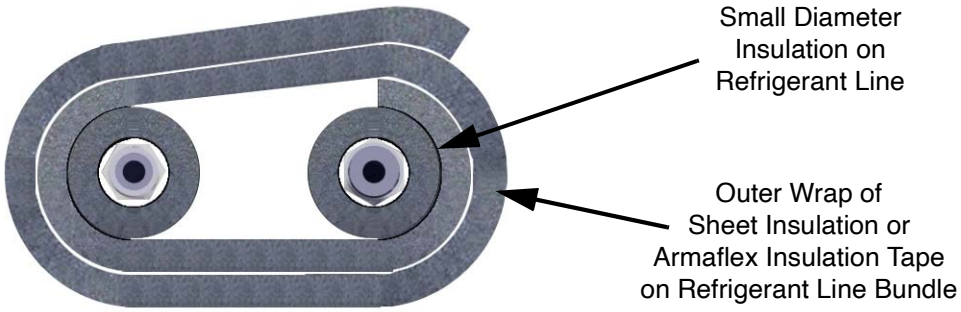


Figure 4-35: Cutaway View B-B Showing Sheet Insulation on Refrigerant Lines to Cryosurface

7. Cover the exposed tubes between the pre-insulated refrigerant line and the feed-through with a spiral wrap of Armaflex Insulation Tape. Overlap the previous wrap of insulation tape by at least 1 inch to ensure there are no gaps.

   If using sheet insulation, fit the sheet of insulation onto the exposed tubes. Wrap the insulation around the exposed tubes three times. Put adhesive on the last 1-1.5 inches (25-40 mm) of the overlapping sheet to secure it in place.

   Seal both ends of the insulation with tape to secure the insulation on to the insulation on the refrigerant lines and to the feed-through. Do not put the tape closer than 1-2 inches (25-50 mm) to the threads on the feed-through.

Figure 4-36: View of Armaflex Insulating Tape on Refrigerant Line Bundle on Polycold Cryochiller

8. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Startup and Test

Item	Description
Electrical Category	Type 2 - Equipment is energized. Energized circuits are covered or insulated
Tools and materials:	No tools required

The Startup and Test section requires that the Polycold Cryochiller is fully installed and that the vacuum chamber is operational.

1. Confirm that cooling water is on and flowing properly through the system.
2. Turn on the electrical power source for the refrigeration unit.
3. Move CB-1 to the ON position. See Figure 4-37.
4. Move CB-2 to the ON position. See Figure 4-38

Figure 4-37: Move CB-1 to ON

Figure 4-38: Move CB-2 to ON

5. Wait for the system to boot up. Boot up takes less than one minute.
   When boot up is complete, the system HMI screen displays information.
6. On systems equipped with the EMO, twist the EMO switch clockwise to confirm that it is in the Out or disengaged position. See Figure 4-39
7. Move the compressor On/Off switch to the ON position. See Figure 4-39
   The unit should go to the Standby mode. See Figure 4-40.

Figure 4-39: Set Compressor Switch to ON (Optional EMO shown)

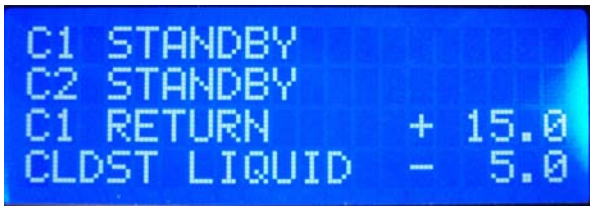


Figure 4-40: Standby Mode

8. Let the unit stay in the Standby mode for 30 minutes for the "Polycold Stack" to reach operating temperature. The Polycold Stack is the heat exchangers and other components that are encased in insulating foam

9. Evacuate the vacuum chamber where the cryosurface is installed to at least 0.01 torr (1.33 Pa)

10. After the 30 minutes of Standby, scroll through the menu to check the temperature and pressure parameters. See Figure 4-41
    - Circuit feed, return, coil in, and coil out temperatures should be positive values.
    - Coldest liquid temperatures should be below -80C.

Figure 4-41: Check Parameters

11. Record the temperature and pressure parameter data.

12. Select **Cool.** See Figure 4-42.
    - Wait 5 minutes if the refrigeration line plus coil is 6 meters (20 feet) or less.
    - Wait 10 minutes if the refrigerant line plus coil is longer than 6 meters (20 feet).
    - When pressed, the Cool LED blinks slowly.

Figure 4-42: Select Cool Mode

13. Check the coil inlet and coil outlet temperatures to make sure that they reach the desired temperatures.

14. Select **Defrost**. The unit automatically goes to Standby when Defrost is complete.

15. Allow the unit to remain in Standby for 5 minutes.

16. Repeat the Cool, Defrost, and Standby cycle two or three times.

17. For systems with dual refrigerant circuits, repeat steps 9 through 16 for channel 2.

18. Go to the Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Evaluate the Polycold Cryochiller / Place Into Service

Item	Description
Electrical Category	Type 2 - Equipment is energized. Energized circuits are covered or insulated
Tools and materials:	No tools required

This section requires that the Polycold Cryochiller Startup and Test procedure is complete and the unit is still running in Standby.

Unless you are installing a remote interface, this is the last task for installing a Polycold Cryochiller.

WARNING

Electric Shock

The compressor electrical box contains hazardous voltages. Failure to have a qualified electrician do all electrical work could result in serious injury or death.

- Do not reach inside the unit with power applied.
- Have a qualified electrician perform all electrical work.

CAUTION

Extreme Temperatures

The compressor's heads and discharge line may be hot when operating. Contact with the hot surface may result in minor or moderate injury.

- Do not reach inside the compressor compartment when the unit is operating.
- Do not touch the compressor's heads or discharge lines.

1. With the Polycold Cryochiller in Standby, make sure the minimum water flow rate is adequate for the temperature of the water. See Cooling Water on page 3-6.

2. Select **LOCAL**.

3. Listen to the compressor. It should run continuously without cycling or turning off.

4. If the back side of the system is not accessible, disregard this step.

   If the back side of the system is accessible, remove the unit's lower rear panel and locate the oil sight glass on the body of the compressor. Oil level should be 1/8 to 1/2 full on a compressor that has been running for at least 60 minutes. Preferred level is 1/8 full. See Figure 4-43.

   Record the compressor oil level after the compressor has run for at least 60 minutes.

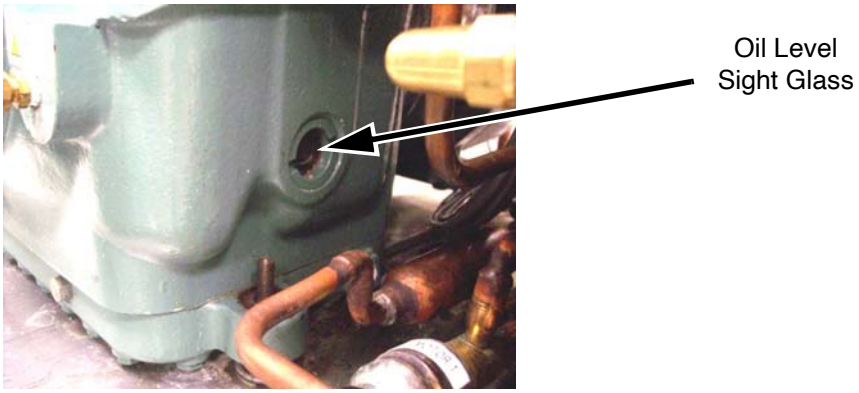


Figure 4-43: Compressor Oil Level Sight Glass

5. Check the direction of the flow of the cooling water.
   - The left water line is the water OUT or drain line.
   - The right water line is the water IN or supply line.
   - The OUT line should be warmer than the IN line.
   - If the OUT line is cooler than the IN line, then turn off the unit, disconnect the water lines, and connect the supply and drain lines to the proper ports.

6. Record the pressures and temperatures in Table 4-4.

*Table 4-4: Cryochiller Pressures and Temperatures in **Standby***

Item	Acceptable Range for MaxCool 4000H	Acceptable Range for MaxCool 2500L	Your Measurements
SUCTION PRESSURE	21 to 345 kPa (3 to 50 psig)	21 to 345 kPa (3 to 50 psig)	_____ kPa (psig)
DISCHARGE PRESSURE	689 to 2068 kPa (100 to 300 psig)	689 to 2068 kPa (100 to 300 psig)	_____kPa (psig)
DISCHARGE LINE (TC # 1)	80 to 125°C	80 to 125°C	_____°C
LIQUID LINE (TC # 2)	15 to 38°C	15 to 38°C	_____°C
COLDEST LIQUID TEMPERATURE (TC # 4)	-120 to -155°C	-130 to -155°C	_____°C

7. Evacuate the vacuum chamber where the cryosurface is installed to at least 0.01 torr (1.33 Pa).

8. Select Cool and wait 30 minutes.

NOTE: *If a dual circuit system, select Cool for both refrigerant circuits.*

9. Check the outlet temperature of the cooling water. The drain line (OUT) should be 16 to 41°C (60 to 105°F) If not, adjust the water flow to attain a temperature in this range.

10. If there is any ice or water on the refrigerant line, turn off the unit and remove the ice or water. Apply additional insulation at the points where ice was formed or another complete layer of insulation if the lines were icy. Re-evaluate the cryopump starting at Step 1 of this section.

11. Record the pressures and temperatures in Table 4-5.

*Table 4-5: Cryochiller Pressures and Temperatures in **Cool Mode***

Item	Acceptable Range for MaxCool 4000H	Acceptable Range for MaxCool 2500L	Your Measurements
SUCTION PRESSURE	21 to 414 kPa (3 to 60 psig)	21 to 414 kPa (3 to 60 psig)	_____ kPa (psig)
DISCHARGE PRESSURE	689 to 2827 kPa (100 to 410 psig)	689 to 2827 kPa (100 to 410 psig)	_____kPa (psig)
DISCHARGE LINE (TC # 1)	80 to 128 °C	80 to 128 °C	_____°C
LIQUID LINE (TC # 2)	15 to 41°C	15 to 41°C	_____°C
COLDEST LIQUID TEMPERATURE (TC # 4)	-80 to -150 °C	-100 to -155 °C	_____°C
COIL IN TEMPERATURE	-96 to -145 °C (application based)	-118 to -155 °C (application based)	_____°C
COIL OUT TEMPERATURE	-80 to -145 °C (application based)	-102 to -155 °C (application based)	_____°C
MAXIMUM COIL IN -COIL OUT DIFFERENCE	20 °C	20 °C	_____°C

12. Select **Defrost**.

NOTE: *If a dual circuit system, select Defrost for both refrigerant circuits.*

13. Record the time it takes for the cryosurface to defrost. Actual Defrost Time:_____ minutes When Defrost completes, the unit automatically switches to Standby. Default temperature is 20 C.

14. Open the vacuum chamber. The cryosurface should be dry and at room temperature or warmer.

15. Recheck the balance pressure, see Table 3-10, and cooling water temperature, see Table 3-6, to verify that the Polycold Cryochiller is operating within specifications. Check that TC8, and TC10 if a dual circuit, are at or near 20C.

16. Record all measurements taken in this task in a maintenance log for future use as a baseline.

17. Go to Installation Checklist Table 4-1. Initial and date this task. Go to the next task on the checklist.

Install Seismic Restraints

Item	Description
Electrical Category	Type 2 - Equipment is energized. Energized circuits are covered or insulated
Tools and materials:	Seismic Restraint Brackets - Customer Supplied. Mounting tools and hardware - Customer Supplied, as required.

The Cryochiller is provided with four (4) seismic anchor points for mounting seismic restraints. Two (2) anchor points are located on the left and on the right side of the frame. See Table 4-6 for dimensions.

Seismic bracket design and construction is the responsibility of the facility where the Cryochiller is installed.

Table 4-6: Seismic Bracket Mount Specifications

Item	Description
Mounting Hole Size	(2) 9/16 inch (14.28mm) thru holes on the left side and on the right side of the bottom frame
Mounting Hole Height Mounting Hole Separation	With casters - 4 inches above floor Without casters - 1 inch above floor / bottom of frame. 23.5 inches between centers
Fasteners on System	Up to 1/2 inch (M12) hardware including backing flat washers against the inside Cryochiller frame.
Fasteners on Floor	As specified by facility and local regulations
Working Load	1800 pounds or greater to comply with SEMI S2

1. Confirm that the Cryochiller is in its final position and adequate access for operation and service is provided.
2. Secure the seismic brackets to the Cryochiller using 1/2 inch (12mm) hardware. Use flat washers for backing against the inside frame. Use lock washers as appropriate.
3. Secure the seismic brackets to the floor using appropriate hardware as required by the bracket design and facility or local regulations.
4. Tighten all hardware to appropriate torque specifications.
5. Go to the Installation Checklist Table 4-1. Initial and date this task.

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5 Interfacing

Interfacing refers to the methods for communication with or control of the Polycold Cryochiller.

General Interface Information

The Polycold Cryochiller interfaces with many different communication and control protocols. Actual available interfaces is dependent on the model. The available interface options are as follows:

- RS-232 (standard)
- Gauge Relay (standard)
- Human Machine Interface (HMI) (standard)
- Ethernet - Host and Service
- Profibus
- DeviceNet
- 24V DI/DO Remote

All interfaces either connect to external terminals on the Remote Interface Panel or pass through the panel and connect on the panel on the top of the Low Voltage Box. The connections that are available on each unit depend on the communications options ordered with that unit.

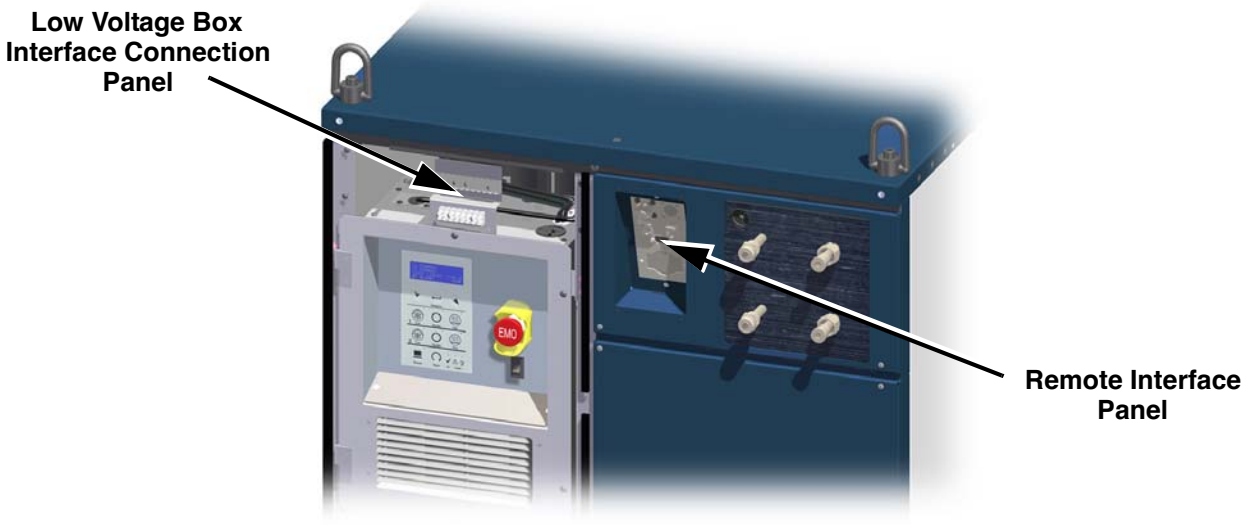


Figure 5-1: Interface Communication Connections

General Interface Rules

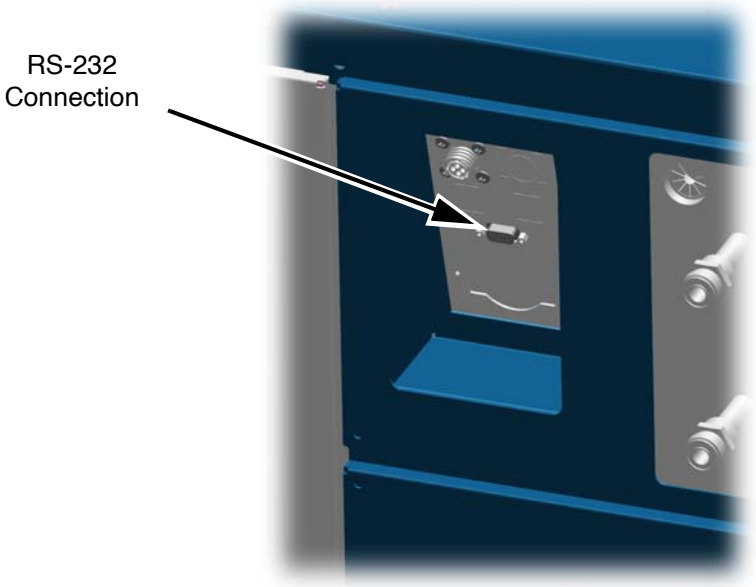
For information on commands, see Chapter 7: *Host Commands*.

- Only one interface can be in “Control” at a time
- “Set” commands can only be executed by the interface that is in “Control”.
- “Get” commands can be executed by any interface at any time if the security level is satisfied. See Security Levels on page 7-7.
- Interface control is set by Ethernet or RS-232 using the command SYSTEM_CONTROL_MODE or by the HMI.
- The system is set to Local mode, or HMI control, when the Remote key is pressed when the system is in remote mode.
- The default control mode becomes the control interface when the Remote key is pressed.
- The Remote LED is on when in Remote mode and off when in Local mode.
- The system is set to the default “Control” mode when the system boots or when the Remote key is pressed when the system is in local mode.
- The default “Control” interface can be set by the command SYSTEM_CONTROL_MODE_DEF or by the HMI.

RS-232 Interface

RS-232 Interface is standard on all models of Polycold Cryochiller.

Port	DB9 Female connection on Communications Panel
Cable	Standard RS-232 Null Modem cable with 9-pin D male connector
Communication Settings	Fixed Settings 9600 baud, 7 data, even parity, 1 stop bit, no hardware flow control
Protocol	EIA-232-E



Gauge Relay (J4)

The Gauge Relay connection provides external control to place each refrigerant circuit into Cool Mode.

Item	Description
J4 Port	4-pin Connector (female pins)
Cable Connector	4-pin Cable Connector (male pins) (Amp CPC-11 - 206429-1)
Cable Terminal Pins	(4) crimp-style male pins for 16 to 18AWG wire size.
Cable Size	20 - 24 AWG
Input	Non-polar fully isolated 24VAC or 24VDC input signals
Circuit 1 Control	Pins 1 and 2
Circuit 2 Control	Pins 3 and 4 (Only on units with full Circuit 2 control)

When the refrigerant circuit is in Standby mode and the Gauge Relay is enabled and the appropriate Gauge Relay contact pair is provided a 24V AC/DC (-25%/+17%) 10MA input voltage across a Gauge Relay pin pair, the selected refrigerant circuit goes into the current default Cool mode.

Example: A Granville-Phillips (G-P) Mini-Convectron® Gauge is used to control circuit 1. This gauge has a pair of Process Setpoint Relay contacts that close when the gauge detects the setpoint pressure.

- One side of the relay contacts on the gauge is connected to a 24V power source.
- The other side of the relay contacts on the gauge is connected to either pin 1 or pin 2 of the Polycold Cryochiller Gauge Relay input.
- Common for the 24V power source is connected to the remaining pin 2 or pin 1 of the Polycold Cryochiller Gauge Relay input.

When the G-P gauge detects that the process has reached the programmed set point vacuum level, the G-P gauge contacts close and the 24V is applied across Gauge Relay input pins 1 and 2. The Polycold Cryochiller responds by setting refrigerant circuit 1 to the current default Cool mode.

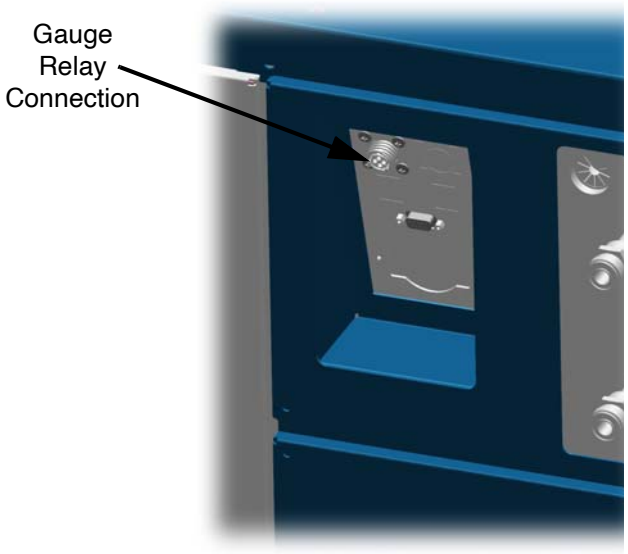


Figure 5-3: Gauge Relay Connection

See Gauge Relay Kit in Optional Parts on page 11-3 for the kit part number.

See External Vacuum Control on page 8-4.

Human Machine Interface - HMI

The HMI consists of a 4-line display and a keypad for navigation and selection.

Navigation Keys

Use Navigation keys to select the display menus.

- Use Arrow keys to move the cursor up and down to scroll through screen menus
- Use Enter key to select the highlighted item.
- Use Arrow keys to increase or decrease the selected screen value.
- Use Enter key to increment through the characters of a displayed value.
- Use Enter key to save the value after the incrementing past the last character.

Figure 5-4: HMI Display and Keyboard

Cool/Standby/Heat Keys

Press the Cool, Heat, or Standby mode keys to set the mode for each circuit.

The default mode for Cool and Heat mode set by the Cool and Heat keys is set by OPERATING_MODE_DEF_COOL and OPERATING_MODE_DEF_DEFROST or by the HMI input.

Each Mode has a green LED which is illuminated when the mode is active.

Remote Key

Remote key allows Remote / Local interface control

- When Remote LED is lit, the remote interface is active.
  Remote interface is set by the SYSTEM_CONTROL_MODE_DEF command.
- When Remote LED is NOT lit, the controlling interface is the HMI Local interface keypad.
- HMI Local must be active to change modes and change values using the keypad and the HMI display.
- HMI Local is not required to be active in order to browse the HMI screens.

OK LED

- If OK LED is lit, indicates compressor contactor is closed. (compressor on)
- If OK LED is not lit, indicates compressor contactor is not closed.

Fault LEDs

Fault LED (amber and red) indicates a warning or fault has occurred.
Red fault LED is reserved for High Pressure Faults
Some Faults cause the compressor contactor to open (Compressor OFF)

Reset Button

Reset button can perform 2 functions.

- Acknowledges Alarms / Faults the same as the RESET_ALARMS command.
  - If the alarm / fault condition still exists, then the alarm / fault does not clear.
  - If the alarm / fault is acknowledged and cleared, the Amber / Red Fault LED turns off.
- Turns on Compressor if compressor was turned OFF by an alarm / fault condition and the compressor switch is in the ON position (contactor closed)

HMI Display

Use Navigation keys to move to each display menu and make selections.

- HMI display is 4 rows with 20 characters per row.
- Use **Arrow** keys to scroll cursor up and down through current screen selections
- Use **Enter** key to select highlighted item.
- Pressing an **Arrow** key to move the cursor past the end of a nested display returns you to the next higher display.
- If highlighted item has an right arrow (**>**), then **Enter** will bring you to a nested sub-menu.
- If highlighted item does not have a right arrow (>), then **Enter** toggles the selection or allows data entry using the up and down arrows.

HMI Display

- Press the up and down arrow key to advance to additional items on the same menu.
- Asterisk at the end of a menu item (*) indicates the current setting.
- Up and down arrows in the display indicate more display selections are available. Use the up and down arrows to advance up and down in the display.
- Right arrow (**>**) at the end of a menu line indicates this entry has additional nested pages. Use the Enter key to display the nested menu.
- After a period of inactivity, the display selection returns to the previous display until it reaches the Home Screen Display. The period of inactivity is configurable.
- Selecting a nested display opens the nested display at the selection that was last displayed.
- Numeric values in the display may be either a reported value or a set point value.
- Reported display values cannot be changed.
- Set point display values may be changed by using the Enter key to open the value for setting and then using the up and down arrows to change the value of each digit and using the Enter key to move to next digit and then use the Enter at the last digit to store the value.
- Display illustrations in this chapter show the full list of screen options for each nested display.

HMI Home Screen Display

Home Screen is the default HMI display that is displayed at initial power up and after a configurable internal 30 seconds (default) of HMI keyboard inactivity at each of the nested menus.

The 4-line display shows the mode for each circuit plus user programmable information as shown in the tables below.

LN2, LN3 and LN4 values are programmed from the appropriate HOME SCREEN LN(number) MEAS selection in the MONITOR CONFIG display under CONFIGURATION display. Selecting the blank selection for the LN value leaves that line blank.

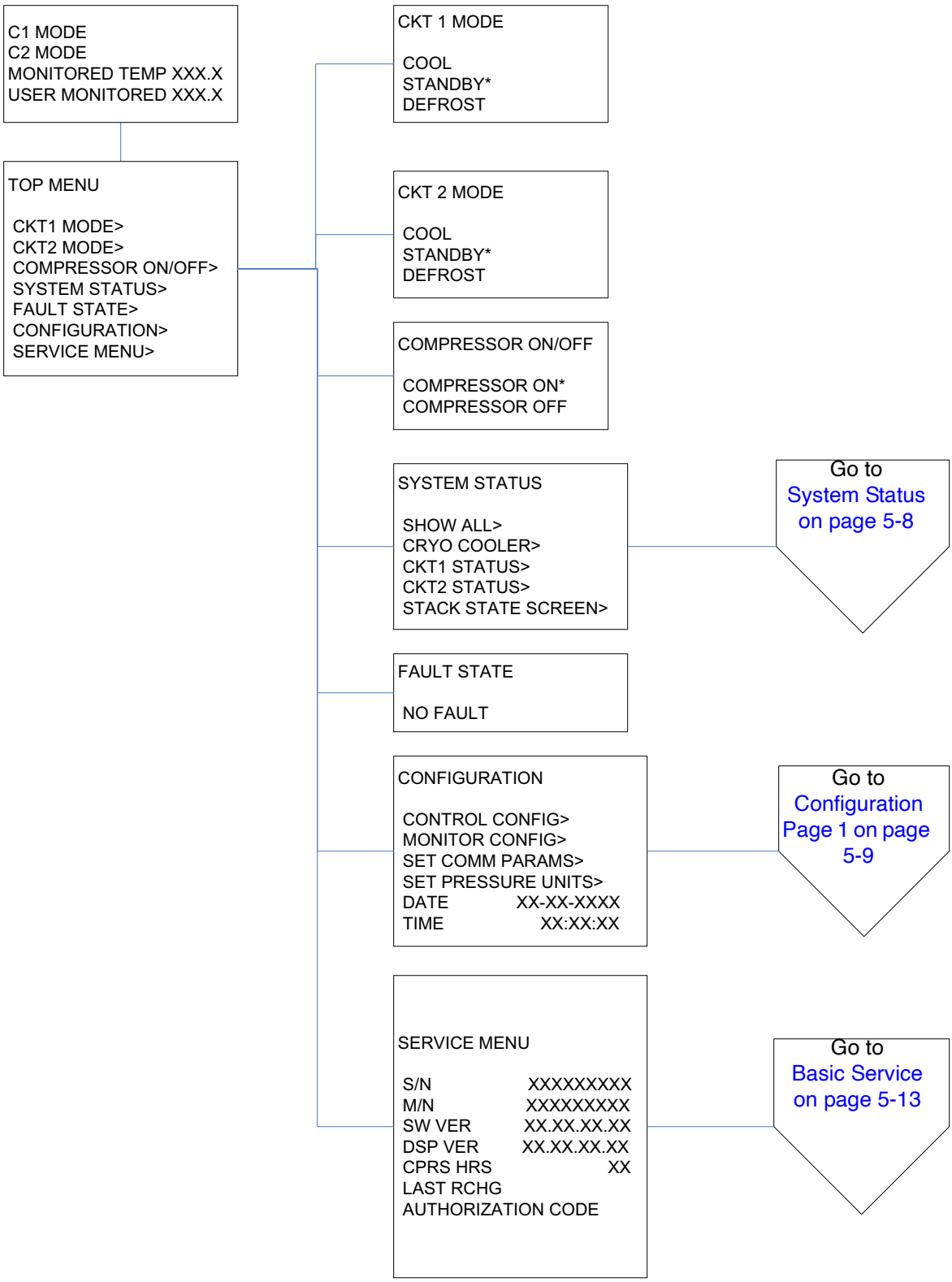
Table 5-1: Default HMI Home Menu for Single Circuit

Single Circuit Home Screen	Description
C1 (mode)	Static display of the specific mode of Circuit 1
1 user selected value from LN2 list	Static display of selected LN2 value
1 user selected value from LN3 list	Static display of selected LN3 value
Up to 8 user selected values from LN4 list	Static display if only 1 LN4 value is selected. Scrolling display of all selected LN4 values if 2 or more values are selected.

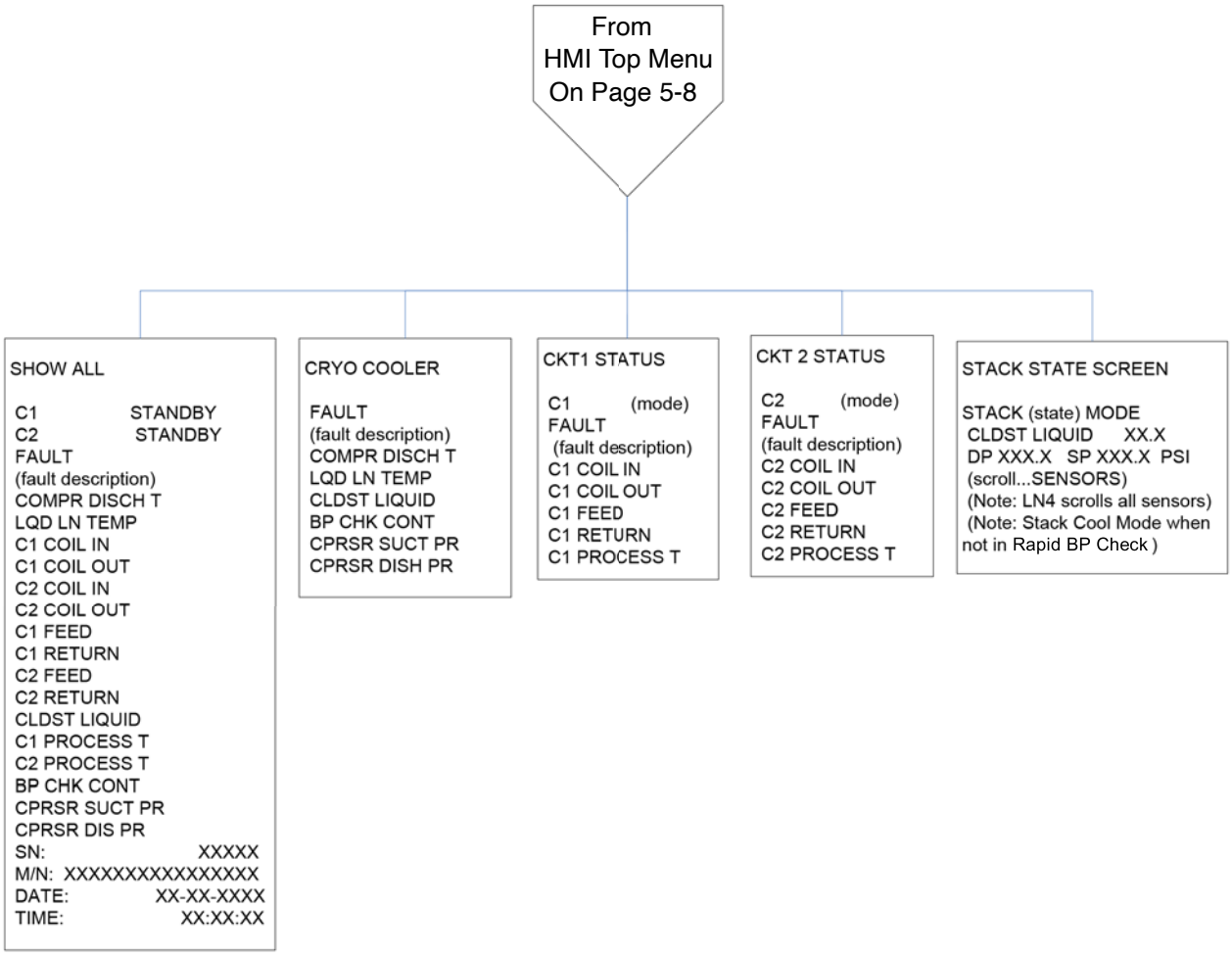
Table 5-2: Default HMI Home Menu for Dual Circuit Units

Dual Circuit Home Screen	Description
C1 (mode)	Static display of the specific mode of Circuit 1
C2 (mode)	Static display of the specific mode of Circuit 2 On Base models, this may only read “Cool”
1 user selected value from LN3 list	Static display of selected LN3 value
Up to 8 user selected values from LN4 list	Static display if only 1LN4 value is selected. Scrolling display of all selected LN4 values if 2 or more values are selected.

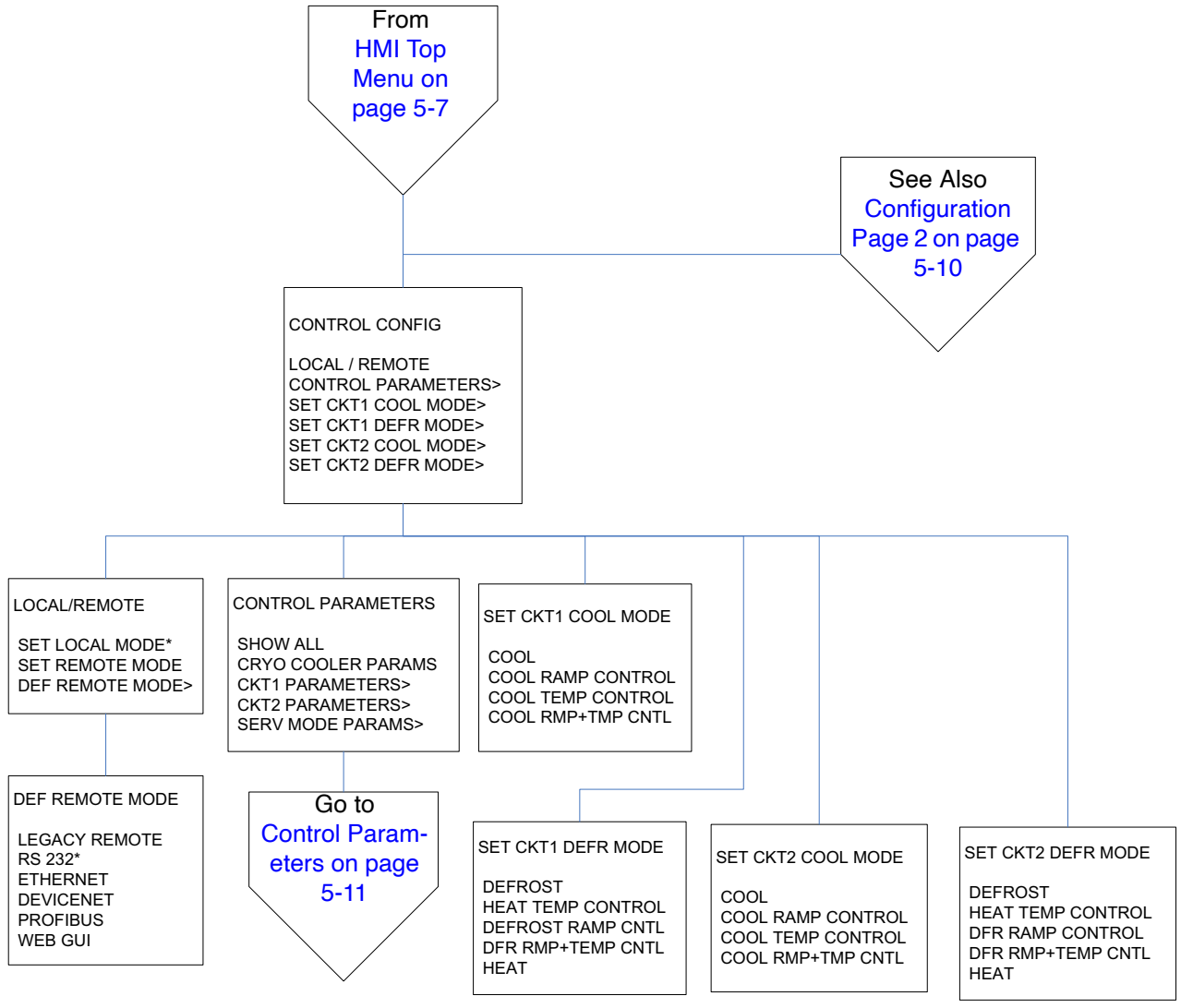
HMI Top Menu


C1 MODE
C2 MODE
MONITORED TEMP XXX.X
USER MONITORED XXX.X
TOP MENU
CKT1 MODE>
CKT2 MODE>
COMPRESSOR ON/OFF>
SYSTEM STATUS>
FAULT STATE>
CONFIGURATION>
SERVICE MENU>
CKT 1 MODE
COOL
STANDBY*
DEFROST
CKT 2 MODE
COOL
STANDBY*
DEFROST
COMPRESSOR ON/OFF
COMPRESSOR ON*
COMPRESSOR OFF
SYSTEM STATUS
SHOW ALL>
CRYO COOLER>
CKT1 STATUS>
CKT2 STATUS>
STACK STATE SCREEN>
Go to System Status on page 5-8
FAULT STATE
NO FAULT
CONFIGURATION
CONTROL CONFIG>
MONITOR CONFIG>
SET COMM PARAMS>
SET PRESSURE UNITS>
DATE XX-XX-XXXX
TIME XX:XX:XX
Go to Configuration Page 1 on page 5-9
SERVICE MENU
S/N XXXXXXXXX
M/N XXXXXXXXX
SW VER XX.XX.XX.XX
DSP VER XX.XX.XX.XX
CPRS HRS XX
LAST RCHG
AUTHORIZATION CODE
Go to Basic Service on page 5-13

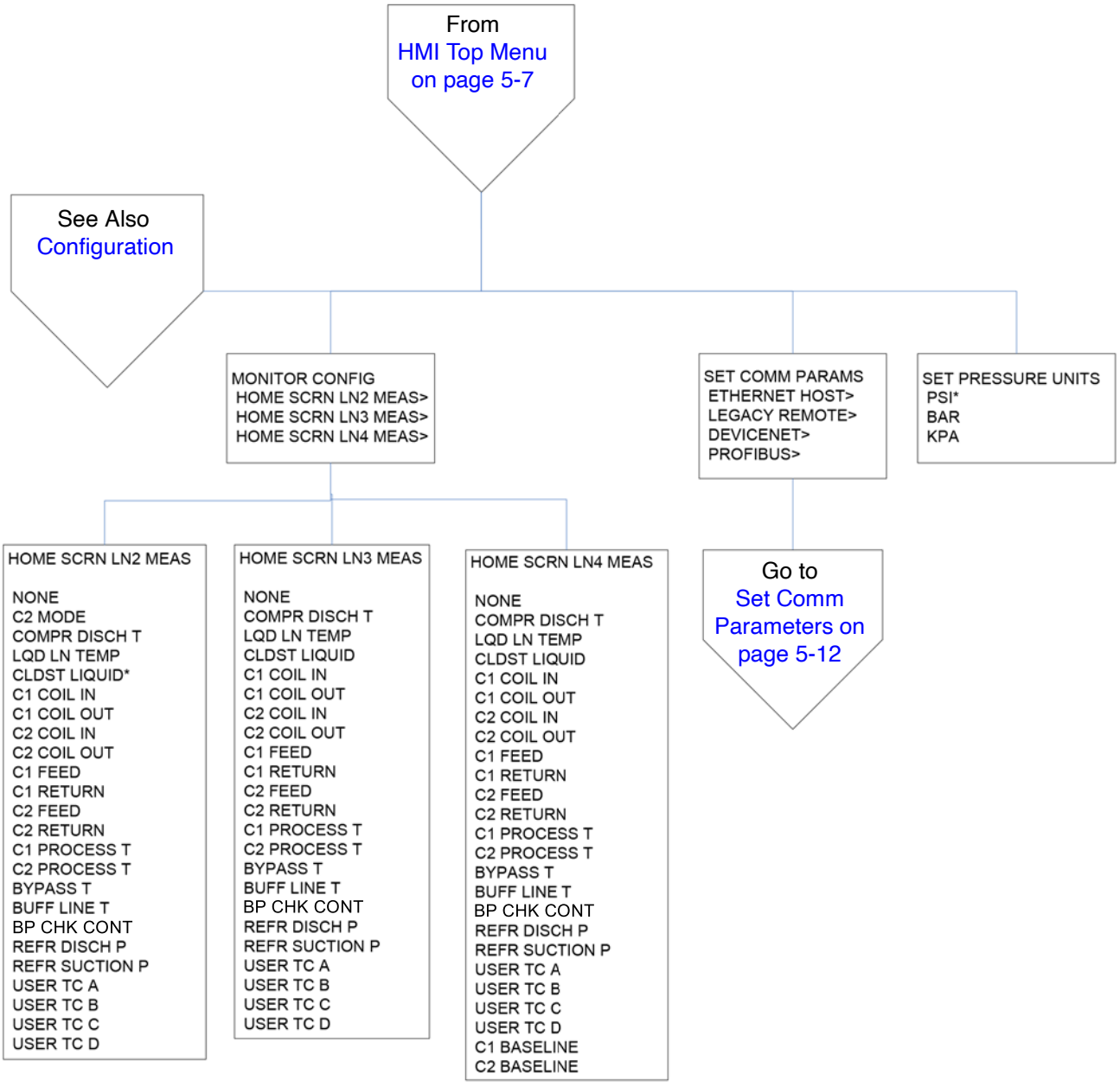
System Status



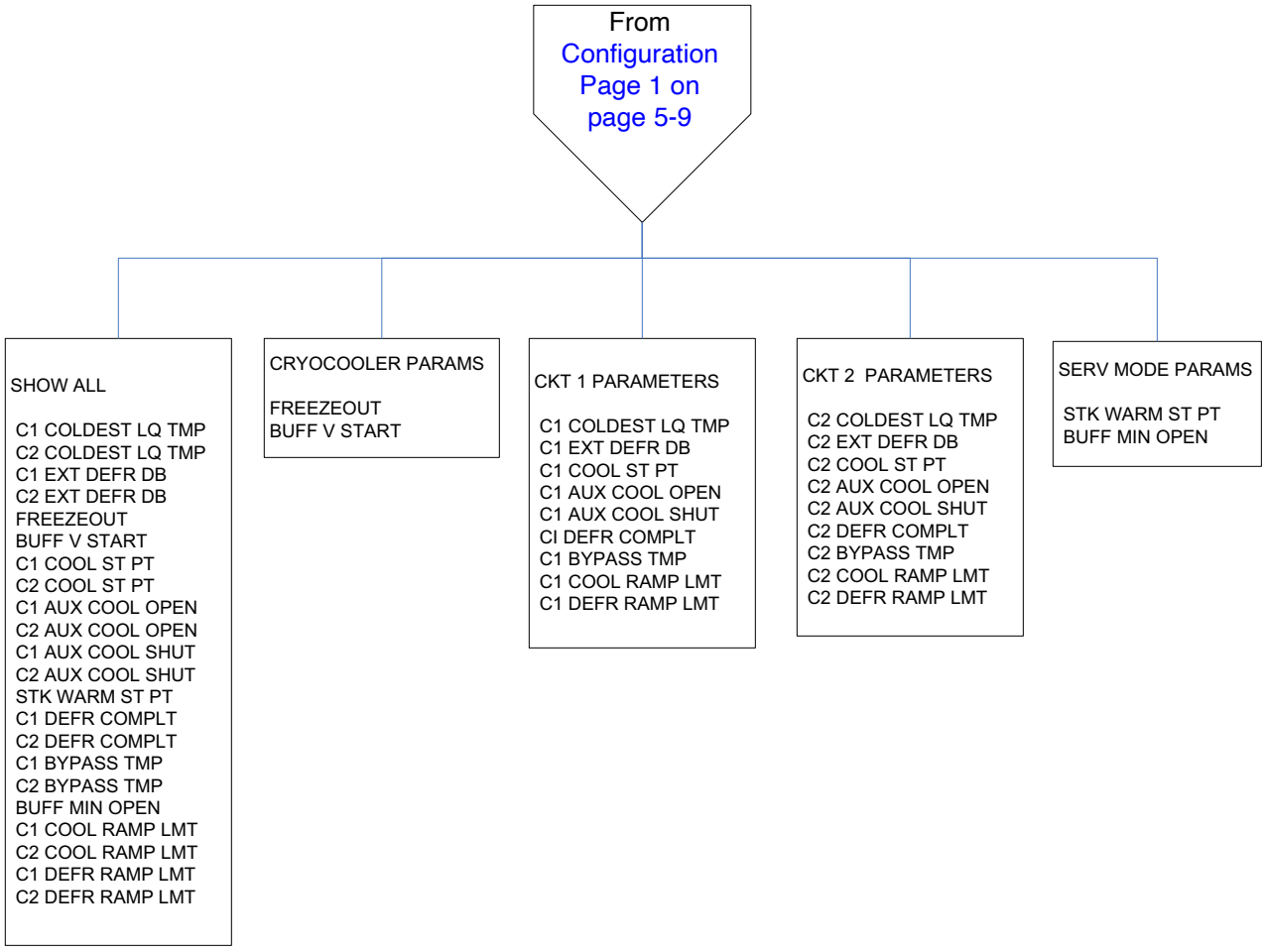
Configuration Page 1



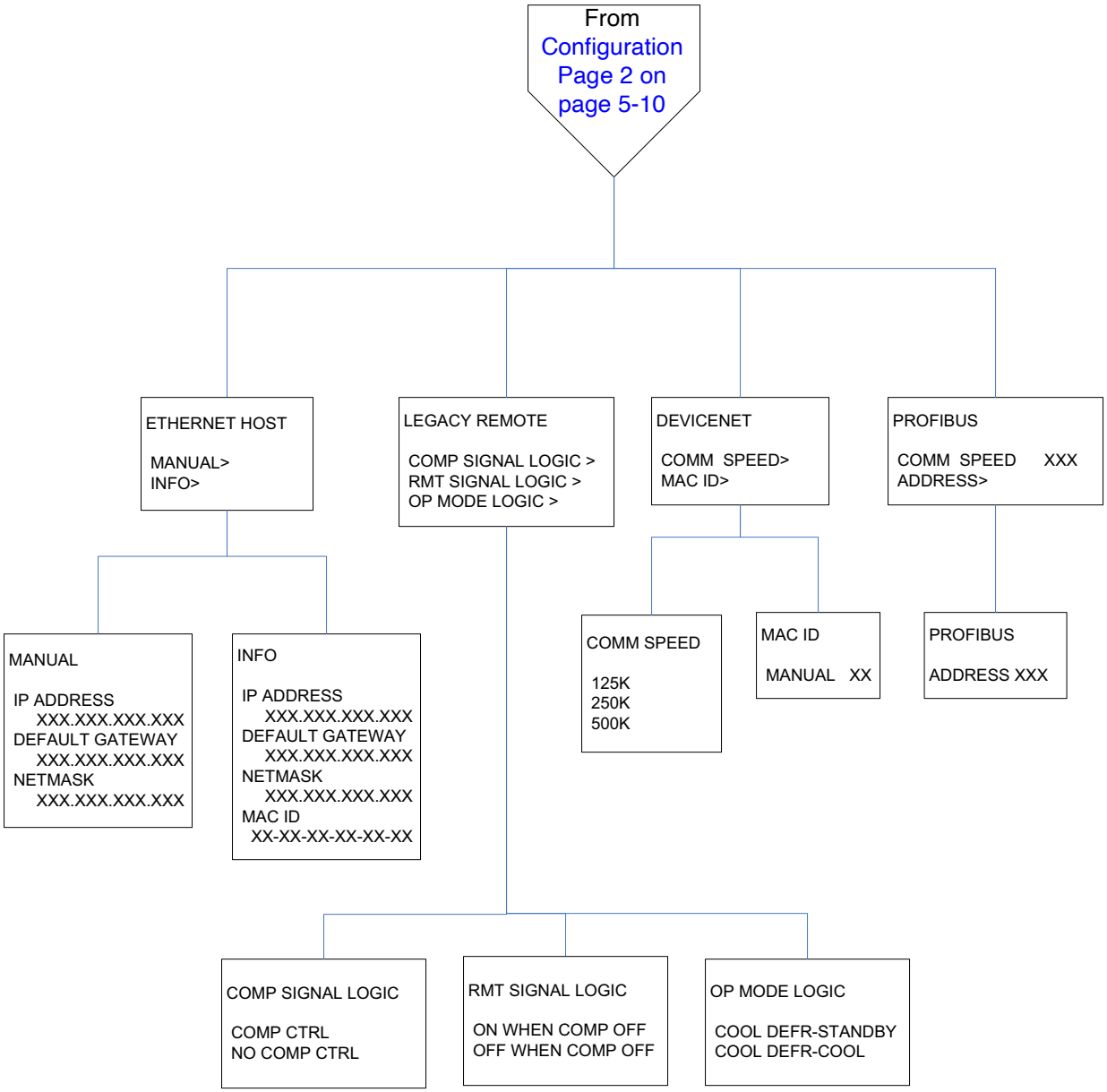
Configuration Page 2



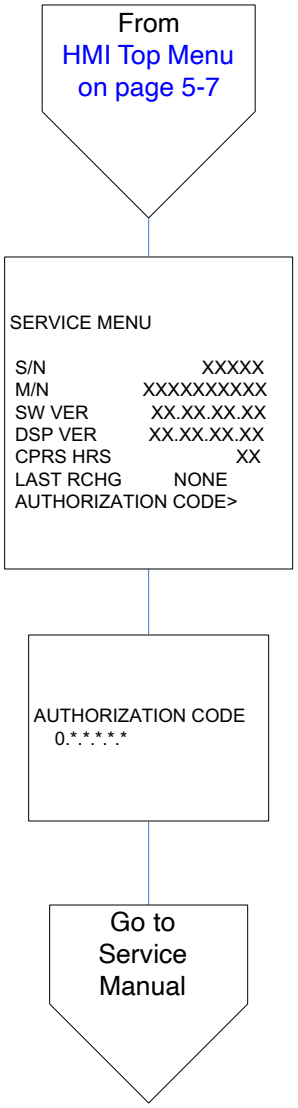
Control Parameters



Set Comm Parameters



Basic Service



Ethernet

Host and Service Ethernet communication is an available option on some packages. Ethernet connection requires specific protocols for setting IP and Mask addresses. Set the Cryochiller Ethernet settings using the HMI - Configuration - Set Comm Params - Ethernet menus. Set PC settings as stated below. The Cryochiller is a non DHCP connection. The host or service PC will not automatically set the IP address. If the IP address is changed, a new connection using the new IP address must be made.

Port	Host or Service port RJ45 on the Communications Panel
Cable	Crossover CAT5 / 6 cable with RJ45 connector Standard CAT5 / 6 is OK if computer supports auto crossover.
IP Address	(nnn.nnn.nnn.nnn) First 3 fields same as Cryochiller. 4th field must be different Host command IP_ADDRESS HMI “Set Comm Params - Ethernet Host”
Network Mask (Subnet Mask) (Subnet)	(nnn.nnn.nnn.nnn) Same mask as Cryochiller - recommended Host command NETWORK_MASK HMI “Set Comm Params - Ethernet Host”
Default Gateway	(nnn.nnn.nnn.nnn) May be left blank or all zeros Host command DEFAULT_GATEWAY HMI “Set Comm Params - Ethernet Host”
Speed	10/100 Mbps
Protocol	IEEE 802.3 10Base-T, IEEE 802.3u 100Base-TX

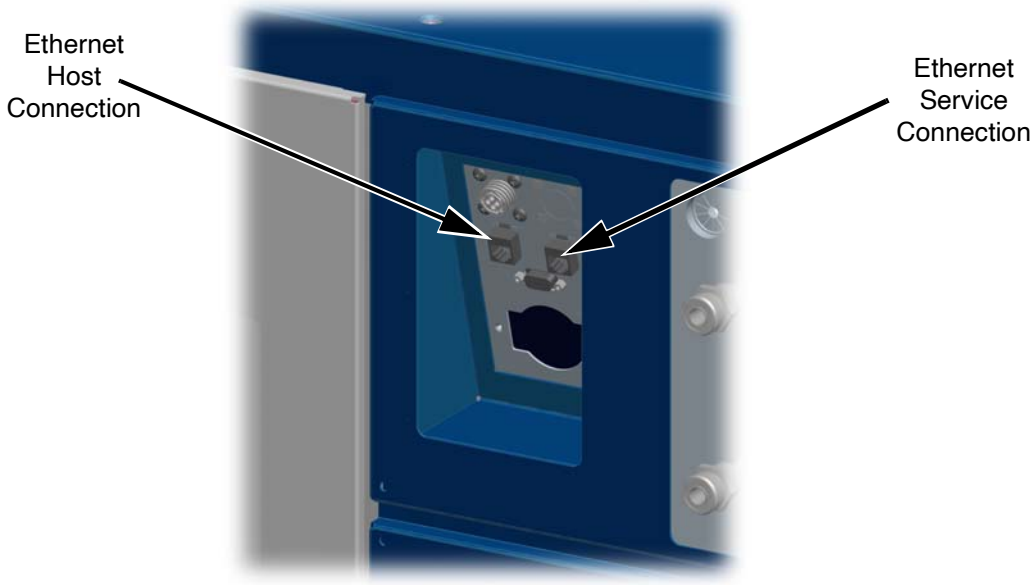


Figure 5-5: Ethernet Host and Ser-

Profibus

Profibus communication is an available option. Refer to Profibus Interface User Manual, p/n 200989.

Profibus is a communication protocol designed for controlling process equipment. It uses its own hardware and software command set to retrieve system data and to control some functions such as Mode selection and turning the compressor on and off.

Port	Standard ProfiBus DB9 connector on top of low voltage box Route through pass-through on Communications Panel
Cable	Standard ProfiBus DB9 Cable
“Slave ID” Address	1-125 Host command PROFIBUS_PARAMS,ADDRESS HMI “Set Comm Params”
Speed	9.6k, 19.2K, 45.45K, 93.75, 187.5K, 500K, 1.5M, 3M, 6M, 12M Set by: ProfiBus master controller Read by: Host command PROFIBUS_PARAMS,SPEED HMI “Set Comm Params”
Configuration	Profibus DP-V0 Slave Use appropriate GSD file to configure ProfiBus on host system

Figure 5-6: Profibus Pass-Through and Low Voltage Box Top Panel Connection

DeviceNet

DeviceNet communication is an available option. Refer to DeviceNet Interface User Manual, p/n 213645.

DeviceNet is a communication protocol designed to interconnect control devices for data exchange. It uses its own hardware and software command set to retrieve system data and has the ability to control some functions such as Mode selection and turning the compressor on and off.

Port	Connects to a standard microsealed DeviceNet connector on the Communications Panel
Cable	Standard DeviceNet 5-pin microsealed cable
Mac ID	(0-63) Host command DEVICENET_PARAMS HMI “Set Comm Params”
Speed	(125, 250, 500 Kbps) Host command DEVICENET_PARAMS HMI “Set Comm Params”
Protocol	Common industrial protocol (CIP), ODVA DeviceNet specification

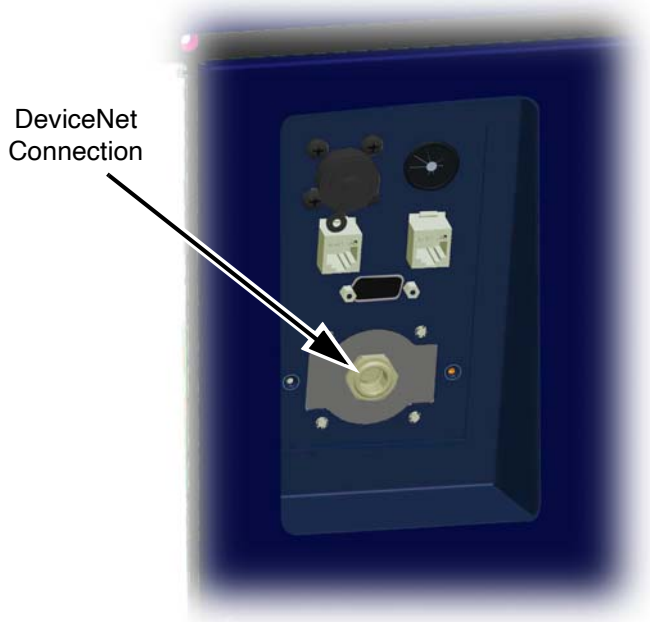


Figure 5-7: DeviceNet Communication Connection

24V DI/DO Remote Interface

The optional 24V DI/DO interface connection allows for direct wiring for inputs to and outputs from the Polycold Cryochiller similar to earlier PFC models.

The 24V DI/DO may be Isolated or Non-Isolated. Both isolated and non-isolated can control Single Circuit or Dual Circuit systems. See System Operational State Commands on page 7-16.

24V DI/DO Remote pins are either incoming commands or outgoing data.

- Incoming command lines carry control signals from the remote user to the Polycold Cryochiller.
- Incoming command lines are referred to as “Operate”.
- Outgoing data information lines send data from the Polycold Cryochiller to the remote user.
- Output data lines are either active or inactive.
- MaxCool Cryochiller Remote provides 2 set point relays instead of optional on the PFC.
- MaxCool Cryochiller Remote provides 1.2A maximum to power external devices.
- MaxCool Cryochiller Remote Interface does not support outgoing analog temperature signals.
- The Indicate Remote signal on the PFC goes away when in Remote mode when the compressor is off. On the MaxCool Cryochiller, this signal stays on.
  - This behavior is configurable in v1.4.0.3 and above by command LEGACY_REMOTE,COMP_SIGNAL_LOGIC or from HMI -> Top Menu -> Configuration -> Set Comm Params -> Legacy Remote -> Comp Signal Logic.
  - Default behavior in v1.4.0.3 is PFC backward compatible when v1.4.0.3 is installed. Users will see a change from the previous MaxCool behavior. In v1.4.0.3, jumping Pins 1/2 is not necessary as this function is controlled by software.
- Remote compressor on/off is supported by the MaxCool using pins 1 and 2.
  - Connect a switch or relay contact set to pins 1 and 2 to remotely control the compressor.
  - Connect a jumper between pins 1 and 2 to bypass the remote compressor control.
  - Customers who used J11 with a PFC unit must add a jumper between pins 1 and 2 on their side of the 37 pin connector. See also Remote EMO Connector Wiring on page 12-7.
  - This behavior is configurable in v1.4.0.3 and above by command LEGACY_REMOTE,COMP_SIGNAL_LOGIC or from HMI -> Top Menu -> Configuration -> Set Comm Params -> Legacy Remote -> Comp Signal Logic.
  - Default behavior in v1.4.0.3 is PFC backward compatible when v1.4.0.3 is installed. Users will see a change from the previous MaxCool behavior. In v1.4.0.3, jumping Pins 1/2 is not necessary as this function is controlled by software.
- When both COOL and DEFROST Legacy Remote signals are High, early PFC behavior was to put unit in Cool Mode. Original MaxCool behavior put unit in Standby Mode.
  - This behavior is configurable in V1.4.0.3 and above by command LEGACY_REMOTE,OP_MODE_LOGIC or from HMI -> Top Menu -> Configuration -> Set Comm Params -> Legacy Remote -> Op Mode Logic.
  - Default behavior in v1.4.0.3 is PFC backward compatible when v1.4.0.3 is installed. Users will see a change from the previous MaxCool behavior.

Item	Non Isolated (standard)	Isolated
Power	24 (-25/+17%) V AC/DC 10mA	
Port on Cryochiller	37-pin bulkhead connector (female pins)	37-pin bulkhead connector (male pins)
Connector	37 pin (Amp CPC-23) Male pins Use kit 840104-00	37 pin (Amp CPC-23) Female pins Use kit 840105-00
Input Connections	Customer-supplied external switch closes and returns the 24V AC (10mA) provided by the Polycold Cryochiller when active.	Customer-supplied 24(-25/+17%)V AC/DC (10mA) power must be applied to the input pin to activate internal opto isolator when active.
Output Connections	24VAC (10MA) output from Polycold Cryochiller when active. 1.2 A maximum total output. Customer must supply external relay or indicator to detect the output.	Internal relay contacts in the Polycold Cryochiller close when active. Contact rating is 10A Customer must supply 24 V AC/DC power which is returned by the output relay contacts when output is active.

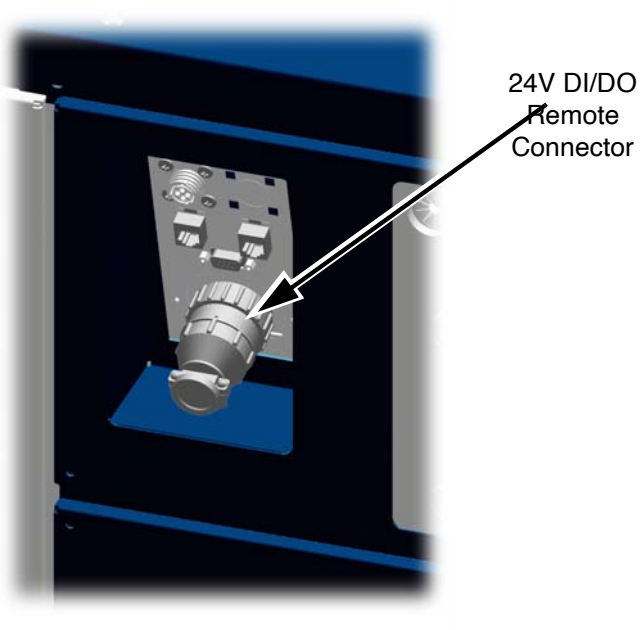
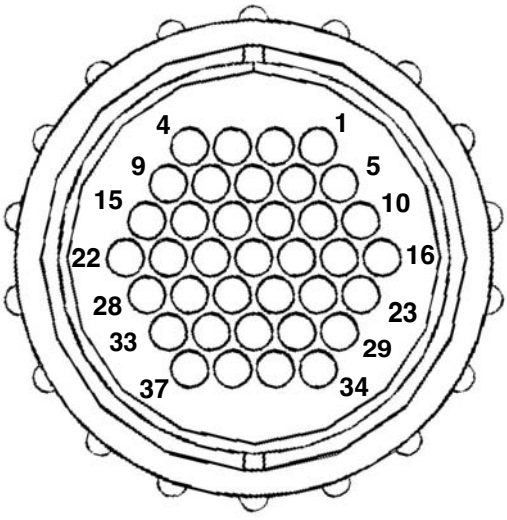
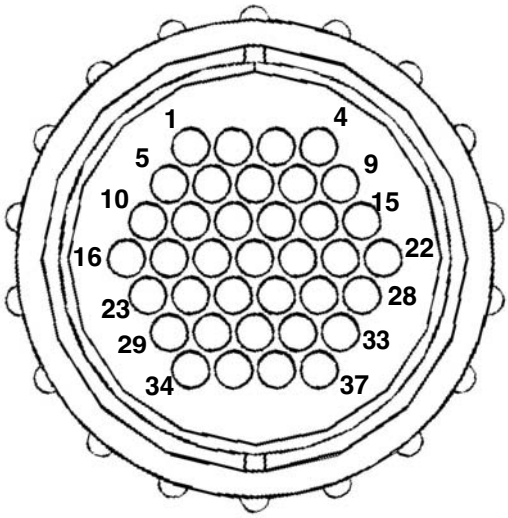


Figure 5-8: 24V DI/DO Remote
Communication Connection



Isolated pin sequence
Female pins, wire side view



Non-Isolated pin sequence
Male pins, wire side view

Figure 5-9: 24V DI/DO Connector Wire-Side Pin-Out

24 V DI/DO Single Circuit Non-Isolated

If a Polycold Cryochiller with the new 24V DI/DO non-isolated interface is replacing a PFC unit that used the standard PFC remote interface, please note that the Cryochiller isolated remote has some differences. Please carefully review the wiring information in this section.

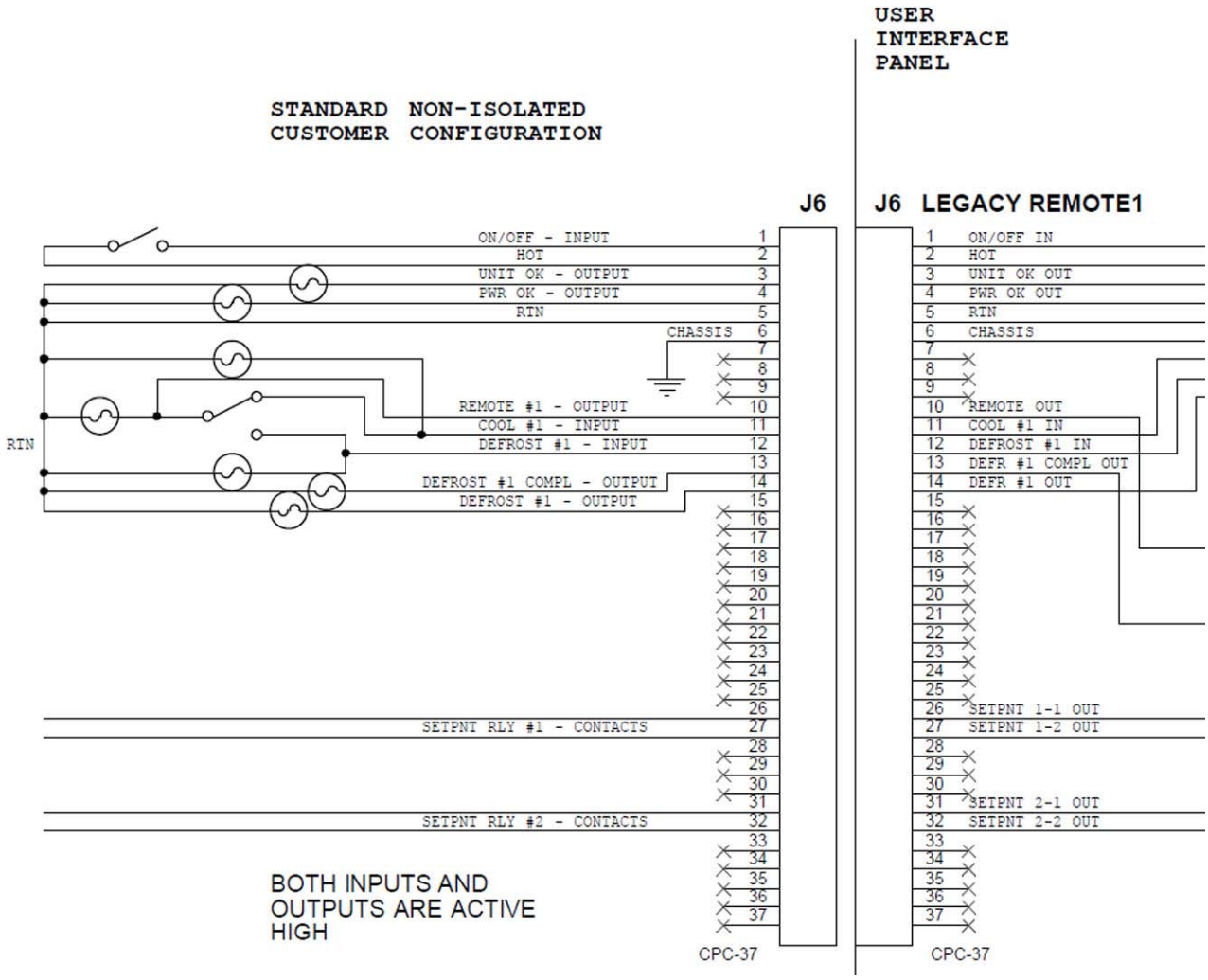


Figure 5-10: 24V DI/DO Single Circuit Non-Isolated

24 V DI/DO Dual Circuit Non-Isolated

If a Polycold Cryochiller with the new 24V DI/DO non-isolated interface is replacing a PFC unit that used the standard PFC remote interface, please note that the Cryochiller isolated remote has some differences. Please carefully review the wiring information in this section.

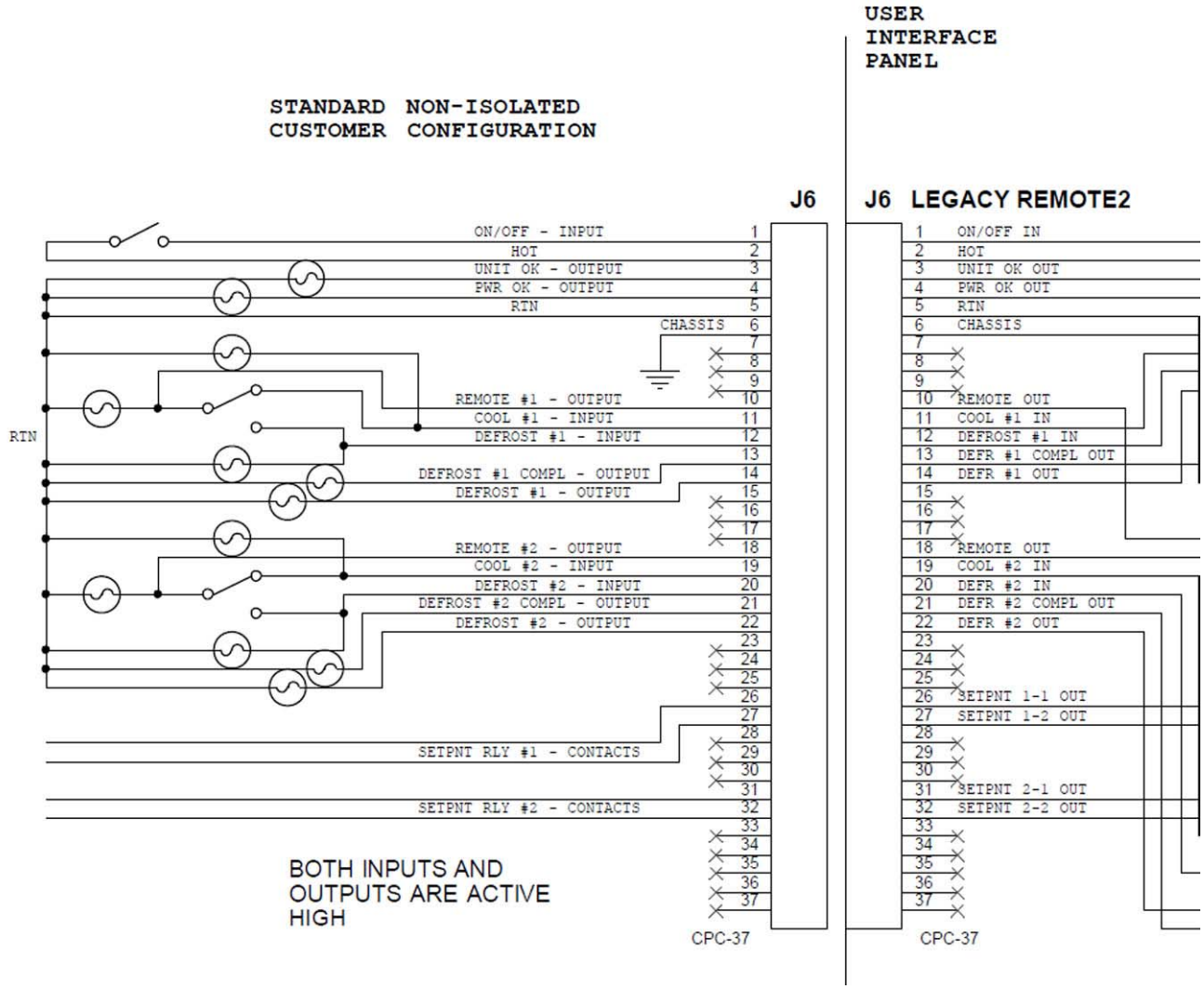


Figure 5-11: 24V DI/DO Dual Circuit Non-Isolated

24 V DI/DO Single Circuit Isolated

If a Polycold Cryochiller with the new 24V DI/DO isolated interface is replacing a PFC unit that used the optional PFC isolated remote interface, please note that the Cryochiller isolated remote has some differences. Please carefully review the wiring information in this section.

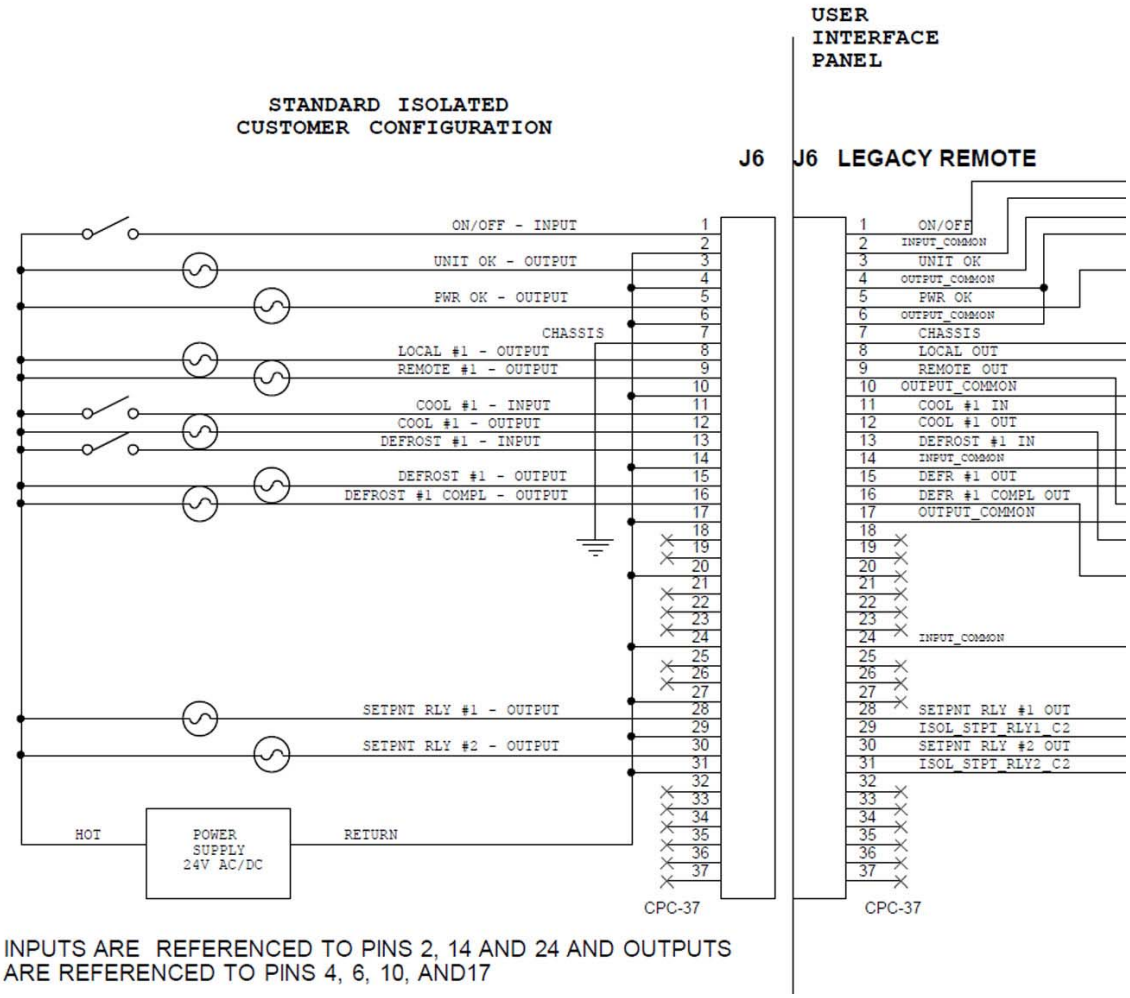


Figure 5-12: 24V DI/DO Single Circuit Isolated

1. External power supply can be connected per customer requirements (reversible supply support)

2. Active HIGH inputs and active LOW outputs. - Wire as above.

3. Active LOW inputs and active HIGH outputs. - Wire as above but reverse polarity of external power supply

4. Active HIGH input and active HIGH outputs. - Connect GND signal at the INPUT_COMMON TERMINALS (Pin 2, 14 and 24 of 37-Pin CPC connector) and +24V DC at the OUTPUT_COMMON TERMINALS (Pins 4, 6, 10 and 17 of 37-Pin CPC connector)

5. Active LOW inputs and active LOW outputs - Connect +24DC at the INPUT_COMMON terminals (Pins 2, 14 and 24 of 37-Pin CPC connector) and GND signal at the OUTPUT_COMMON terminals (Pin-4, 6, 10 and 17 of 37-Pin CPC connector)

24 V DI/DO Dual Circuit Isolated

If a Polycold Cryochiller with the new 24V DI/DO isolated interface is replacing a PFC unit that used the optional PFC isolated remote interface, please note that the Cryochiller isolated remote has some differences. Please carefully review the wiring information in this section.

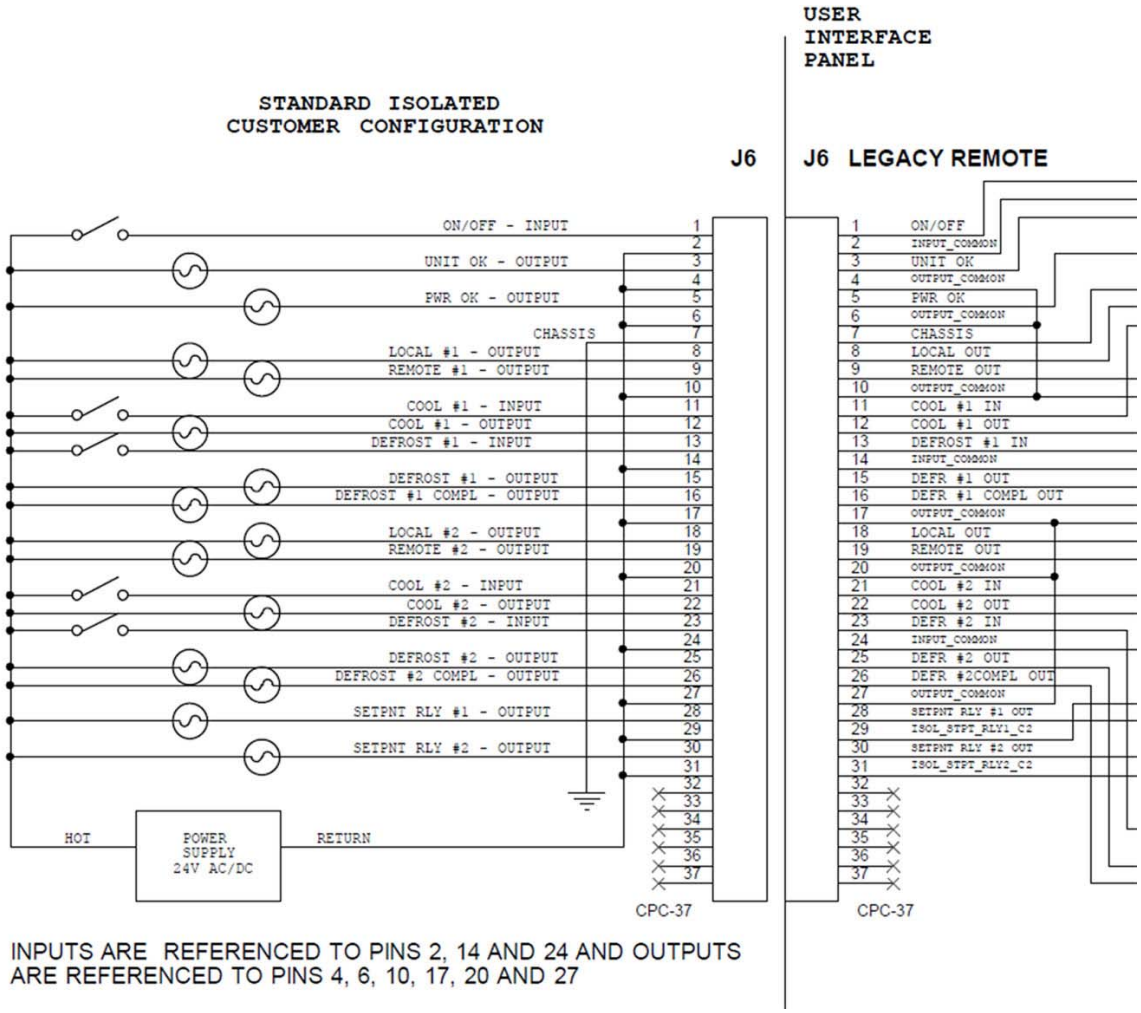


Figure 5-13: 24V DI/DO Dual Circuit Isolated

1. External power supply can be connected per customer requirements (reversible supply support)

2. Active HIGH inputs and active LOW outputs. - Wire as above.

3. Active LOW inputs and active HIGH outputs. - Wire as above but reverse polarity of external power supply

4. Active HIGH input and active HIGH outputs. - Connect GND signal at the INPUT_COMMON TERMINALS (Pin 2, 14 and 24 of 37-Pin CPC connector) and +24V DC at the OUTPUT_COMMON TERMINALS (Pins 4, 6, 10 and 17 of 37-Pin CPC connector)

5. Active LOW inputs and active LOW outputs - Connect +24DC at the INPUT_COMMON terminals (Pins 2, 14 and 24 of 37-Pin CPC connector) and GND signal at the OUTPUT_COMMON terminals (Pin-4, 6, 10 and 17 of 37-Pin CPC connector)

24V DI/DO Remote Installation

1. Locate the remote control plug parts kit that shipped with the unit. Note that the customer must provide a cable that is suitable for their interface requirements.

2. Slide the back shell of the connector over the cable.

3. Remove no more than 13mm (1/2 inch) of the outer cable jacket that covers the cable wire bundle.

4. Strip 4mm (5/32 inch) of insulation from each of the wires and pre-tin each wire.

5. Solder each wire to the solder tail of a pin. Do not insert the wire into the hole on the solder tail.

6. Cut the heat shrinkable insulating tubes into 13mm (1/2-inch) lengths. Slide one of the insulation tubes onto each soldered wire but do not shrink at this time.

7. Insert each pin into the appropriate contact socket on the back side of the connector. Push each pin in until it clicks into place. Gently tug the wire to confirm the pin is properly inserted.

8. Slide the 13mm (1/2-inch) long insulating tubes down to the connector so that they cover the uninsulated wire and solder joint. Shrink the insulating tubes in place using a heat gun.

9. Thread the connector back shell onto the connector and screw it on until tightened firmly.

10. Install the cable clamp using the two screws provided and tighten it over the cable jacket so it firmly holds the cable. The cable clamp may be reversed for large or small cables.

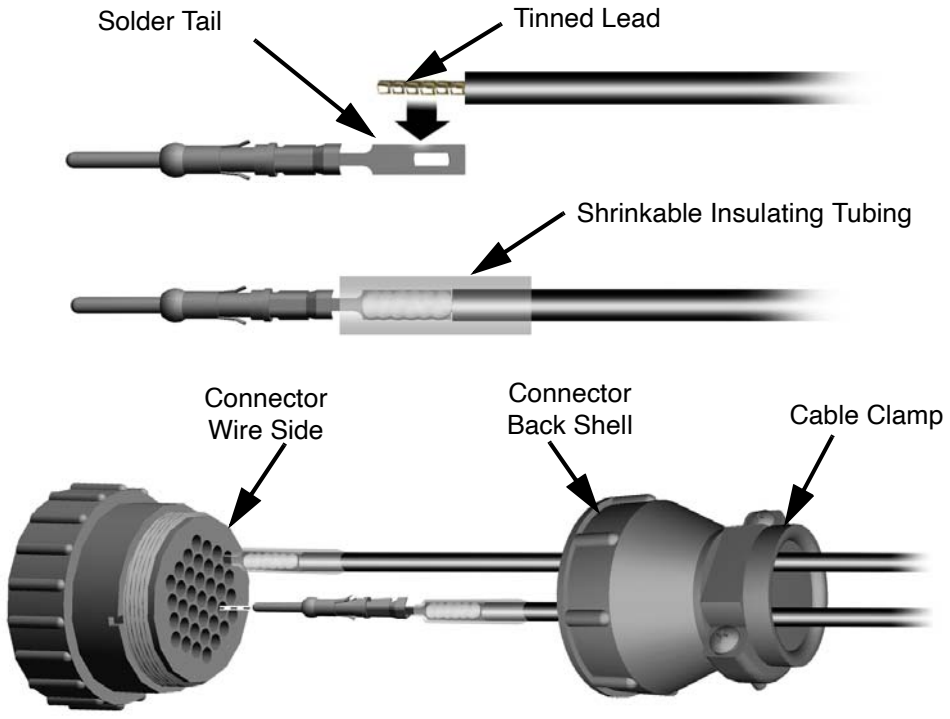


Figure 5-14: 24V DI/DO Remote Solder-tail Connector Wiring (non-isolated male pins shown)

6 Operation

Introduction

The Polycold Cryochiller is ready to operate as soon as it is installed.

Basic startup consists of only a few steps:

- Turn on the cooling water and ensure it is flowing through the system.
- Turn on the power at the electrical power source for the refrigeration unit.
- Switch CB-1 to the ON position.
- Switch CB-2 to the ON position.
- Wait about a minute for the system to boot up and the HMI screen to display information.
- Turn the EMO switch clockwise to set it to the disengaged position, if equipped.
- Switch the compressor On/Off switch to the ON position.
- The Polycold Cryochiller operates in Standby mode while it cools the internal stack and gets ready for normal operation.

To manually operate the unit,

- Set the unit to Local control by pressing the Remote key to turn off the LED. When the Remote LED is not lit, the system is in Local control.
- When ready, select Cool by pressing the Cool key.
- When ready, select Defrost by pressing the Heat key.

The Polycold Cryochiller has many different methods of operation that can be used to meet the specific needs of your application.

This chapter discusses the standard operating methods as well as other methods used for a variety of different application requirements and system configurations.

Review this chapter and your application to ensure that you use the appropriate features and get the best performance from your system.

System Components

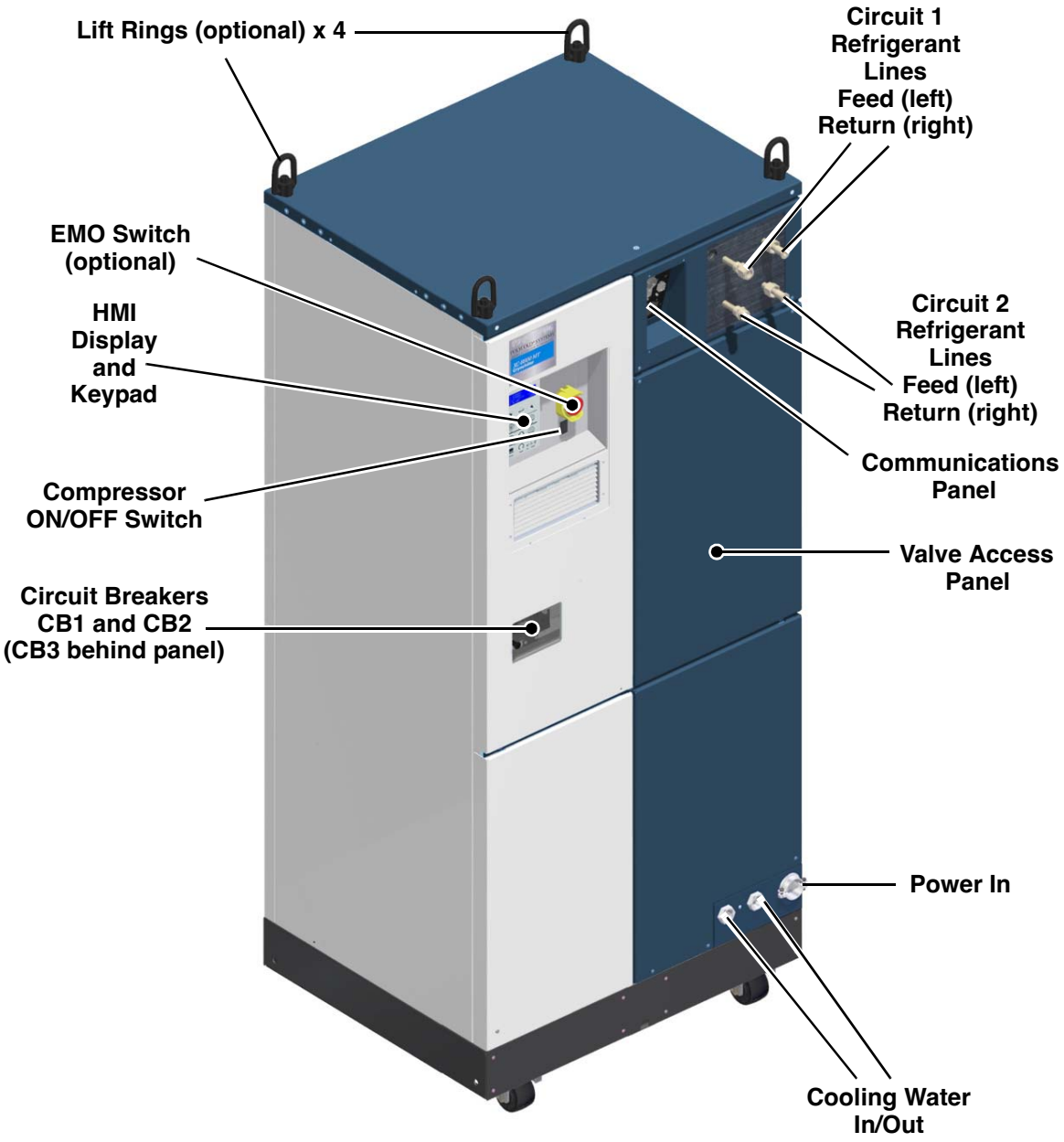


Figure 6-1: Illustration of Polycold Cryochiller Components

Local Controls and Indicators

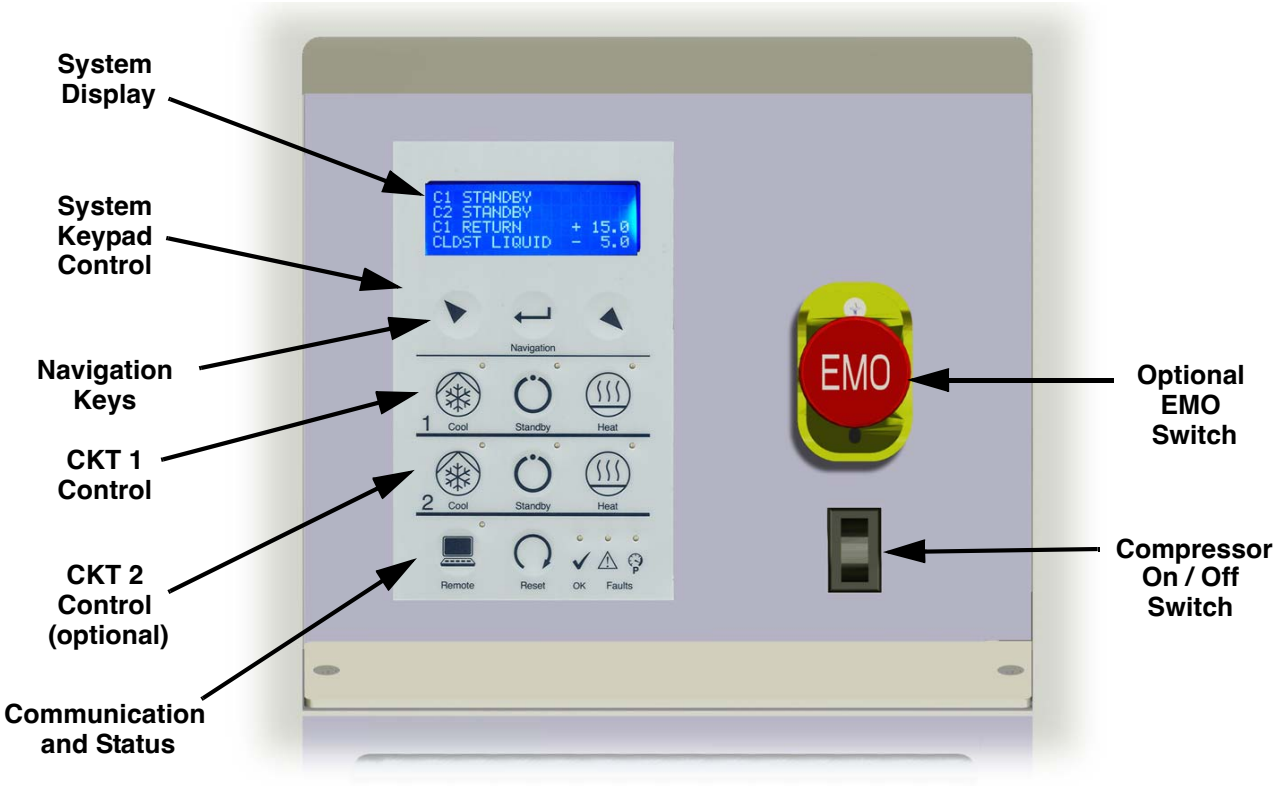


Figure 6-2: HMI Keyboard and Display

HMI Keypad

Table 6-1: Polycold Cryochiller Key Descriptions

	Switch or Indicator	Function
 	Up or Left Arrow Down or Right Arrow	Move cursor up or down or left or right. Increase or decrease the value of a highlighted field.
	Enter	Selects the current highlighted field. Enters the current submenu designated by > character Advances to next character in a selected field. Saves the current value after last character is selected Note: Cannot go backwards. Enter and redo if an error is created.

Table 6-1: Polycold Cryochiller Key Descriptions

	Switch or Indicator	Function
	Cool	Places associated refrigeration circuit in Cool Mode Green LED flashing • when cold cycle is running Green LED on solid • when unit is in Cool mode
	Standby	Places associated refrigeration circuit in Standby Mode Green LED on solid • when in Standby mode • when defrost is complete
	Heat	Places associated refrigeration circuit in Heat (Defrost) Mode Green LED flashing • when defrosting Green LED on solid • when defrost is complete
	Remote	Toggles the system between Remote and Local mode. Green LED on solid when system is in Remote mode Green LED off when system is in Local mode
	Reset	Resets faults
	OK	Green LED on solid • when the compressor contactor is on and contacts are closed.
	Faults - General (!) Faults - Pressure (P)	Amber General LED on solid • when a general fault has occurred See HMI message Red Pressure LED on solid • when high pressure fault has occurred See HMI message

LED Status Table

Table 6-2: LED Status Table

Status / LED	Cool LED	Standby LED	Heat LED	OK LED	Remote LED	Faults LED
Power On Compressor Off	Off	Off	Off	Off	Off	Off if no fault
Power On Compressor On	As set	As set	As set	On when contactor on	As set	Off if no fault
At Cool	On	Off	Off	On when contactor on	As set	Off if no fault
Standby	Off	On	Off	On when contactor on	As set	Off if no fault
Defrost in Process	Off	Off	Flash	On when contactor on	As set	Off if no fault
Defrost Complete	Off	On	On	On when contactor on	As set	Off if no fault
Rapid BP Check	Off	Off	Off	On when contactor on	As set	Off if no fault
Fault	As set	As set	As set	On when contactor on	As set	On

Single Circuit Modes of Operation

The MaxCool Cryochiller must have a proper refrigerant line and cryosurface connected to it in order to operate in any mode, including standby.

The Base Model cryochiller has three modes of operation.

Standby

When the unit is in Standby, the Cool and Defrost solenoid valves are closed. The unit circulates (and cools) the refrigerant in the “stack” in the top of the refrigeration unit. The refrigerant is not pumped to the cryosurface. The refrigerant is coldest when the unit is operating in this mode because it has the least heat load.

All solenoids and valves are closed when in Standby mode with the exception of the following:

- Freezeout Prevention valve logic based on the FRZ_PREVENT_SETPT Host command value controlled around the Coldest Liquid Temperature (TC4) thermocouple reading. Default is -148C.
- Logic associated with compressor startup where the Buffer valve may be opened
- Logic for the Cylinder Unloader solenoid for power management

If the Cylinder Unloader solenoid is enabled, it is activated if the unit is in Standby for more than the time designated by the command POWER_MGMT_STANDBY_DELAY. Default value is 20 minutes. E_MGMT_ENABLE is enabled by default if the system is equipped with Cylinder Unloader.

Compressor will continue to run when in Standby Mode.

After power up, when the compressor is turned on, the system always defaults to Standby mode.

On system Alarm/Fault which shuts down the compressor, once the compressor is turned back on, the system defaults to Standby mode.

Standby mode can be selected using HMI or the command line interface.

If the unit is in a Standby mode, another mode (Cool or Defrost mode) can be selected.

Cool

When the unit is put into Cool, the Cool solenoid valve opens and the Defrost solenoid valve closes. Cold refrigerant is pumped into the feed line then to the cryosurface and cools the cryosurface and returns through the return line to the refrigeration unit. Inside the refrigeration unit, the refrigerant releases the heat it absorbed from the cryosurface and then it is pumped through the system to repeat the process.

Cool Mode	Description
Cool (Standard)	Cool valve is open continuously until the unit is switched to Standby or Defrost. The cryosurface gets as cold as possible as fast as possible for the applied heat load.

Cool Mode Selection

Cool modes can be selected using the HMI or the remote command line interface or the web GUI to set the default Cool mode for the Cool button(s).

The unit must first be turned to Standby or Defrost then back to the desired Cool mode.

Defrost

When the unit is put into Defrost, the Cool solenoid valve closes and the Defrost solenoid valve opens. Hot refrigerant is pumped from the unit into the feed line then to the cryosurface where it warms the cryosurface and returns through the return line. The unit automatically switches to Standby when the return temperature or coil out temperature has reached the programmable set point temperature.

Some optional configurations of the Polycold Cryochiller include multiple Defrost Modes

Defrost Mode	Description
Standard Defrost (standard)	Defrost valve is open until DEFR_SETPT is reached. After DEFR_SETPT is reached, the valve is closed.

Defrost Mode Selection

Defrost modes can be selected using the HMI or the remote command line interface to set the default Defrost mode for the heat buttons.

Dual Circuit Modes of Operation

Each refrigerant circuit in the dual-circuit Polycold Cryochiller functions in the same way as the single-circuit Polycold Cryochiller. The only difference is that the refrigerant is split into two separate feed and return lines so that it serves two cryosurfaces. Both refrigerant circuits can be put into Defrost mode or Cool Mode or Standby Mode.

When one circuit is in Defrost while the other circuit is in Cool, the circuit in Cool may warm by a few degrees, nominally about 5 degrees.

The timing of the Defrost activity may be considered to maintain your process requirements. If the second circuit is a baffle for a diffusion pump, this is not an issue. However, when both circuits are used to cool cryocoils, you must evaluate the impact on your process when you defrost one circuit while the other circuit is in Cool during a deposition process.

If the refrigerant circuits are operated in different modes, the following will happen.

One Circuit Standby and One Circuit Cool

The cryosurface being cooled will get several degrees colder than when both cryosurfaces are cooled simultaneously. This is because there is less total heat load on the system. It is not possible, however, to get 100% of the cooling capacity into one circuit simply by not using the other circuit.

One Circuit Defrost and One Circuit Cool

The cryosurface being cooled may warm by about 20 C degrees. The warming is caused by refrigerant from both cryosurfaces being combined in the common return line.

One Circuit Defrost versus One Circuit Standby

The cryosurface being defrosted may have a defrost time that is slightly longer than when both cryosurfaces are defrosted at the same time.

Compressor Safety Chain

If the compressor does not start, it is usually caused by an item in the Compressor Safety Chain.

The compressor safety chain consists of several hardware and software interlocks that cause the compressor to stop or prevent the compressor from starting.

Table 6-3: Compressor Safety Chain

Safety Chain Item	Description
Compressor ON/OFF switch (SW1)	Switch on HMI panel controls compressor contactor. Must be manually turned on for contactor to close and compressor to run.
Circuit breaker CB1 (CB1)	CB1 controls input power for entire compressor unit Must be manually turned on or manually reset.
Circuit breaker CB2 (CB2)	CB2 controls power to the low voltage transformers Must be manually turned on or manually reset.
Circuit breaker CB3 (CB3)	CB3 controls low voltage power to the control PC Board. If off, the main control PC Board looses power and contactor opens and all electrical valves close Must be manually turned on or manually reset.
Emergency Off Button (EMO) (if equipped on unit)	EMO provides emergency control for compressor contactor. If the EMO button is pressed in, compressor contactor opens. EMO button must be manually disengaged to enable contactor
Optional Remote Emergency Off Button (EMO) (if equipped on unit)	Remote EMO provides remote emergency control for compressor contactor. If the Remote EMO connection is open, compressor contactor opens. Remote EMO connection must be closed to enable contactor
Compressor Over Temp Switch	Over Temp switch is a thermal cut out switch located inside the compressor motor and wired in series with the compressor power. Opens when compressor motor temperature is above the rated value. Closes when compressor motor temperature is below rated value.
Pressure switch (PS1)	Pressure switch is mounted in compressor discharge line. Wired in series with EMO and SW1. Trigger pressure is preset. Switch opens if discharge pressure is above the rated value. Switch closes when pressure is below rated value.
Software “Thermal Overload” Fault	Software monitors system performance comparing suction and discharge pressures. Generates “Thermal Overload” fault when conditions are met. Fault condition opens the compressor contactor. Fault resets after a 30 minute wait period.

Polycold Cryochiller Startup

System Boot/Power-Up

1. Before compressor power up, read the pressure gauge and compare the reading to the recorded system static pressure. If the pressure reading is off by greater than 10%, record the value and contact service for advice.
2. Open the Circuit Breaker Access panel.
3. Set CB1 to the UP or ON position.
4. Set CB2 to the UP or ON position.
5. Wait several seconds for the system to fully boot up.
   - Boot up is complete when the 4-line HMI displays shows the “Home” screen.
   - Cool / Standby / Heat mode LED’s are not lit until the contactor is closed
   - Boot up is not affected by compressor contactor or On/Off or EMO switches.

Compressor Startup

Use one of the following methods to start the compressor after system boot up completes.

- If the compressor switch is in the OFF position when system boot up completes, switch the compressor switch to ON
- If the compressor switch is in the ON position when system boot up completes, toggle the compressor switch to OFF and then to ON.
- If the compressor does not startup, refer to Compressor Safety Chain on page 6-7 and Compressor Motor Troubleshooting on page 10-4.

Alternate Compressor Startup

1. Set the compressor switch on the control panel to the ON position.
2. Use the **Remote** button to set the system to Local mode (Remote LED not Lit)
3. Press the **Reset** key to set the compressor contactor to ON.
   - Compressor turns on
   - OK LED is lit.
4. After the compressor starts, the Standby LED is on until the operating mode is changed.

NOTE: *Several conditions prevent compressor starting. See Compressor Motor Troubleshooting on page 10-4*

Operating the Polycold Cryochiller with a Cryocoil

Start and Cool the System

1. Follow the System Boot/Power-Up and Compressor Startup procedures in the previous section.

2. Switch the unit to Standby using the HMI or remote control.

3. Monitor the temperature indicated by Coldest Liquid (TC # 4).
   - TC # 4 monitors the temperature of the refrigerant in the coldest part of the stack and is a good indicator of when to switch to Cool mode.
   - For quick cooling when switching to Cool, TC # 4 should be 5 -10°C colder than the desired cryocoil temperature. See Table 12-1 on page 12-9

NOTE: *The unit may be operated indefinitely in Standby.*

If the unit is off for more than 12 hours, it may take up to 30 minutes after going into Standby to attain complete precooling.

4. Once the unit has cooled to the desired temperature, the circuit may be switched to Cool mode any time after the vacuum chamber has achieved vacuum. Most users switch to Cool at crossover when opening the high vacuum valve. The cryocoil will start capturing water vapor within 60 seconds.

NOTE: *Experiment to determine the shortest pumpdown time for each application.*
The sooner the unit is switched to Cool, the faster the vacuum chamber's pumpdown time will be. However, switching too soon may cause the cryocoil to capture too much water vapor causing the cryocoil's apparent surface temperature to rise and limit the ultimate attainable base pressure.

NOTE: *You can use a relay contact from a vacuum gauge on your system to control when to switch into cool. See Gauge Relay (J4) on page 5-3.*

Defrost the Cryocoil

Defrost allows the “regeneration” of a cryocoil in preparation for the next vacuum cycle.

1. Switch the unit to Defrost using the unit's control panel or remote control.

NOTE: *Start Defrost so that the cryocoil is warm before the vacuum chamber reaches atmospheric pressure. A typical Defrost takes 4 minutes or less. The exact time depends upon the length of the refrigerant line and the size of the cryocoil.*

2. By default, the unit terminates Defrost when the return temperature of the refrigerant reaches 20°C. This assures that no additional moisture condenses on the cryocoil from the atmosphere.

   The thermocouple and the end point temperature are user configurable if a shortened Defrost cycle is desired.

3. The unit automatically goes into Standby when Defrost is complete.

CAUTION

Defrost Hazard

If large amounts of water are collected during the vacuum cycle, liquid or ice may drop from the cryocoil during Defrost.

You may need to provide a drip pan or similar device to prevent liquid water from accumulating in an undesirable location

NOTICE

Dual Polycold Cryochiller Defrosting

When defrosting one circuit while the other circuit is in Cool, the temperature of the circuit in cool may increase.

Review the required temperatures for the affected process to make sure the warming does not affect the process. If the temperature change is not acceptable, wait until the completion of the cool process before performing Defrost.

Both circuits may be defrosted at the same time.

Operating the Polycold Cryochiller with a Cryobaffle

An optically transparent cryobaffle enhances the water vapor pumping speed of the turbomolecular pumps and an optically opaque cryobaffle minimizes oil backstreaming from oil diffusion pumps. Backstreaming is the process of hot vapor migrating and condensing on cold surfaces. When an oil diffusion pump is in operation, the pump oil heats up and hot oil vapor can travel opposite of the pumping direction and condense on the interior vacuum chamber walls and contaminate the system.

Standby and Cool Modes

1. Switch the unit to Standby using the unit's control panel or remote control.
2. If the compressor switch is turned OFF, turn the switch to ON.
3. When in Standby, the refrigeration unit cools the refrigerant so the unit is ready to go into Cool mode.

NOTE: *If the unit is off for more than 12 hours, it may take up to 30 minutes after going into Standby to attain complete precooling.*

4. Evacuate the vacuum chamber where the cryobaffle is installed to at least 0.01 torr (1.33 Pa).
5. From Standby, select Cool and allow the cryobaffle to cool down.
6. Turn on the high vacuum pump. It is not necessary to wait until the cryobaffle has cooled down.

Defrost the Cryobaffle

NOTE: *If the cryobaffle captures too much water, the cryobaffle's apparent surface temperature will rise and limit the ultimate attainable base pressure. Regular defrosting is recommended to "regenerate" the cryobaffle. Complete defrosting can take 8 hours or more depending upon the amount of moisture captured, the mass of the cold surface, and the vacuum level.*

1. When ready to defrost, switch the high vacuum pump to OFF.

2. Switch the refrigeration unit OFF or switch it to Standby.

NOTICE

Do not select Defrost if the cryobaffle is not isolated from the oil diffusion or turbomolecular pump. The Defrost cycle may release the captured moisture too quickly and damage the equipment.

3. When the cryobaffle is free of moisture, return the system to Cool mode as described at the beginning of this procedure.

7 Host Commands

This chapter lists the common commands used by RS-232 or Ethernet for an operator to control and configure the Polycold Cryochiller from a host or service computer. Refer to the Interface chapter in the Polycold Cryochiller Installation and Operation manual for interconnect information.

The Host Commands are not used by Profibus or DeviceNet which each have their own communication protocols.

Command Group Listing

Command Format

Command Format

Command Format

Commands are either **GET** or **SET** commands based on comma separated parameters following the command name. Use GET to check the status of something and SET to change a setting.

Host commands use the following protocol

- Must be sent by RS-232 or Ethernet connection
- Ethernet port for Host commands is port 5000
- Must begin with the $ character followed by the specific command with associated parameters.
- Parameters are separated with a comma.
- Command must end with a single character checksum.
- The Checksum is a single character that follows the parameters and is not separated by a comma. Software interprets the last character in a string as the command checksum.
- Checksum is calculated by the 8 bit sum of all characters sent following $calculated by the equation in Checksum Calculation on page 7-4.
- Must be terminated with an ASCII Carriage Return (CR) (Hex 0D).
- Must be sent complete to Polycold Cryochiller under 10 seconds from the $ to the <CR> for the unit to recognize data sent as a complete command
- Must be sent as uppercase ASCII characters

Get Example:

Get software version "***$SW_VER,?P****(CR)*".

Set Example:

Set cooling termination set point "***DEFR_SETPT,1,19D****(CR)*".

Response Format

The first character of the response from the Polycold system to the external device provides information about the specific command received along with information about whether the command succeeded.

Table 7-1: Command Response Codes

Letter	Meaning
'A'	Command understood, reply (if any) follows.
'C'	Proper command, which cannot be acted upon currently for some reason which, may be temporary or correctable. Typically because you have not entered the correct security level.
'F'	Invalid command or invalid data argument for the given command. Set commands have min and max values associated with each command. If a set command uses a value outside the min/max range, 'F' is the response.

Command Terms

The following will be used to represent the format of command and reply parameters.

[n] = a numeric value (0 thru 9)

[nnnn] or [nnn.n] = a multi-numeric value which may contain a decimal place (Example: 1234 or 567.8)

[nnnnnnnn] = 32 bit number / bitfield

[c] = a character value such as an alphabetic character

[cccc] = a multi-character value which may contain alphabetic character and/or numeric values.

[A] = the reply code. The first character of the response from the Polycold system to the external device provides information about the specific command received along with information about whether the command succeeded. Refer to Response Code Table 7-1.

32 Bit Numbered Bitfield

Bitfields are hexadecimal data that contain parameter data that is interpreted using the decimal value. Follow the steps below to find the decimal values in the hexadecimal bitfield value.

- Convert the hexadecimal value to binary.
- Determine the value of each set bit by counting the binary bits starting from the least significant bit as zero.
- Record the decimal value of all of the bits that are set.
- Look up the decimal values of each set bit in the parameter listing for the command.

Example of Remote Monitor Usage Use with Table 7-2.

1. Send the command “ACTIVE_ALARMS, 1, ?

2. Receive the response ACTIVE_ALARMS $A 00002000, 0, 0.
   00002000 is the Hexadecimal response.

3. Translate the hexadecimal value of 00002000 to binary.
   - The first three hex digits are 0 and the 4th hex digit is 2.
   - The 4th hex digit value of 2 decodes to 0010 in binary.

4. Find the decimal value of each set binary bit by counting from the LSB with the LSB being 0.
   - The table shows that hex 00002000 is decimal value 13.

5. Look up the decimal value in the parameter list. This example shows that alarm bit 13 is set.

Table 7-2: Hexadecimal Bit Field Decoding

Hex Bit	Hex Digit 4				Hex Digit 3				Hex Digit 2				Hex Digit 1			
Hex Value	**2**				0				0				0			
Binary Value	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7-2: Hexadecimal Bit Field Decoding

Hex Bit	Hex Digit 4				Hex Digit 3				Hex Digit 2				Hex Digit 1			
Decimal Value	15	14	**13**	12	11	10	9	8	7	6	5	4	3	2	1	0

Hex Bit	Hex Digit 8				Hex Digit 7				Hex Digit 6				Hex Digit 5			
Hex Value	0				0				0				5			
Binary Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decimal Value	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Checksum Calculation

Each command must end in a valid checksum. For heavy usage, it s recommended that the checksum be calculated using a program/script/macro.

The checksum algorithm is defined as follows:

Perform the 8 bit sum of all the ASCII characters sent in the data field (with the most significant bit cleared to 0, ignore parity). This is performed on the first character following the '$' up to the last data character before the checksum and Carriage Return (CR)

C Language example for checksum calculation:

```
////////////////////////////////////////////////////////////////////////////////////////////////
// Function:    CtiChkSum
// Purpose:     Calculate the checksum for a given NULL terminated
//              command.
unsigned char CtiChkSum (unsigned char * pCommand)
{
unsigned char checkSum = 0;
unsigned char
 = 0;
do
{
    checkSum = checkSum + (pCommand[charNum] & 0x7f);
    charNum++;
} while ( pCommand[charNum] != 0 );
checkSum = 0x3f & (checkSum ^ (checkSum >> 6) );
checkSum = (0x30 + checkSum) & 0x7f;
   return checkSum;
}// End Function CtiChkSum
```

Excel Macro for Checksum Calculation

A macro may be created in Microsoft Excel using Visual Basic to calculate a checksum of a command.

Create an Excel Macro

1. Open Excel.
   Click the Microsoft Office button on the upper left corner.
   Click on the “Excel Options” button.
   Click on the check box to enable “Show Developer tab in the Ribbon”.
   Click OK.

2. Click the Developer Tab.
   In the “Code” tab click Macro Security.
   Select “Enable all Macros”.
   Click OK.
   Note: at the end of this session, return the settings to their original state.

3. In the Developer Tab, Code Tab, click on “Visual Basic”. The Visual Basic program opens.
   If a “Module” window does not open, click “Insert” in the Visual Basic tool bar and click “Module”.

4. Copy the command strings below and paste it into the Macro window.

```
Sub CalculateCheckSum()

Dim CommandString, checksum, character

Dim LengthofCommandString, Counter As Integer

checksum = 0

CommandString = Application.InputBox("Enter the Command To Calculate checkSum (ex.
SW_VER,?)", "CommandString")

LengthofCommandString = Len(CommandString)

For Counter = 1 To LengthofCommandString

character = Mid(CommandString, Counter, 1)

checksum = checksum + (Asc(character) And &H7F)

Next Counter

checksum = checksum And &HFF

checksum = &H3F And (checksum Xor (Int(checksum / (2 ^ 6))))

checksum = (&H30 + checksum) And &H7F

checksumChar = Chr(checksum)

checksumstring = "CheckSum Character is: " & checksumChar

Response = MsgBox(checksumstring, 0, "CheckSum Result")

End Sub
```

5. Save the Excel program using a name you might remember such as “CheckSum Macro”.

Test or Use the Excel Macro

1. Test the Macro by closing Excel and then opening the CheckSum Macro Excel file.
2. Click on Developer tab, click Macros. Select the CalculateCheckSum Macro. Click Run.
3. Enter the sample command SW_VER,? using upper case only. Press OK.
4. Excel calculates the checksum and a checksum window appears. The window should show the checksum is P. If not, check the command that you entered and check the macro.
5. To use the macro, follow the steps above entering the command in all caps without the $.

Example of Interface Usage:

A user has a Polycold Cryochiller with connections for both the RS-232 port and Ethernet Port and wants to set a parameter value for DEFR_SETPT using the RS-232 connection.

In the RS-232 terminal, the user must

- Send a command to set **SYSTEM_CONTROL_MODE** to **2** (RS-232 port)
- Send a command to set **DEFR_SETPT** along with the value to be set

If the interface sends a Set command and the interface does not have control, the host will respond with **"C"** which means that the command is OK but cannot be executed.

Example of a Get Host Command

$SW_VER,?P command to get current installed software version

$ then command **SW_VER** then **,?** (get parameter) then **P** (command checksum)

$AQF0.1.0.32I response to command to get current installed software version

$ then response code **A** (accepted) then response value **QF0.1.0.32** then I (response checksum)

Example of a Set Host Command

$SYSTEM_CONTROL_MODE,04 command to Set System Control Mode

$ then command **SYSTEM_CONTROL_MODE** then **,0** (set to 0 local mode) then **4** (checksum)

$A0 is the response for Set System Control Mode

$ then response code **A** (accepted) then **0** (checksum)

Set Command Information

Most Set values for parameter Host commands are stored to non-volatile flash memory when the SET is executed.

However, some configuration Set command values are not stored and must be set again after a power cycle or CPU reset.

Example SECURITY_LEVEL, SYSTEM_CONTROL_MODE

Set commands have min and max values associated with each command. If a set command uses a value outside the min/max range, F is the response.

Set values take affect immediately and do not require a system restart or power cycle to take effect.

Security Levels

Polycold Cryochiller command functions are security protected and require that the security level be set to a specific level in order to perform the Get or Set command functions.

- Security Level 1 - Limited Operator Access -Password: 02030A (where all 0s are zeros) Limited user access. Allows for locking operators out of access to commands.
- Security Level 2 - Default Operator Access - Password: 02030B (where all 0s are zeros) Normal unit access. Normal operations are available such as Cool, Defrost, Rapid BP Check.
- Security Level 3 - Some Configuration / Maintenance (manager access) Contact Brooks Polycold for password Access to service menu for Zero Line Loss function to allow disconnect and installation.

Security levels follow these rules.

- “Get” and “Set” functions for each command require a specific security level and the command function does not perform unless the security level is set to the required level or higher.
- Security level for Get and Set functions for each command are hard coded and cannot be changed.
- The default system security level is 2 and cannot be changed.
- Current security level can be temporarily changed by Host command SECURITY_LEVEL.
- Security level set to 1 stays at 1 until changed by the SECURITY_LEVEL command or the system is power cycled.
- Security level set above level 2 changes back to default level 2 after 5 minutes of inactivity.
- Time to change back to default can be set using the SERVICE_INTERVAL command.
- Security Levels are interface dependant.
  Example: setting a SECURITY_LEVEL of Level 3 through RS232 Host port does not change the Security Level of the ETHERNET Host port, WEBGUI, or HMI.
- Security level does not affect HMI access.
- HMI access to Service Modes "Authorization Code" menu requires a Security Level password of 2 or higher. The HMI Service Modes menu options are based on the Security Level password that is entered.

Example of Security Level

User wants to set DEFR_SETPT value. This command has a Get security level of 1 and a Set level of 3. System security level is 2 by default.

- User can use a **Get** command for **DEFR_SETPT** since get is level 1.
- User cannot use **Set** command since the set level is 3.
- User must change the security level to 3 or above to use **Set** command for **DEFR_SETPT**.
- If a command is not accepted for security reasons, the response is “C”.

Command Listing Format

The commands are listed in this chapter using the title block and table format shown below.

ABC_DEF Description of the Command

Purpose:	Describes the purpose of the command	
Parameter(s):	List of parameters	
Return Value:	Lists information the system returns for this command [A][nn.nn.nn.nn]	
Default Value:	Default command value, if applicable	
Security Level:	Security required to Get the value	Security required to Set the value
Example:	Sample of command with exact syntax	
Interface	Interface options available for this command	

Commonly Used Host Commands

Table 7-3: Commonly Used Host Software Commands

Command	Description
SENSOR_SNAPSHOT	Returns value of all current system thermocouple and state of all system commanded valves Return value: 1e70ff7f,0,23.5,23.5,23.5,171.8,171.8,171.8,121.1,0.0,171.8,171.8,171.8,171.8,171.8,171.8,171.8,171.8,0.0,0.0,0.0,0.0,23.9,25.2,0.0,0.0,0.0,0.0,0.0,180.6,92.0,0.0,0.0,0.0,0.0,0
SYSTEM_CONTROL_MODE	Get/Set the current “Control” interface of the system (ie. RS-232, Ethernet etc.
SYSTEM_CONTROL_MODE_DEF	Get/Set the current default “Control” interface of the system (ie. RS-232, Ethernet etc.)

Command	Description
SECURITY_LEVEL	Get the current security level setting
COMP_MOTOR_STATE	Get / Set the current state of the Compressor Motor ON/OFF
ACTIVE_ALARMS	Get current alarms/warning pending on the system. The return value is a Hex encoded bitfield corresponding to the current alarms
RESET_ALARMS	Acknowledge Alarms. Clears alarms if the condition causing the alarm is resolved
OPERATING_MODE	Get/Set the system Cool/Defrost modes and Standby mode
SW_VER	Get the currently running system software/firmware version
UNIT_BALANCE_PRESSURE	Get the system balance pressure (static charge)
DEFR_SETPT	Get/Set the system setpoint for Defrost modes

System Configuration Commands

SW_VER Software Version & Build Number

Purpose:	Returns identifier strings for the current software version and build number.	
Parameter(s):	?	
Return Value:	[A][nn.nn.nn.nn] (major.minor.patch.build)	
Default Value:	N/A	
Security Level:	Get: 1	Set (none)
Example:	“SW_VER,?” Get application software revision	
Interface	RS-232, Ethernet	

VENDOR_ID Get the DeviceNet Vendor ID

Purpose:	Returns identifier string indicating the vendor ID. Only returns a value if DeviceNet config is installed	
Parameter(s):	?	
Return Value:	[A][cccccccc]	
Default Value:	N/A	
Security Level:	Get: 1	Set: N/A
Example:	“VENDOR_ID,?”	
Interface	RS-232, Ethernet	

IP_ADDR IP Address

Purpose:	Get/set the IP Address for the system.	
Parameter(s):	? or [nnn.nnn.nnn.nnn] [nnn.nnn.nnn.nnn] is the IP address	
Return Value:	[A] or [A][nnn.nnn.nnn.nnn]	
Default Value:	0.0.0.0	
Security Level:	Get: 1	Set: 3
Example:	“IP_ADDR,192.168.1.100” Set the IP Address for host port	
Interface:	RS-232, Ethernet	

DEFAULT_GATEWAY Default Gateway

Purpose:	Get/set the default network gateway for the system.	
Parameter(s):	? or [nnn.nnn.nnn.nnn] [nnn.nnn.nnn.nnn] is the Gateway address	
Return Value:	[A] or [A][nnn.nnn.nnn.nnn]	
Default Value:	0.0.0.0	
Security Level:	Get: 1	Set: 3
Example:	“DEFAULT_GATEWAY,192.168.1.1” Set the default gateway for host port	
Interface	RS-232, Ethernet	

NETWORK_MASK Network Mask

Purpose:	Get/set the subnet mask for the system.	
Parameter(s):	? or [nnn.nnn.nnn.nnn] [nnn.nnn.nnn.nnn] is the Network Mask address	
Return Value:	[A] or [A][nnn.nnn.nnn.nnn]	
Default Value:	0.0.0.0	
Security Level:	Get: 1	Set: 3
Example:	“NETWORK_MASK,255.255.255.0” Set the subnet mask for host port	
Interface	RS-232, Ethernet	

DEVICENET_PARAMS DeviceNet parameters

Purpose:	Set / Get the DeviceNet speed and mac id	
Parameter(s):	? or [speed],[Mac ID] [speed] is - 0 = 125k - 1 = 250k - 2 = 500k [Mac ID] is 0 - 63	
Return Value:	[A] or [A][speed],[Mac ID]	
Default Value:	A,63	
Min: [speed] = 0 [Mac ID] = 0		Max: [speed] = 2 [Mac ID] = 63
Security Level	Get: 1	Set: 3
Example:	“DEVICENET_PARAMS,?”	
Interface	RS-232, Ethernet	

PROFIBUS_PARAMS Profibus parameters

Purpose:	Bet the profibus speed and Get/Set Profibus	
Parameter(s):	SPEED,? or ,ADDRESS,? or ,ADDRESS,[address] [speed] is READ ONLY - 0 = 9.6k - 1 = 19.2k - 2 = 45.45k - 3 = 93.75k - 4 = 187.5k - 5 = 500k - 6 = 1.5M - 7 = 3M - 8 = 6M - 9 = 12M [address] is 1 - 125.	
Return Value:	[A] or [A][speed] or [A][address]	
Default Value:	[speed] = 0 [address] = 7	
Min: [speed] = 0 Read Only [address] = 1		Max: [speed] = 9 Read Only [address] = 125
Security Level	Get: 1	Set: 3
Example:	“PROFIBUS_PARAMS,SPEED,?” Get the Profibus speed	
Interface	RS-232, Ethernet	

HMI_TIMEOUT HMI Timeout

Purpose:	Get/Set the timeout of the HMI menu to previous menu	
Parameter(s):	? or [nnnn] [nnnn] is HMI timeout in seconds	
Return Value:	[A] or [A][nnnn]	
Default Value:	300	
Min: 30		Max: 1800
Security Level:	Get: 1	Set: 3
Example:	“HMI_TIMEOUT,?” get the current HMI timeout setting	
Interface	RS-232, Ethernet	

LEGACY_REMOTE,COMP_SIGNAL_LOGIC Compressor Input Signal Logic

Purpose:	Get/Set the Legacy Remote compressor input signal logic. Default setting is equivalent to jumper “J11” being placed on PFC system control board. The compressor will not be controlled by Legacy Remote compressor on/off input signal.	
Monitor Data:	N/A	
Parameter(s):	? or [n] [n] 0 = Compressor controlled by Legacy Remote compressor input signal Equivalent to “J11” jumper being removed from PFC system control board 1 = Compressor not controlled by Legacy Remote compressor input signal. Equivalent to “J11” jumper being placed on PFC system control board	
Return Value:	[A] or [A][n]	
Data Type:	[n]: Integer	
Default Value:	[n] = 1	
Min: [n] = 0		Max: [n] = 1
Units:	N/A	
Security Level	Get: 1	Set: 3
Example:	“LEGACY_REMOTE,COMP_SIGNAL_LOGIC,0” Set the Legacy Remote interface to use the state of the compressor on/off input signal to control the compressor.	
Interface	RS-232, Ethernet	

LEGACY_REMOTE,RMT_SIGNAL_LOGIC Legacy Remote Output Signal Logic

Purpose:	Get/Set the Legacy Remote, remote output signal logic. Default setting is to remain compatible with remote signal functionality on PFC. The remote output signal will be Low when the Compressor is off regardless of unit being in Local or Remote control.	
Monitor Data:	N/A	
Parameter(s):	? or [n] [n] 0 = Remote output signal will be: Low when compressor is Off in Local Control High when compressor is Off in Remote Control Original MaxCool remote signal logic 1 = Remote output signal will be: Low when compressor is Off in Local Control Low when compressor is Off in Remote Control Original PFC remote signal logic	
Return Value:	[A] or [A][n]	
Data Type:	[n]: Integer	
Default Value:	[n] = 1	
Min: [n] = 0		Max: [n] = 1
Units:	N/A	
Security Level	Get: 1	Set: 3
Example:	“LEGACY_REMOTE,RMT_SIGNAL_LOGIC,0” Set the Legacy Remote, remote signal logic to the original MaxCool logic.	
Interface	RS-232, Ethernet	

LEGACY_REMOTE,OP_MODE_LOGIC Legacy Remote Operating Mode Logic

Purpose:	Get/Set the Legacy Remote, operating mode logic when cool and defrost signals are both High. Default setting is to remain compatible with operating mode functionality on PFC. When the Cool and Defrost input signals are both High, the unit will switch to Cool operating mode.	
Monitor Data:	N/A	
Parameter(s):	? or [n] [n] 0 = When both Cool and Defrost input signals are High, system will switch to Standby Mode Original MaxCool mode signal logic 1 = When both Cool and Defrost input signals are High, system will switch to Cool Mode Original PFC mode signal logic	
Return Value:	[A] or [A][n]	
Data Type:	[N]: Integer	
Default Value:	[n] = 1	
Min: [n] = 0		Max: [n] = 1
Units:	N/A	
Security Level	Get: 1	Set: 3
Example:	“LEGACY_REMOTE,OP_MODE_LOGIC,0” Set the Legacy Remote, operating mode logic to the original MaxCool operating mode logic.	
Interface	RS-232, Ethernet	

System Operational State Commands

SYSTEM_CONTROL_MODE_DEF Default System Control Mode

Purpose:	Get/set the default system control mode on startup. This command does not actually change the mode.	
Parameter(s):	? or [mode] [mode] is 0 = local mode 1 = remote Ethernet 2 = remote RS232 3 = remote RS485 (Not supported) 4 = remote 24V DI/DO Remote 5 = remote DeviceNet 6 = remote Profibus	
Return Value:	[A] or [A][n]	
Default Value:	Base Units: 2 Units with Ethernet: 1	
Security Level	Get: 1	Set: 3
Example:	“SYSTEM_CONTROL_MODE_DEF,0” Set the system default control mode to local mode.	
Interface	RS-232, Ethernet	

SYSTEM_CONTROL_MODE System Control Mode

Purpose:	Get/set the system control mode.	
Parameter(s):	? or [mode] [mode] is 0 = local mode 1 = remote Ethernet 2 = remote RS232 3 = remote RS485 4 = remote 24V DI/DO Remote 5 = remote DeviceNet 6 = remote Profibus 8 = Default Control Mode (SYSTEM_CONTROL_MODE_DEF)	
Return Value:	[A] or [A][n]	
Default Value:	Determined by command SYSTEM_CONTROL_MODE_DEF	
Security Level	Get: 1	Set: 2
Example:	“SYSTEM_CONTROL_MODE,0” Set the system to local mode.	
Interface	RS-232, Ethernet	

FAULT_STATUS Current Fault Status

Purpose:	Get the current fault status.
Parameter(s):	?
Return Value	[A] or [A][nnnnnnnn],[nnnnnnnn] parameter 1: Equipment operation faults: 32 bit number / bitfield hex encoded bit 0: HIGH DISCHRG PRESS bit 1: EXCESS SUCT PRESS bit 2: VOLT OUT OF RANGE bit 3: THERMAL OVERLOAD bit 4: PRESSURE SWITCH bit 5: WATER TEMP or WATER TEMP HIGH bit 6: DISCHARGE TEMP bit 7: PRESS SENSOR FAULT bit 8: Not Used bit 9: LOW SUCT PRESSURE bit 10: Not Used bit 11: C1/C2 COOL TEMP SETPT bit 12: C1/C2 DFR TEMP SETPT bit 13: SYSTEM DATE (Not supported) bit 14: C1/C2 COOL VLV CYCLE bit 15: C1/C2 DFR VALVE CYCLE bit 16-27: Not Used bit 28: EMO SW ACTIVATED bit 29: FAN WARNING bit 30: CONTACTOR CHATTER bit 31: EXCESS COMPRESS ON parameter 2: Sensor value range faults: 32 bit number / bitfield hex encoded bit 0: DSCHRG TEMP SENSOR (TC1) bit 1: LQD LN TEMP SENSOR (TC2) bit 2: C1 INLET SENSOR (TC9) bit 3: C1 OUTLET SENSOR (TC10) bit 4: C2 INLET SENSORTC (TC11) bit 5: C2 OUTLET SENSOR (TC12) bit 6: C1 FEED SENSOR (TC13) bit 7: C1 RETURN SENSOR (TC3) bit 8: CLDST LQD TEMP (TC4) bit 9: C2 FEED SENSOR (TC14) bit 10: C2 RETURN SENSOR (TC5)

Return Value	bit 11: C2 OUTLET SENSOR (TC12) bit 12: C1 PROC CTRL SENSOR (TC7) bit 13: C2 PROC CTRL SENSOR (TC8) bit 14: Not Used bit 15: BUFFER LINE TC FAULT (TC16) bit 16: OPTION1 TC FAULT (TC17) bit 17: OPTION2 TC FAULT (TC18) bit 18: OPTION3 TC FAULT (TC19) bit 19: BP CHK CTRL (TC6) bit 20: CLD JUNCTION SENSOR (TC21) bit 21: Not Used bit 22: Not Used bit 23: OPTION4 TC FAULT (TC20) bit 24: Not Used bit 25: Not Used bit 26: DSCHRG PRESS SENSOR (PT2) bit 27: SUCT PRESS SENSOR (PT1) bit 28: Not Used bit 29: Not Used bit 30: Not Used bit 31: Not Used	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“FAULT_STATUS,?”	
Interface	RS-232, Ethernet	

ALARM_STATUS Current Alarm Status

Purpose:	Get the current alarm or warning status.
Parameter(s):	[n], [nnnnnnnn],? [n] is 0 = Equipment operation alarms 1 = Sensor range alarms 2 = Performance Monitor alarms [nnnnnnnn] is a 32 bit number / bitfield that represents the state of the alarm. Displays the hex number that represents the state of the 6 bits of one of the bitfields returned by ACTIVE_ALARMS command

Return Value:	[A] or [A], [alarm status bits] or [A], [circuit 1 alarm status bits], [circuit 2 alarm status bits] The alarm name and status. “alarm name” is the name used to refer to the alarm “alarm status bits” is a bit field with the following values: bit 0: 0 = warning, 1 = alarm bit 1-4: alarm or warning level as an integer. bit 5: alarm clear state (0 = not cleared, 1 = cleared) bit 6: alarm acknowledge state (0 = not acknowledged, 1 = acknowledged)	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“ALARM_STATUS,0,40000,?” returns the alarm status of the cool temperature ramp monitor alarm	
Interface	RS-232, Ethernet	

ACTIVE_ALARMS Current Active Alarms

Purpose:	Get the current active alarms and warnings
Parameter(s):	[n],? [n] is 0 = Warnings 1 = Alarms 2 = Both
Return Value	[A],[nnnnnnnn], [nnnnnnnn], [nnnnnnnn] parameter 1: Equipment operation alarms: 32 bit number / bitfield (different from parameter 1 from FAULT_STATUS) hex encoded • bit 0: C1/C2 USER TC FAILED • bit 1: Not Used • bit 2: LOW REFRIG TEMP • bit 3: Not Used • bit 4: PRESS SENSOR FAULT • bit 5: EXCESS SUCT PRESS • bit 6: SYSTEM DATE (Not Supported) • bit 7: HIGH DISCHRG PRESS • bit 8: DISCHARGE TEMP • bit 9: Not Used • bit 10: VOLT OUT OF RANGE • bit 11: COOLING WATER • bit 12: WATER TEMP HIGH • bit 13: PRESSURE SWITCH • bit 14: LOW SUCT PRESSURE • bit 15: THERMAL OVERLOAD

Return Value	• bit 16: Not Used • bit 17: C1/C2 DFR TEMP SETPT • bit 18: Not Used • bit 19: Not Used • bit 20: Not Used • bit 21: Not Used • bit 22: C1/C2 COOL VLV CYCLE • bit 23: C1/C2 DFR VALVE CYCLE • bit 24; FREEZEOUT VLV CYCLE • bit 25: Not used • bit 26: Not Used • bit 27: Not Used • bit 28: EMO SW ACTIVATED • bit 29: FAN WARNING • bit 30: CONTACTOR CHATTER • bit 31: EXCESS COMPRESS ON parameter 2: Sensor value range alarms: 32 bit number / bitfield (different from parameter 2 from FAULT_STATUS) hex encoded • bit 0: DSCHRG TEMP SENSOR • bit 1: LQD LN TEMP SENSOR • bit 2: CLD JUNCTION SENSOR • bit 3: Not Used • bit 4: Not Used • bit 5: Not Used • bit 6: DSCHRG PRESS SENSOR • bit 7: SUCT PRESS SENSOR • bit 8: Not Used • bit 9: Not Used • bit 10: CLDST LQD TEMP • bit 11: BP CHK CTRL • bit 12: C1 INLET SENSOR • bit 13: C2 INLET SENSOR • bit 14: C1 OUTLET SENSOR • bit 15: C2 OUTLET SENSOR • bit 16: C1 FEED SENSOR • bit 17: C2 FEED SENSOR • bit 18: C1 RETURN SENSOR • bit 19: C2 RETURN SENSOR • bit 20: C1 PROC CTRL SENSOR • bit 21: C2 PROC CTRL SENSOR • bit 22: Not Used • bit 23: BUFFER LINE TC FAULT • bit 24: Not Used • bit 25: Not Used • bit 26: OPTION1 TC FAULT • bit 27: OPTION2 TC FAULT • bit 28: OPTION3 TC FAULT • bit 29: OPTION4 TC FAULT • bit 30: Not Used • bit 31: Not Used parameter 3: Performance Monitor alarms: 32 bit number / bitfield • bit 0: Balance Pressure

Return Value	• bit 1: Cool Performance • bit 2: Trend Cool • bit 3: Cool Deviation • bit 4: Not Used • bit 5: Trend Cool Deviation • bit 6: Not Used • bit 7: Defrost Performance • bit 8: Trend Defrost • bit 9: Not Used • bit 10: Not Used • bit 11: Not Used • bit 12: Not Used • bit 13: Cooling Under • bit 14: Defrost End • bit 15: Cool Down Time • bit 16: Cool Down Asymptote • bit 17: Defrost time • bit 18: Cool Steady	
Security Level	Get: 1	Set: N/A
Example:	“ACTIVE_ALARMS,1,?” Get current active alarms	
Interface	RS-232, Ethernet	

CAPACITY_TARGET_TEMP Cooling Capacity Target Temperature

Purpose:	Get/Set the target temperature used to define the normal capacity for non-temperature controlled cooling modes to engage power management mode.	
Monitor Data:	Refrigerant Return temperature	
Parameter(s):	? or [nnnn] [nnnn] is target temperature	
Return Value:	[A] or [A][nnnn]	
Data Type:	Integer	
Default Value:	-120	
Min: -190		Max: -70
Units:	Degrees Celsius (signed)	
Security Level:	Get: 1	Set: 3
Example:	“CAPACITY_TARGET_TEMP,?” Get the normal cooling capacity target temperature.	
Interface	RS-232, Ethernet	

POWER_MGMT_STANDBY_DELAY Excess Capacity Temperature difference

Purpose:	Get/Set Power Management Standby Mode delay time	
Monitor Data:	Time	
Parameter(s):	? or [nnnn] [nnnn] is delay in seconds	
Return Value:	[A] or [A][nnnn]	
Data Type:	Integer	
Default Value:	1200	
Min: 1		Max: 36000
Units:	Seconds	
Security Level	Get: 1	Set: 3
Example:	“POWER_MGMT_STANDBY_DELAY,?” Get the power management delay	
Interface	RS-232, Ethernet	

E_MGMT_ENABLE Energy Management Enable

Purpose:	Get/set the enable state of energy management. (also referred to as power management)	
Monitor Data:		
Parameter(s):	? or [n] [n] is 1 = enabled 0 = disabled	
Return Value:	[A] or [A][n]	
Data Type:	Integer	
Default Value:	1	
Min: 0		Max: 1
Units:	N/A	
Security Level:	Get: 1	Set: 3
Example:	"E_MGMT_ENABLE,?" Get the enable state of energy management	
Interface	RS-232, Ethernet	

System Sensor Readings

SENSOR_SNAPSHOT Sensor Data Snapshot

Purpose:	Get a snapshot of the current sensor data.
Parameter(s):	?
Return Value	[A][nnnnnnnn1],[nnnnnnnn2],[nnn.n]…. Param 1 is bit field for if sensors values are valid (valid = 1) hex encoded • bit 0 – 20: T1 – T21 • bit 21: Voltage transformer • bit 22: Not Used (0) • bit 23: Not Used (0) • bit 24: Not Used (0) • bit 25: Not Used (0) • bit 26: Not Used (0) • bit 27: Discharge Pressure Transducer • bit 28: Suction Pressure Transducer • bit 29: Not Used (0) • bit 30: Not Used (0) • bit 31: Not Used (0)

Return Value	Param 2 is bit field for if sensors are faulted • same bit mapping as above (faulted = 1) hex encoded Param 3-23 TC1-TC21 temperature values Param 24 Voltage transformer value Param 25 Not Used (0) Param 26 Not Used (0) Param 27 Not Used (0) Param 28 Not Used (0) Param 29 Not Used (0) Param 30 Discharge Pressure Transducer value Param 31 Suction Pressure Transducer value Param 32 Not Used (0) Param 33 Not Used (0) Param 34 Not Used (0) Param 35 Not Used (0) Param 36 is bit field for Valve states, hex encoded (1=valve open) • bit 0: Fault Relay • bit 1: Buffer Valve • bit 2: Not Used (0) • bit 3: Not Used (0) • bit 4: Cylinder Unloader Valve • bit 5: Ckt1 Cool Valve • bit 6: Ckt1 Defrost Valve • bit 7: Not Used (0) • bit 8: Not Used (0) • bit 9: Not Used (0) • bit 10: Not Used (0) • bit 11: Ckt2 Cool Valve • bit 12: Ckt2 Defrost Valve • bit 13: Not Used (0) • bit 14: Not Used (0) • bit 15: Not Used (0) • bit 16: Not Used (0) • bit 17: Freezeout Prevention Valve	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“SENSOR_SNAPSHOT,?” Get the sensor snapshot	
Interface	RS-232, Ethernet	

SYSTEM_VALVE_STATE Valve Open/Closed State for system valves.

Purpose:	Get the open/closed state of a system valve. A value of 1 indicates the valve is open. A value of 0 indicates the valve is closed.	
Parameter(s):	[n],? [n] is Valve identifier: 0 = Buffer 1 = Not Used 2 = Not Used 3 = Cylinder Unloader 4 = Freeze Out Prevention	
Return Value:	[A] [n]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“SYSTEM_VALVE_STATE,0,?”	
Interface	RS-232, Ethernet	
Note:		

CLDST_LQD_TEMP Unit Coldest Liquid Temperature

Purpose:	Get the unit coldest liquid temperature sensor value. (TC4)	
Parameter(s):	?	
Return Value:	[A][nnnn]	
Default Value:	N/A	
Units:	Degrees Celsius (signed)	
Security Level	Get: 1	Set: N/A
Example:	“CLDST_LQD_TEMP,?”	
Interface	RS-232, Ethernet	

COLD_JUNCT_TEMP Cold Junction Temperature

Purpose:	Get the cold junction temperature. (TC21)
Parameter(s):	?
Return Value:	[A][nnn.n]
Default Value:	N/A

Units:	Degrees Celsius (signed)	
Security Level	Get: 1	Set: N/A
Example:	“COLD_JUNCT_TEMP,?”	
Interface	RS-232, Ethernet	

BUFFER_LINE_TEMP Buffer Line Temperature

Purpose:	Get the buffer line temperature. (TC16)	
Parameter(s):	?	
Return Value:	[A][nnn.n]	
Default Value:	N/A	
Units:	Degrees Celsius (signed)	
Security Level	Get: 1	Set: N/A
Example:	“BUFFER_LINE_TEMP,?”	
Interface	RS-232, Ethernet	

WARM_CTL_TEMP Rapid Balance Pressure Check Control Temperature

Purpose:	Get the Rapid Balance Pressure Check control temperature sensor value. (TC6)	
Parameter(s):	?	
Return Value:	[A][nnn.n]	
Default Value:	N/A	
Units:	Degrees Celsius (signed)	
Security Level	Get: 1	Set: N/A
Example:	“WARM_CTL_TEMP,?”	
Interface	RS-232, Ethernet	

System Actions Commands

RESET_ALARMS Reset alarms

Purpose:	Acknowledge all outstanding alarms.	
Parameter(s):	N/A	
Return Value:	[A]	
Default Value:	N/A	
Security Level	Get: N/A	Set: 2
Example:	“RESET_ALARMS”	
Interface	RS-232, Ethernet	

SECURITY_LEVEL Security Level

Purpose:	Get/set the system security level.	
Parameter(s):	? or [n],[cccccc],[userID] [n] is security level 1-3 [cccccc] is password [userID] is userID string	
Return Value:	[A] or [A][n]	
Default Value:	2	
Security Level	Get: 1	Set N/A
Example:	“SECURITY_LEVEL,?” Get the current security level.	
Interface	RS-232, Ethernet	
Note	Security level timeout is set by SERVICE_INTERVAL command	

Compressor Configuration Commands

COMP_SERIAL_NUM Compressor Serial Number

Purpose:	Get / Set identifier string representing the serial number of the specified Compressor Module.	
Parameter(s):	[n],? or [cccccccc] [n] is 0 = Refrigerant compressor 1 = Nitrogen compressor [cccccccc] is serial number string (32 character max)	
Return Value:	[A] or [A][cccccccc]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“COMP_SERIAL_NUM,0,?”	
Interface	RS-232, Ethernet	

COMP_MOTOR_HOURS Refrigerant Motor Operating Hours

Purpose:	Get / Set the total number of hours that the specified compressor motor has run in its lifetime.	
Parameter(s):	[n],? or [nnnn] [n] is 0 = Refrigerant compressor 1 = Nitrogen compressor [nnnn] is motor hours	
Return Value:	[A][nnnn]	
Default Value:	N/A	
Range	Min: 0	Max: 2000000
Security Level	Get: 1	Set: 3
Example:	“COMP_MOTOR_HOURS,0,?”	
Interface	RS-232, Ethernet	

Compressor Operational State Commands

COMP_MOTOR_STATE Refrigerant Compressor On/Off State

Purpose:	Get/Set the refrigerant compressor motor on/off state.	
Parameter(s):	[n],? or [n1] [n] is 0 = Refrigerant compressor 1 = Not Used [n1] is motor state 0 = motor off (contactor open) 1 = motor on (contactor closed)	
Return Value:	[A] or [A][n1]	
Default Value:	N/A	
Security Level	Get: 1	Set: 2
Example:	“COMP_MOTOR_STATE,0,?” Get the motor state.	
Interface	RS-232, Ethernet	

Compressor Sensor Readings

UNIT_BALANCE_PRESS Compressor Static Charge Pressure

Purpose:	Get the unit balance (static charge) pressure.	
Parameter(s):	[n],? [n] is 0 = Refrigerant compressor 1 = Not Used	
Return Value:	[A] [nnn.n]	
Default Value:	N/A	
Units:	PSI	
Security Level	Get: 1	Set: N/A
Example:	“UNIT_BALANCE_PRESS,0,?”	
Interface	RS-232, Ethernet	

COMP_DISCHRG_TEMP Compressor Discharge Temp

Purpose:	Read the compressor discharge temperature sensor value. (TC1)	
Parameter(s):	[n],? [n] is 0 = Refrigerant compressor 1 = Not Used	
Return Value:	[A][nnn.n]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“COMP_DISCHRG_TEMP,0,?”	
Interface	RS-232, Ethernet	

COMP_LINE_TEMP Compressor Liquid Line Temperature

Purpose:	Read the compressor liquid line temperature sensor value. (TC2)	
Parameter(s):	[n],? [n] is 0 = Refrigerant compressor 1 = Not Used	
Return Value:	[A][nnn.n]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“COMP_LINE_TEMP,0,?”	
Interface	RS-232, Ethernet	

COMP_SUCT_PRESS Compressor Suction Pressure

Purpose:	Read the compressor suction pressure sensor value.
Parameter(s):	[n],? [n] is 0 = Refrigerant compressor 1 = Not Used
Return Value:	[A][nnn.n]
Default Value:	N/A

Security Level	Get: 1	Set: N/A
Example:	“COMP_SUCT_PRESS,0,?”	
Interface	RS-232, Ethernet	

COMP_DSCHRG_PRESS Compressor Discharge Pressure

Purpose:	Read the compressor discharge pressure sensor value.	
Parameter(s):	[n],? [n] is 0 = Refrigerant compressor 1 = Not Used	
Return Value:	[A][nnnn]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“COMP_DSCHRG_PRESS,0,?”	
Interface	RS-232, Ethernet	

Circuit Configuration Commands

CLDST_LQD_SETPT Coldest Liquid Temperature Set Point

Purpose:	Get/set the temperature set point at which to transition from Standby to Cool mode.	
Monitor Data:	Coldest liquid temperature	
Parameter(s):	[n],? or [n],[nnn.n] [n] is circuit number (1or 2) or * for all circuits [nnnn] is the set point	
Return Value:	[A] or [A][nnn.n]	
Data Type:	Double	
Default Value:	-200	
Min: -200		Max: -80
Units:	Degrees Celsius (signed)	
Security Level	Get: 1	Set: 3

Example:	“CLDST_LQD_SETPT,1,?” Get the coldest liquid temp. set point for circuit 1
Interface	RS-232, Ethernet

SETPOINT_RELAY Setpoint Relay Control

Purpose:	Get/set the External Relay 1 or Relay 2 parameters These relays are internal to the unit and contact outputs are accessible from the 24V DI/DO interface. All MaxCool Cryochiller models equipped with a 24V DI/DO 37-pin interface include this feature as standard. Defines the sensor, setpoint, and parameters for sensor monitored by each relay.
Monitor Data:	Setpoint Type
Parameter(s)	SETPOINT_RELAY,[1..2],? SETPOINT_RELAY,[1..2],[Setpoint Type],[Relay Logic],[Setpoint],[Deadband] Parameters: - Relay [1..2] = Setpoint Relay 1 or Relay 2 - Setpoint Type: Sensor to monitor None = 0, 1 = Circuit1_FeedTemp, 2 = Circuit1_ReturnTemp, 3 = Circuit1_CoilInTemp, 4 = Circuit1_CoilOutTemp, 5 = Circuit1_ProcessCtrlTemp, 6 = Circuit1_Avg_FeedReturn, 7 = Circuit1_Avg_CoilInOut, 8 = Circuit2_FeedTemp, 9 = Circuit2_ReturnTemp, 10 = Circuit2_CoilInTemp, 11 = Circuit2_CoilOutTemp, 12 = Circuit2_ProcessCtrlTemp, 13 = Circuit2_Avg_FeedReturn, 14 = Circuit2_Avg_CoilInOut, 15 = Compressor_DischargeTemp, 16 = Customer_Option1, 17 = Customer_Option2, 18 = Customer_Option3, 19 = Customer_Option4, 20 = Discharge_Pressure, 21 = Suction_Pressure 22 = Coldest_LiquidTemp , 23 = RefrigerantLiquid_LineTemp, 24 = Not Used, 25 = Stack_WarmerTemp, 26 = Buffer_LineTemp,

Parameter(s)	- Relay Logic: Relay will close when either above or below Setpoint value 0: = Close_Above 1: = Close_Below - Setpoint: Setpoint of selected sensor to initiate relay logic - Deadband: deadband value from setpoint to open relay	
Return Value:	[A] or [A][nn],[n],[nnn.n],[nnn.n]	
Data Type:	Integer	
Default Value:	0,0,0.0,0.0	
Min: Setpoint Type: 0 Relay Logic: 0 Setpoint: -200 Deadband: 0		Max: Setpoint Type: 21 Relay Logic Setpoint: -200 Deadband: 600
Units:		
Security Level:	Get: 1	Set: 3
Example:	“SETPOINT_RELAY,1,?” Get the external vacuum device set point for Relay 1 “SETPOINT_RELAY,2,3,1,-30,5” Set the external relay set point for Relay 2, monitor sensor Circuit1_CoilInTemp, close relay below -30c, open relay at -25c (-30 setpoint plus the 5 degree deadband)	
Interface	RS-232, Ethernet	

EXT_VAC_CONTACT External Vacuum Device Contact Closure Monitor

Purpose:	Get/set the enable/disable state for using the gauge relay input to change the mode of the circuit.	
Monitor Data:	External vacuum contact	
Parameter(s):	[n],? or [n],[n] [n] is circuit number (1 or 2) or * for all circuits [n] is the enable state of the external vacuum contact 0 = Disabled 1 = Enabled	
Return Value:	[A] or [A][n]	
Data Type:	Integer	
Default Value:	0	
Min: 0		Max: 1
Units:		
Security Level	Get: 1	Set: 3

Example:	“EXT_VAC_CONTACT,1?” Get the external vacuum device enable state for circuit 1
Interface	RS-232, Ethernet

DEFR_SETPT Defrost Complete Set Point

Purpose:	Get/Set the defrost complete temperature set point.	
Monitor Data:	Refrigerant return temperature.	
Parameter(s):	[n],? or [n],[nnn.n] [n] is circuit number (1 or 2) or * for all circuits [nnn.n] is the setpoint	
Return Value:	[A] or [A][nnn.n]	
Data Type:	Double	
Default Value:	+20	
Min: -40		Max: 100
Units:	Degrees Celsius (signed)	
Security Level	Get: 1	Set: 3
Example:	“DEFR_SETPT,1,?” Get the defrost compete set point for circuit 1.	
Interface	RS-232, Ethernet	

EXT_TC_ENABLE Enable external thermocouple

Purpose:	Get/set the enable state of the external thermocouple on the circuit. If enabled, the external Thermocouple is used to monitor the temperature, else the internal Return temperature Thermocouple is used.	
Parameter(s):	[n],? or [n],[state] [n] is circuit number (1or 2) [state] is enable state 1 = Enabled 0 = Not Enabled	
Return Value:	[A] or [A][0 or 1]	
Data Type:	Integer	
Default Value:	0	
Security Level	Get: 1	Set: 3

Example:	“EXT_TC_ENABLE,1,?” Get the enable state of the circuit 1 external thermocouple
Interface	RS-232, Ethernet

EXT_TC_ALARM External thermocouple alarm

Purpose:	Get/set the alarm setpoint for the External Thermocouple if enabled. Alarm is raised if difference between External TC temperature and Return temperature of circuit is greater than setpoint	
Parameter(s):	[nnn.n] or ? [nnn.n] is temperature difference	
Return Value:	[A] or [A][nnn.n]	
Data Type:	Double	
Default Value:	20	
Min: 0	Max: 200	
Units:	Deg C	
Security Level:	Get: 1	Set: 3
Example:	“EXT_TC_ALARM,?” Get the setpoint for external thermocouple alarm	
Interface	RS-232, Ethernet	

Circuit Operational State Commands

OPERATING_MODE_DEF_COOL Cool operating mode default state

Purpose:	Get/set the operating mode's default cool state.	
Parameter(s):	[n],? or [n],[mode] [n] is the circuit number (1or 2) [mode] is 0 = COOL 1 = Not Used 2 = Not Used 3 = Not Used 4 = Not Used 5 = Not Used	
Return Value:	[A][mode]	
Default Value:	N/A	
Security Level	Get: 1	Set: 2
Example:	"OPERATING_MODE_ DEF_COOL,1,?" Get the current default cool mode.	
Interface	RS-232, Ethernet	

OPERATING_MODE_DEF_DEFROST Defrost operating mode default state

Purpose:	Get/set the operating mode's default defrost state.	
Parameter(s):	[n],? or [n],[mode] [n] is the circuit number (1 or 2) [mode] is 0= DEFROST 1 = Not Used 2 = Not Used 3 = Not Used 4 = Not Used 5 = Not Used	
Return Value:	[A][mode]	
Default Value:	N/A	
Security Level	Get: 1	Set: 2
Example:	"OPERATING_MODE_ DEF_DEFROST,1,?" Get the current default defrost mode.	
Interface	RS-232, Ethernet	

OPERATING_MODE Current Operating Mode

Purpose:	Get/set the current operating mode.	
Parameter(s):	[n], ? or [n],[mode] [n] is the circuit number (1 or 2) [mode] is -1= INACTIVE (Note: Cannot “Set” this mode) 0 = STANDBY 1 = cool (default) – use the default cool mode 2 = defrost (default) – use the default defrost mode 3 = COOL 4 = Not Used 5 = Not Used 6 = Not Used 7 = Not Used 8 = Not Used 9 = DEFROST 10 = Not Used 11 = Not Used 12 = Not Used 13 = Not Used 14 = Not Used	
Return Value:	[A][mode]	
Default Value:	N/A	
Security Level	Get: 1	Set: 2
Example:	“OPERATING_MODE,1,?” Get the current operating mode on circuit 1	
Interface	RS-232, Ethernet	

Circuit Sensor Readings Commands

CIRCUIT_VALVE_STATE Valve Open/Closed State of a Circuit's valve

Purpose:	Get the open/closed state of a valve belonging to a circuit. A value of 1 indicates the valve is open. A value of 0 indicates the valve is closed.

Parameter(s):	[n],[valve],? [n] is circuit number (1 or 2) [valve] is Valve identifier: 0 = Cool 1 = Not Used 2 = Defrost 3 = Not Used 4 = Not Used 5 = Not Used	
Return Value:	[A][n] [n] = 0 valve closed [n] = 1 valve open	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“CIRCUIT_VALVE_STATE,1,0,?” Get circuit 1 cool valve state	
Interface	RS-232, Ethernet	

CIRC_INLT_TEMP Circuit Inlet Temperature

Purpose:	Read the circuit inlet temperature sensor value. TC9/TC11	
Parameter(s):	[n],? [n] is circuit number (1 or 2)	
Return Value:	[A][nnn.n]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“CIRC_INLT_TEMP,1,?” Get circuit 1 inlet temperature	
Interface	RS-232, Ethernet	

CIRC_OTLT_TEMP Circuit Outlet Temperature

Purpose:	Read the circuit outlet temperature sensor value. TC10 / TC11	
Parameter(s):	[n],? [n] is circuit number (1 or 2)	
Return Value:	[A][nnn.n]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“CIRC_OTLT_TEMP,1,?” Get circuit 1 outlet temperature	

Interface	RS-232, Ethernet

CIRC_FEED_TEMP Circuit Feed Temperature

Purpose:	Read the circuit feed temperature sensor value.TC13 / TC14	
Parameter(s):	[n],? [n] is circuit number (1 or 2)	
Return Value:	[A][nnn.n]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“CIRC_FEED_TEMP,1,?”	
Interface	RS-232, Ethernet	

CIRC_RTN_TEMP Circuit Return Temperature

Purpose:	Read the circuit return temperature sensor value. TC3 / TC5	
Parameter(s):	[n],? [n] is circuit number (1 or 2)	
Return Value:	[A][nnn.n]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“CIRC_RTN_TEMP,1,?”	
Interface	RS-232, Ethernet	

CIRC_PROC_CTL_TEMP Circuit Process Control Temperature

Purpose:	Read the circuit process control temperature sensor value. TC7 /TC8	
Parameter(s):	[n],? [n] is circuit number (1 or 2)	
Return Value:	[A][nnnn]	
Default Value:	N/A	
Security Level	Get: 1	Set: N/A
Example:	“CIRC_PROC_CTL_TEMP,1,?”	
Interface	RS-232, Ethernet	

8 Configuration

About System Configuration

The operation of the Polycold Cryochiller is configurable using the system commands. Some of the common configuration options and the associated commands are listed in this section.

For clarity, the letter **P** is used in place of the actual command checksum. See Checksum Calculation on page 7-4 to determine the actual checksum for a specific command.

For simplicity, only a single sample of command parameters may be shown instead of listing the full set of command options.

For full list of options for each command, go to the command description in Chapter 7: *Host Commands*.

Power Management - Cylinder Unloading

Cylinder unloading is used to save energy during periods of low cooling load. Cylinder Unloading disables one of the compressor cylinders which allows for saving a significant amount of energy. Cylinder Unloading is only available with systems equipped with the power management option.

Key elements of Cylinder Unloading are as follows:

- Enable the Cylinder Unloading using the E_MGMT_ENABLE command
- Set a delay before engaging Cylinder Unloading
- Establish the target temperature to be maintained while unloading is active.
- Establish a delta which creates a safety margin for the target temperature before engaging cylinder unloading.

Power Management in Standby Mode

When in Standby mode, if cylinder unloading is enabled, the Cylinder Unloader goes active after a delay period defined by the command POWER_MGMT_STANDBY_DELAY.

- **E_MGMT_ENABLE,1P**
  Enables cylinder unloading - ? = get the status, 0 = disable, 1 = enable
- **POWER_MGMT_STANDBY_DELAY,300P**
  Sets Cylinder Unloader to activate after the system has been in Standby mode for 300 seconds and power management is enabled.

Power Management in Cool Mode

When in the Cool modes of either Standard Cool or Ramp Controlled Cool, a target temperature is used to define the temperature at which Cylinder Unloading stays active and an additional delta temperature that must be reached for the Cylinder Unloading to go active.

The typical temperature warming experienced with the cylinder unloader activated varies based on application conditions. You need to verify and adjust the settings based on the performance of your application.

- **E_MGMT_ENABLE,1P**
  Enables cylinder unloading - ? = get the status, 0 = disable, 1 = enable
- **CAPACITY_TARGET_TEMP, -120P**
  Sets maximum temperature of -120 for Cylinder Unloading to remain active Will only stay active once per cycle.
- **EXCESS_CAP_TEMP_DELTA,8P**
  Sets an 8º C delta T value that the temperature must be below CAPACITY_TARGET_TEMP for Cylinder Unloader to begin.

Mode Selection

All models have only one Standby mode.

Standby

Set the unit to standby using the operating mode command.

- **OPERATING_MODE,1,0P** sets circuit 1 to Standby Mode.

Cool Mode Selection

Standard Cool Mode

Standard cool means that the cool valve is activated continuously. It is available on all units. Set the unit to cool mode using the operating mode command.

- **OPERATING_MODE,1,1P** sets the Cool mode to Standard.

Defrost Mode Selection

Standard Defrost Mode

In Standard Defrost mode, the unit defrosts the circuit until the return refrigerant reaches a specified set point. The default defrost termination set point is + 20 °C on all models. The defrost termination set point is configurable from -40 °C to + 20 °C.

- **OPERATING_MODE,1,9P**
- **DEFR_SETPT,1,10P** sets the Defrost complete temperature set point for circuit 1 to 10 C.

Alternate Thermocouple Control

Allows an alternate external or internal thermocouple to monitor and control the circuit performance.

Use this command to define which thermocouple to use for circuit control functions. By default, the control thermocouple for all circuit functions (i.e. defrost complete, temperature control, etc) is the Return thermocouple for that circuit. This command allows you to select either the Coil Out, average of Coil In and Coil Out, or customer process thermocouple.

- **EXT_TC_ENABLE,1,1P** enables the External Thermocouple for circuit 1.
- **EXT_TC_ENABLE,1,0P** enables the Internal Thermocouple for circuit 1

External Vacuum Control

Allows external vacuum devices to change the Polycold Cryochiller's operating mode from Standby to Cool.

When the circuit is in standby and the external vacuum control is enabled, a 24V signal (AC or DC) applied to the designated contacts on the 4-pin Gauge Relay port will be detected and cause the unit to switch to cool.

See Gauge Relay (J4) on page 5-3 for more information on the use of this feature.

- **EXT_VAC_CONTACT,1,?P** gets the enable/disable status of the circuit 1 Gauge Relay control.
- **EXT_VAC_CONTACT,1,1P** enables the Gauge Relay input to be used for circuit 1.

Set Point Relays

All Polycold Cryochillers models equipped with the 24V DI/DO 37 pin interface include this feature. Set-point relays are outputs that are enabled or disabled by the status of programmable parameters.

A user can configure the behavior of these two relays via software. This allows the user to select the sensor to be associated with each relay, the set point, deadband and relay logic.

See 24V DI/DO Remote Interface on page 5-17 for more information on the use of this feature.

- **SETPOINT_RELAY,1,?P** gets the external vacuum device setpoint for Relay 1.
- **SETPOINT_RELAY,2,3,1,-30,5P** sets the Relay 2 external setpoint to monitor sensor Circuit1_CoilInTemp and close relay below -30 C with 5º C of dead band which means the relay opens at -25º C.

Remote Control Methods

The Polycold Cryochillers may be controlled remotely by RS232 or Ethernet or other interfaces. Once in remote control, system commands may be sent to configure or control the unit.

Commands for remote control are as follows:

- **SYSTEM_CONTROL_MODE,2P** sets the system to the mode designated by the value sent by this command, in this case, RS232.
  RS232 and Ethernet can set the control and take control using this command. Other remote interfaces can only set the control when they are in control.

- **SYSTEM_CONTROL_MODE_DEF** sets the default system control mode that the system is set to on startup and that the unit goes to when the Remote key is pressed to set the unit to remote mode.

9 Preventive Maintenance

Preventive Maintenance

The best way to ensure maximum productivity for your system is through Polycold's Preventive Maintenance servicing option.

Polycold recommends that the user inspect the system at daily, weekly, monthly and quarterly intervals.

Polycold recommends that every 12 months a preventive maintenance service visit is performed by Polycold authorized service personnel.

Benefits of Polycold preventive maintenance include:

- Improved system reliability
- Decreased cost of replacement
- Decreased system downtime

Preventive maintenance activities include

- Equipment check
- Top off charge (if required),
- Evacuate and recharge (if required)
- Valve replacement, as necessary
- Insulation inspection and repair
- Data backup
- Battery replacement, as required, (every 5 years)

In addition, the Polycold Engineer will record any equipment deterioration and recommend replacement parts or repair before these items cause system failure. Preventive maintenance will result in savings due to an increase of effective system service life.

Preventive Maintenance Schedules

Interval	Action
Daily	Ensure the unit is functioning as expected
Weekly	Ensure the unit is functioning as expected
	Check Temperatures (during process)
	Check Pressures (during process)
Monthly	Perform Weekly Maintenance
	Check Time to Cool Down
	Check for air flow from E-box fans
Quarterly	Perform Monthly Maintenance
	Check system balance pressure
	Verify LCD display is not missing characters
	Verify HMI keypad / Remote Control functions properly
	Verify Insulation is intact
	Verify Oil Level in Compressor is appropriate
	Power cycle the system. leaving it off for minimum of 10 seconds.
	Replace Fan Filter (as appropriate)
Annual	Perform Quarterly Maintenance
	Replace fan filter (mandatory) and check fan operation
	Replace valve and valve components as necessary
	Review event files for errors and backup system data (future capability)
	Check Cool Down Cycle Time, Pressure, and Temperature
	Check Defrost Cycle Time, Pressure, and Temperature
	Verify Water Flow and Temperatures Confirm that customer-provided water filters are replaced as required
	Inspect Frame, Compressor, and Components for wear
	Reinsulate (as appropriate)
	Perform Compressor Pump Down Test
	Perform Leak Check on fittings within the Cryochiller and feedthroughs
	Clean electronic control box and replace mother board battery as required (nominally every 3-5 years)
	Inspect all harness connections
	Top off charge as required
	Evacuate and recharge as necessary

10 Troubleshooting

Troubleshooting Techniques

Successful troubleshooting involves gathering enough information and asking enough questions to define the problem using a single statement of how the system is supposed to operate and how the system is operating improperly.

Define the Problem

You may be able to define and solve the problem by creating a simple statement that describes the problem.

- Observe and list the symptoms of the problem
- Determine what is happening that is different from what should happen
- Determine the items that have the problem and those that do not
- Determine when the problem first occurred and how often it occurs
- Determine the state of the system when the problem occurred or occurs
- Reduce the list of symptoms to the primary symptom.
- List the possible causes of the symptom
- Reduce the list of causes based on what is happening and what is supposed to happen.

Contacting Authorized Service

When contacting authorized service, have as much of the following information available as is possible.

- Record the model number, part number, and serial number from the equipment.
- Provide installed location
- Provide name, address, E-mail address, and phone number of person to contact.
- List error codes or symptoms.
- List work done on unit before problem occurred, function unit was performing when the problem occurred, actions taken after problem occurred.

Troubleshooting Tables

Troubleshooting issues are listed in two groups:

- HMI and Observed Errors
- Remote Monitor Troubleshooting using bit mask values

Troubleshooting tables use a 3-column format.

Problem column shows the messages in **BOLD UPPER CASE** and the status of the Fault LED.

- If the system recognizes a fault, the HMI screen may display a fault message and a recommended action and the Fault LED may be lit.
- If the system does not recognize a fault, the display may not provide any fault information and the Fault LED may not be lit and the user must determine the problem.

Possible Cause column lists the probable causes of the problem.

Corrective Action column lists recommended actions to correct the problem.

Fault Reporting

If a Fault occurs, the HMI display automatically goes to the Fault State screen and displays the fault and two lines of the available 3 lines of fault data using the format below:

- Line 1 - Fault State (menu selection header)
- Line 2 - Name of Fault
- Line 3 - Fault description line 1
- Line 4 - Fault description line 2, if applicable
- (scroll) - Fault description line 3, if applicable

To view current Fault information, go to the Fault State display, if required. The Fault State display shows the current fault and descriptions as stated above.

To view additional faults, if applicable, use the down arrow to display the next fault.

To view all information for the displayed fault, press the Enter key to select the current fault and then use the arrow keys to scroll through all three lines of information for the current fault. Note that the arrow keys stay on the selected fault. Press the Enter key again to exit the current fault display.

To exit a selected fault, press the Enter key. The display goes back to the Fault State display and then the arrow keys may be used to scroll through each of the active faults, if applicable.

HMI and Observed Errors

Power Troubleshooting

Troubleshooting power requires that CB1 and CB2 are turned on.

Problem / HMI Display	Possible Cause	Corrective Action
POWER FAILURE **NO RECOMMENDATION** Fault LED is Amber	Control voltage is outside of acceptable limits.	Check the transformer tap settings and ensure they are correct for your supply voltage
		Check supply voltage for deviations beyond the allowable voltage range for this tap setting.
(No HMI message) No LED indicators CB1 or CB2 trip, cannot reset.	Faulty component in the power or control circuit.	Contact authorized service
(No HMI message) No LED indicators CB1 occasionally trips	Power consumption too close to CB1 maximum rated value.	Refer to Appendix C: CB2 Excepted Wiring on page 12-5 Have a qualified electrician rewire CB2 to Excepted Wiring
(No HMI message) No LED indicators System does not boot up. CB1 stays ON	No input power	Check power source fuses, circuit breakers, and wiring Contact authorized service to repair as needed
(No HMI message) Fault LED not lit System boots up Compressor will not turn on	Motor on/off switch fault	Contact authorized service to check the switch and replace if required.

Communication Troubleshooting

Problem / HMI Display	Possible Cause	Corrective Action
System does not communicate on RS232, Ethernet, Profibus, or DeviceNet	System electronics is “confused”	Power cycle the system.
		Contact authorized Service

Compressor Motor Troubleshooting

Troubleshooting the compressor motor requires that the Polycold Cryochiller is fully booted up.

Problem / HMI Display	Possible Cause	Corrective Action
Compressor will not start No LEDs lit Compressor switch is off	Compressor switch must be on for compressor to run.	Set compressor switch to ON.
Compressor will not start No LEDs lit Compressor switch is on.	Compressor contactor circuit needs to be reset after power up.	Turn compressor switch OFF and then ON
	Remote EMO connector or J11 bypass is disconnected	Connect remote EMO cable or install J11 EMO Jumper
	Remote EMO signal open at remote device	Check continuity on pins 3 and 4 on remote EMO connector. Correct remote EMO condition.
	Remote EMO wiring insufficient Must be 16AWG and less than 15M (50 feet).	Check EMO wiring for 16AWG Correct wiring as required.
	Supply voltage too low	Check voltage and correct
Compressor will not start Fault LED flashing	Compressor contactor circuit needs resetting	Press Reset switch
	A Fault that opens the compressor contactor is active	Determine what fault is active and resolve the issue. Contact authorized service if fault continues
Compressor will not start Fault LED flashing	Compressor pressure switch PS1 is open indicating high discharge pressure	Wait for pressure to come down below the threshold level. Contact authorized service if high pressure continues
	Compressor thermal cutout switch is open	Wait for compressor motor to cool. Contact authorized service if over heating continues

Problem / HMI Display	Possible Cause	Corrective Action
EMO SWITCH ALARM **CHECK EMO SWITCH** Fault LED Amber	EMO switch is pressed in and activated	Turn EMO switch clockwise to disengage the switch
	Remote EMO is active - open	Correct remote EMO condition
	Remote EMO bypass J11 disconnected	Connect J11
CONTACTOR CHATTERING **CHECK POWER LINE** Fault LED not lit	Motor contactor is rapidly opening and closing	Verify power supply meets all requirements
		Verify control transformer tap settings are correct for supply voltage
		Verify transformer output voltage is in the correct range
		If all voltages are in spec. contact authorized service.
ABUSIVE COMP ON ALARM **WAIT 60 SECONDS** Fault LED Amber	The compressor has been reset too frequently.	Review cause for multiple resets. If due to faults, investigate root cause of the faults and correct. Contact authorized service if problem cannot be resolved

Fan Fault Troubleshooting

Problem / HMI Display	Possible Cause	Corrective Action
FAN FAULT WARNING **CHECK COOLING FAN** Fault LED not lit	One or more electrical box cooling fans are not operating.	Check power and cable. Check fan operation Replace both cooling fans
		Contact authorized Service

Pressure Related Troubleshooting

Problem / HMI Display	Possible Cause	Corrective Action
DIFFERENTIAL PRESSURE	PT1 > PT2 Differential 20psi PT1 = Suction Pressure Transducer PT2 = Discharge Pressure Transducer Alarm L1	Pressure Sensor Fault Contact Authorized Service
HIGH SUCTION PRESSURE	PT1 > 270 psi PT1 = Suction Pressure Transducer Alarm L1	Escessive Suction Pressure Contact Authorized Service
REF PRESSURE SWITCH **NO RECOMMENDATION** Fault LED is Red	Refrigerant Discharge Pressure Switch has activated.	Contact authorized Service
LOW SUCTION PRESS **REFRIGERANT LEAK CHECK** **BALANCE PRESSURE** Fault LED is Amber	A low suction pressure condition has occurred.	Check system balance pressure. See Appendix H: Rapid Balance Pressure Check on page 12-19
		If pressure has dropped, check for leak
		Contact authorized service
HIGH DISCHRG PRESS **EXCESSIVE HEAT LOAD** Fault LED Red	Discharge pressure is too high	Review application to ensure it is within the capability of the unit.
		Check for excessive heat load.
		Make sure all thermal radiation shields are in place.
		Ensure that the unit has a minimum of 5 minutes in Standby before switching to cool.

Temperature Related Troubleshooting

Problem / HMI Display	Possible Cause	Corrective Action
FREEZOUT PREVENTION Fault LED not lit	Freeze out prevention sensor is experiencing a temperature colder than expected.	Check refrigerant
		Check freezeout prevention valve and thermocouple
		Contact authorized service
C1 CUST TC FAILED **C2 CUST TC FAILED** Fault LED is Amber	Thermocouple not proper type	Verify that a type T (copper - constantan thermocouple sensor is being used.
	Thermocouple not properly installed	Check installed polarity of customer installed thermocouple
		Check TC terminal connection tightness Torque Spec is 0.34 N-m (3 lb-in)
		Check thermal bonding of sensor to tube.
	Thermocouple junction not properly fabricated	Check TC junction is commercially prepared junction OR TC junction is soldered or welded TC Junction must **NOT** be just twisted wires
HIGH DISCHRG TEMP **REFRIGERANT LEAK** **CHECK BALANCE PRESSURE** Fault LED Amber	Compressor discharge temperature is too high	Check cooling water flow
		Contact authorized service
REF LQD LINE TEMP Fault LED is Amber	Cooling water flow and / or temperature are outside of acceptable limits. The system turns off due to excessively low cooling water temperature, excessively high cooling water temperature or insufficient flow.	Check your temperature and flow to ensure it is within acceptable limits.

Problem / HMI Display	Possible Cause	Corrective Action
LQD LINE START TEMP **NO RECOMMENDATION** Fault LED is Amber	Cooling water flow and / or temperature are outside of acceptable limits during system start This fault will occur during startup if the system coolant sensor fails to reach a temperature below 42 C within 14 seconds.	Check your temperature and flow to ensure it is within acceptable limits.
THERMAL OVERLOAD **NO RECOMMENDATION** Fault LED is Amber	Motor thermostat has tripped	Contact authorized service.
	CB1 has tripped	Check for cause of excessive thermal load on the cryocoil,
		Check if supply voltage is below nominal conditions.
		If application has a combination of high load, near max rating and supply voltage is below 93% nominal, have a qualified electrician rewire CB2 to “Excepted Wiring”. See Appendix C: CB2 Excepted Wiring.
C1 COOL VALVE CYCLE **C2 COOL VALVE CYCLE** **NO RECOMMENDATION** Fault LED is Amber	Cool valve requires replacement	Contact authorized service
C1 DEFR VALVE CYCLE **C2 DEFR VALVE CYCLE** **NO RECOMMENDATION** Fault LED is Amber	Defrost valve requires replacement	Contact authorized service

Performance Related Troubleshooting

Problem / HMI Display	Possible Cause	Corrective Action
Too slow to go to cool Fault LED not lit Date and Time rolled back	Cryosurface full and requires defrosting.	Defrost the cryosurface Contact authorized Service

Date or Time Troubleshooting

Problem / HMI Display	Possible Cause	Corrective Action
(No HMI Message) Fault LED not lit Date and Time rolled back	Internal battery is dead and real time clock has reset to default after recent power cycle	Reset the real time clock to correct time using remote interface Contact authorized Service to have battery replaced

Remote Monitor Troubleshooting

This section is for the convenience of Remote Monitor troubleshooting. The tables below are the same faults as previously listed in this chapter but are listed in numerical order of the bitmask value.

This section lists faults in numeric order of the bit mask value as received from the command **ACTIVE_ALARMS.** See ALARM_STATUS Current Alarm Status on page 7-18.

For assistance in decoding bitmask values, see 32 Bit Numbered Bitfield on page 7-3.

Bit Mask Value Listing

Bit Mask Value / Problem	Possible Cause	Corrective Action
Bit 0 Customer Installed TC is out of range Fault LED Amber Compressor ON	Difference between system TC 3/5 and customer installed TC 7/8 greater than value of EXT_TC_ALARM when EXT_TC_ENABLE is set to 1 for the circuit Absolute difference between TC3 and TC7 > EXT_TC_ ALARM or Absolute difference between TC5 and TC8 > EXT_TC_ ALARM Fault sets EXT_TC_ENABLE to 0 for affected Ckt Alarm L1	Check customer installed TC for proper installation and proper operation Press Reset to clear alarm
Bit 1 Not used	N/A	N/A

Bit Mask Value / Problem	Possible Cause	Corrective Action
Bit 2 Freeze out prevention active Fault LED Amber Compressor ON	Coldest Liquid Temperature (TC4) (6C low-side dead band in effect when FRZ_RREVENT_SETPT > -158C) When FRZ_PREVENT_SETPT > -158C, then Alarm when TC4 is lower than 6C below FRZ_PREVENT_SETPT When FRZ_PREVENT_SETPT < -158C, then... Alarm when TC4 is lower than FRZ_PREVENT_SETPT Warning L2	Check freezeout prevention valve. Check freezeout TC installation and operation.
Bit 3 Not used	N/A	N/A
Bit 4 Differential Pressure Fault LED Amber Compressor OFF	PT1 > PT2 Differential 20psi PT1 = Suction Pressure Transducer PT2 = Discharge Pressure Transducer Alarm L1	Pressure Sensor Fault Contact Authorized Service
Bit 5 High Suction Pressure Fault LED Amber Compressor ON	Suction Pressure Transducer (PT1) PT1 > 270 psi Alarm L1	Escessive Suction Pressure Contact Authorized Service
Bit 6 Not used	N/A	N/A
Bit 7 High discharge pressure Fault LED Red Compressor OFF	Pressure Transducer PT2 shows high discharge pressure which indicates excessive heat load PT2 > 3102.6kpa (450 psi) Alarm L1	Check system load and performance

Bit Mask Value / Problem	Possible Cause	Corrective Action
Bit 8 High discharge temperature LED Amber Warning: Compressor ON Alarm: Compressor OFF	Compressor Discharge Temperature (TC1) too high TC1 80 to 125C is normal TC1 125 to 148.9C at startup is normal TC1 135 to 148.9C for 30 min Warning L2 TC1 135 to 148.9C for 40 min Alarm L1 TC1 145 to 148.9C for 2 min Warning L2 TC1 ≥149C immediate Alarm L1	Contact authorized service
Bit 9 Rapid Balance Pressure Check Valve Cycle Count Fault LED Amber Compressor ON	Rapid Balance Pressure Check Valve Cycle Count has exceeded limit CRYO_VALV_OPEN_CNT for Rapid Balance Pressure Check Valve > VALVE_CYCLE_WARN Alarm L1	Contact authorized service
Bit 10 Input power out of range Fault LED Amber Warning: Compressor ON Alarm: Compressor OFF	Input voltage out of range of PWR_WARN_BAND Voltage outside of range of PWR_WARN_BAND for 10sec Waning L2 - Comp On (10 sec to restart compressor) Voltage outside of range of PWR_WARN_BAND for 30min Alarm L1 - Comp Off (10 min to restart compressor) Voltage above 33.2V for 1min Alarm L1 -Comp Off (10 sec to restart compressor)	Check and correct the input voltage

Bit Mask Value / Problem	Possible Cause	Corrective Action
Bit 11 Refrigerant liquid line temp Fault LED Amber Warning: Compressor ON Alarm: Compressor OFF	Refrigerant Liquid Line Temperature (TC2) multiple conditions TC2 is between 9C and 12C for 1 min. Warning L1 TC2 < 9C for 15 min Alarm L1 TC2 > LINE_TEMP_FAULT_LIMIT for 2 min Alarm L1 TC2 > 50C for 1 min Alarm L1 TC2 > 60C for 30 sec Alarm L1	Check cooling water flow and temperature
Bit 12 Refrigerant Liquid Line Temp (TC2) before and during operation Fault LED Amber Compressor OFF	Cooling water is poor Before Comp start TC2 >85C Comp will not start After Comp start TC2 > 85C for 14 seconds, then Alarm L1 Comp OFF	Water temperature too high. Check cooling water flow and temperature
Bit 13 Refrigerant Pressure Switch Fault LED Red Compressor OFF	Pressure switch is open Pressure switch fault Alarm L1	Check refrigerant pressure Contact authorized service
Bit 14 Low Refrigerant Suction Pressure Fault LED Amber Compressor OFF	PT1 < -17.9kpa (-2.6psi) Alarm L1 PT1 < -4.13kpa (-0.6psi) for 5 min Alarm L1	Low refrigerant pressure Possible refrigerant leak Contact authorized service

Bit Mask Value / Problem	Possible Cause	Corrective Action
Bit 15 Thermal Overload Fault LED Amber Compressor OFF	Absolute difference between PT2 and PT1 < 137.9kpa (20 psi) for 20 seconds Alarm 1 30 min to restart compressor **OR** "Aux" contact pair on the Contactor is 1 (open), and contactor is programmed to be 0 (closed) Alarm L1	Wait 30 minutes to clear Check input power and load. Check for cause of thermal overload Check the contactor operation. Check the "Aux" contact set on the Contactor
Bit 16 Not used	N/A	N/A
Bit 17 Not used	N/A	N/A
Bit 18 Not used	N/A	N/A
Bit 19 Not used	N/A	N/A
Bit 20 Buffer Valve Cycle Count Fault LED Amber Compressor ON	Buffer Valve cycle count has exceeded limit CRYO_VALV_OPEN_CNT for Buffer Valve > VALVE_CYCLE_WARN. Alarm L1	Contact authorized service
Bit 21 Cylinder Unloader Valve Cycle Fault LED Amber Compressor ON	Cylinder Unloader Valve Cycle Count has exceeded limit CRYO_VALV_OPEN_CNT for Cylinder Unloader valve > VALVE_CYCLE_WARN Alarm L1	Contact authorized service
Bit 22 Cool Valve Cycle Fault LED Amber Compressor ON	Cool Valve Cycle Count has exceeded limit CIRC_VALV_OPEN_CNT for Cool valve > VALVE_CYCLE_WARN Alarm L1	Contact authorized service

Bit Mask Value / Problem	Possible Cause	Corrective Action
Bit 23 Defrost Valve Cycle Fault LED Amber Compressor ON	Defrost Valve Cycle Count has exceeded limit CIRC_VALV_OPEN_CNT for Defrost valve > VALVE_CYCLE_WARN Alarm L1	Contact authorized service
Bit 24 Freezeout Valve Cycle Fault LED Amber Compressor ON	Freezeout Valve Cycle Count has exceeded limit CRYO_VALV_OPEN_CNT for Freezeout valve > VALVE_CYCLE_WARN Alarm L1	Contact authorized service
Bit 25 Not used	N/A	N/A
Bit 26 Not used	N/A	N/A
Bit 27 Not used	N/A	N/A
Bit 28 EMO Switch Fault LED Amber Compressor OFF	EMO switch is open Alarm L1	Check EMO switch Twist EMO switch CW to reset
Bit 29 Cooling Fan Fault LED not lit Compressor ON	One or both of the (2) E-Box cooling fans is disconnected or has stopped Warning L2	Check if cooling fans are operating properly Check power for cooling fans Repair power connection or replace fan(s)
Bit 30 Contactor Chatter Fault LED not lit Compressor ON	Compressor Contactor is chattering ON/OFF due to low voltage or power issues Warning L2	Check input power Check Transformer tap setting
Bit 31 Abusive Comp On/OFF Fault LED Amber Compressor ON	Compressor has been turned ON/OFF 3 times within 1 minute Alarm L1	Wait one minute to clear before compressor allowed to start

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11 Tools and Parts

Tools and Fixtures

The Polycold Cryochiller does not require special tools or fixtures for normal operation or servicing. A kit of tools and maintenance items comes with each unit.

The tables below list the supplied tools, recommended tools, and optional tools.

Table 11-1: Supplied Tools and Fixtures shipped with the Polycold Cryochiller

Part Number	Description and Use
166937	O Ring Removal Tool (part of shipping kit - as required)

Table 11-2: Recommended Tools and Fixtures for the Polycold Cryochiller

Part Number	Description and Use
	7/16”, 9/16”, 1”, 1 1/16”, 1 5/16”, 1 11/16” wrenches for valve maintenance
	1 1/16” Deep socket for valve maintenance
	1 1/16” Crow Foot for vale maintenance
	1 3/4“ Deep socket for valve maintenance
	Adjustable wrenches, as required, if inch wrenches are not available

Table 11-3: Optional Tools and Fixtures for the Polycold Cryochiller

Part Number	Description and Use
810030-07	2.5 inch spanner (commonly shipped with cryocoils)

Parts

Refer to the system documentation for installed components and options.

Parts Shipped with Unit

Table 11-4: Polycold Cryochiller Standard Parts

Part No.	Description
840164-XX	Shipping Kit Insulation kit. Components dependent on the system configuration.

Maintenance Items

Maintenance items are dependent on the system configuration and application. Standard maintenance items are listed in Table 11-5. Contact Brooks Automation Technical Support for additional maintenance items.

Table 11-5: Polycold Cryochiller Maintenance Items

Part No.	Description	Frequency
171705-01	Fan Filter (one per unit, covers 2 fans)	Annually or as required
081009-00	Compressor Oil, POE LT-32 Solest Oil	As required
840298-00	3/8 inch Superior Valve Service Kit	As required
840279-00	5/8 inch Henry Valve Service Kit	As required
380090-00	B-6S1 Valve Service Kit	As required
380091-00	B-9 Valve Service Kit (with warm valve gasket)	As required
183901	B-14S2 Solenoid Valve Service Kit (with warm valve gasket)	As required
183902	B-9S2 Valve Service Kit (with Polycold Cryo Valve Gasket)	As required
183903	B-14 Valve Service Kit (with Polycold Cryo Valve Gasket)	As required

Optional Parts

Table 11-6: Polycold Cryochiller Optional Parts

Part No.	Description
840302-00	Lift Ring Option
181500	Terminal Block Accessory Kit
183933	Cryochiller Caster Kit
Contact Brooks	Refrigerant Line Set (2 lines)
840305	Gauge Relay Kit (4-pin 11 CPC) (20 to 24AWG)
207104	Remote EMO Kit (4-pin 11 CPC) (16 to 18AWG)
840104-00	24V DI/DO Non-Isolated Remote Connector (37-pin 23 CPC) With backshell and pins For use with customer cable
840105-00	24V DI/DO Isolated Remote Connector (37-pin 23 CPC) With backshell and pins For use with customer cable

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12 Appendices

Contents

Appendix A: Contact Brooks Information

When contacting Polycold Division of Brooks Automation for Technical Support, please follow the procedures described here and have the following information available.

1. Unit Information
   - Serial number, Model number, Name of tool:
   - Balance pressure of the unit or TC9 at ambient temperature (~ 17°C):
     See Appendix H: Rapid Balance Pressure Check on page 12-19
   - TC readouts 1-10 in cool mode and standby after 30 minutes:

2. Site Information
   - Company Name, Site Location, Street Address, City, State Zip:

3. Contact Information:
   - Primary Contact Name, Phone, and E-mail:
   - Secondary Contact Name, Phone, and E-mail:

4. Describe the malfunction observed and any error codes received during the failure.
   - Time that this issue has been occurring
   - Work that was done on the equipment prior to the error
   - Actions taken after the error and the results of those actions
   - Other information that may assist the Specialist

5. E-mail this information to Polycold at: polycoldsupport@brooks.com.

Customer Support Information

You can reach Polycold and Brooks Global Customer Operations Teams around the world at the times and phone numbers below.

Table 12-1:

Weekday Support 5:00 AM to 5:00 PM (PST)	
Polycold	1-707-769-7000 (FAX +1-707-769-1380)
	E-mail: polycoldsupport@brooks.com
After Hours Support	
Brooks Location:	**Contact Number**
North America	1-800-FOR-GUTS (1-800-367-4887) US/Canada
	+1-978-262-2900
	E-mail: techsupport@broks.com
Germany, France, UK	+49 1804 CALL GUTS (+49 1804 2255 4887)
Japan	+81-45-477-5980
China	+86-21-5131-7066
Taiwan	+886-3-552-5225
Korea	+82-31-288-2500
Singapore	+65-6464-1481

For additional contact information, please go to the Brooks Automation web site at www.brooks.com.

Appendix B: Lifting Rings (Optional)

Optional lifting rings may be installed on the top four corners of the Polycold Cryochiller refrigeration units to aid in lifting and moving.

WARNING

Load Shift Hazard

When lifting the Polycold Cryochiller using straps and rings, the straps may shift slightly due to the offset center of gravity and may cause death or severe injury.

Ensure that the area beneath the hoist is clear of personal and equipment when lifting the unit.

WARNING

Heavy Object Hazard

Electrical Equipment Safety guideline IEC61010-1 and UL61010-1 Cl.7.5.3 require that the lifting sling have a safety factor (SF) of at least 4 times (4X) the weight of the load. Other standards have different safety factors.

Use a lifting device and slings rated according to local regulations but not less than 2132 kg (4700 lb)

WARNING

Heavy Equipment

This unit can weigh up to 1300lbs (590kg). This unit may fall when moved improperly which may cause serious injury or death.

To avoid this hazard, follow these precautions:

- Read the user's manual before moving
- Use all four hoist rings with overhead lift equipment rated for use with this load with an adequate safety factor.
- Lift with more than 45 degree angle from horizontal

When using a sling to lift the unit by the lift rings, observe the following:

- The strength the lifting device must be greater than 4 times the weight of the unit being lifted.
- Lift with 4 straps that each have a minimum strength as required by local regulations but not less than the weight of the item being lifted.
- The length for each strap between the lift ring bolt and the lifting point must be greater than **736mm (29 inches)**.
- The angle between the sling strap and horizontal at each lift ring must be **greater** than **45**°.

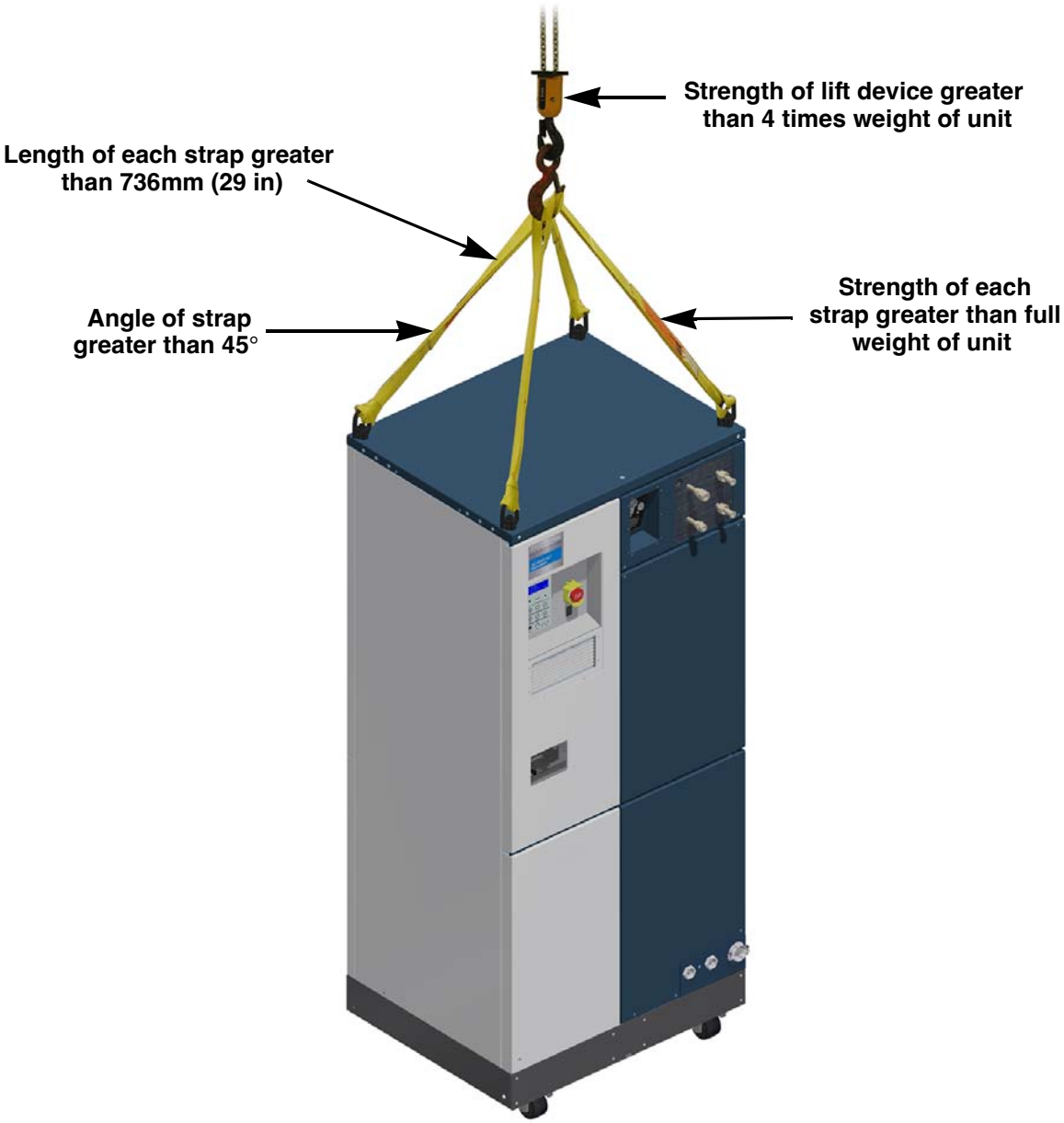


Figure 12-1: Polycold Cryochiller with Lifting Rings

Appendix C: CB2 Excepted Wiring

CB2 input wiring is shipped with input power coming from the output terminals T2 and T3 of CB1.

Customers running at low voltage below 93% of nominal voltage and running the system at or near maximum load may consider an excepted method for wiring CB2. The excepted method is to wire the two input lines to CB2 directly from the input side L2 and L3 of CB1. This wiring change decrease the load on CB1 and will not affect the system safety or performance. When the CB2 is wired in the “excepted method”, wire and label “in accordance to local requirements”.

When CB2 wiring is completed, reinstall the finger guards.

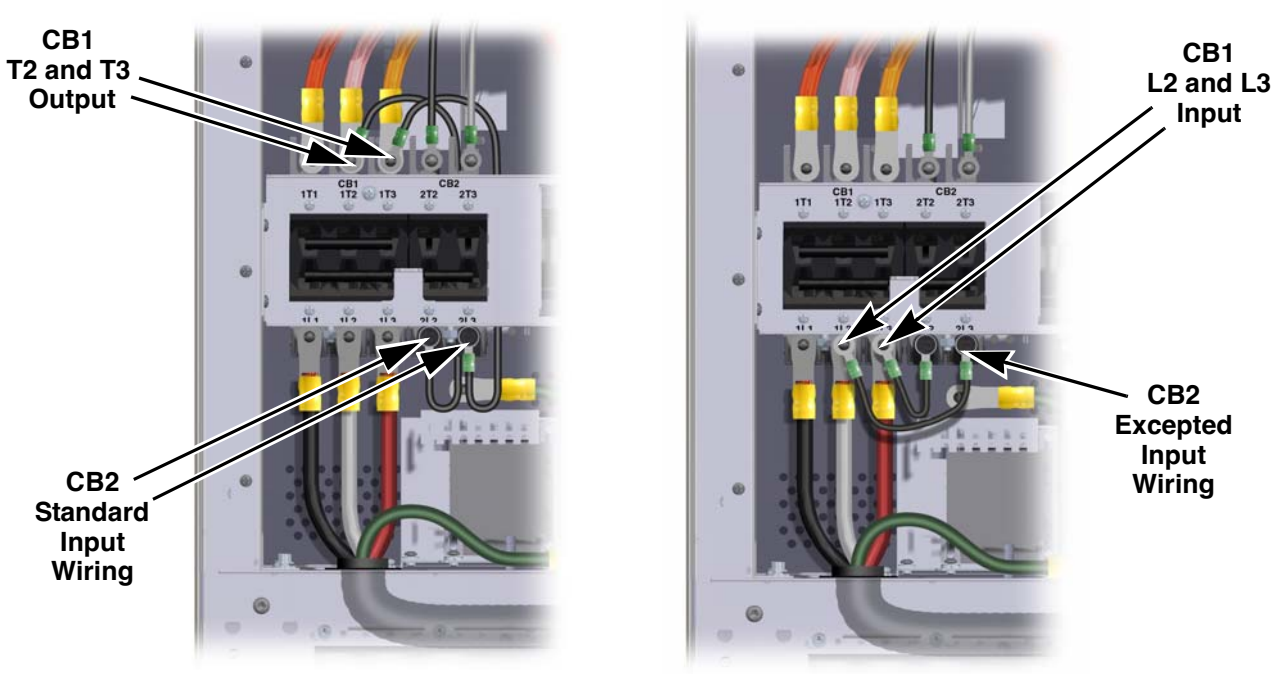


Figure 12-2: CB2 Input Wiring: Standard CB2 Wiring (left) and Excepted CB2 Wiring (right)

WARNING

Electric Shock

Contact with exposed electrical conductors may cause electric shock and death or serious injury.

Replace all finger guards and protective covers for circuit breakers and transformers, as provided, after electrical connections are completed.

Appendix D: Remote EMO

The optional J11 EMO connection allows for a 4-pin Remote EMO control and Remote EMO Status connection at J11 on the Interface panel.

The Remote EMO Status and Remote EMO Control connections allow for monitoring the status of the compressor contactor and controlling the power to the compressor contactor.

If Remote EMO is not used, J11 EMO Jumper must be installed or the compressor will not operate.

Figure 12-3: Remote EMO Connector and J11

EMO Status

Pins 1 and 2 of J11 allow a remote device to sense the status of the Cryochiller EMO circuit.

- Open circuit between this pair of contacts indicates that the compressor contactor is off or open.
- Closed circuit between this contact pair indicates that the compressor contactor is on and the compressor is probably running.

EMO Remote Control

Pins 3 and 4 of J11 allow a remote device to interrupt the power to the coil of the contactor which controls the power to the compressor motor. Pins 3 and 4 are in series with the power to the compressor motor contactor relay.

- When pins 3 and 4 are open, the circuit to the compressor contactor is open. The compressor cannot operate until this pair is closed. These pins directly interrupt the wiring of the power circuit that controls the contactor.
- When pins 3 and 4 are closed, the circuit to the compressor contactor is closed. This allows the compressor contactor to be turned on by the compressor on/off switch on the Cryochiller.

Pins 3 and 4 must be wired to a switch or a set of relay contacts or must be jumpered using the J11 EMO jumper connector.

Remote EMO Connector Wiring

System EMO Connection	4-pin Connector (female pins)
Cable Connector	4-pin Cable Connector (male pins) (Amp CPC-11 - 206429-1)
Cable Terminal Pins	(4) crimp-tail style male pins for 16 to 18AWG wire size.
Cable Size	16AWG wire required for pins 3 and 4 16 to 18AWG for pins 1 and 2 Cable must be less than 15M (50 feet).
EMO Status Connection (Output)	Pins 1 and 2 give dry contact switch closure output signal to remote device to monitor compressor contactor on/off. Closed = contactor on. Open = contactor off
EMO Control Connection (Input)	Pins 3 and 4 interrupt the compressor contactor circuit. Switch set or relay contact pair or jumper wire is required for compressor contactor to turn on. Closed = contactor enabled. Open = contactor disabled

Construct the EMO Remote cable connection following these steps.

- Select a cable that meets the 16AWG size requirements for pins 3 and 4.
- Strip the cable conductors as required for the male crimp terminals.
- Crimp a male terminal onto each conductor in accordance with best practices.
- Place the connector back shell onto the cable.
- Insert the conductor male terminals into the wire side of the connector. See Figure 12-4.
- Thread the connector back shell onto the connector body and tighten firmly.
- Install the cable clamp to the back shell and tighten so that the cable clamp firmly holds the cable. Check for proper cable restraint. Adjust the cable clamp as required.

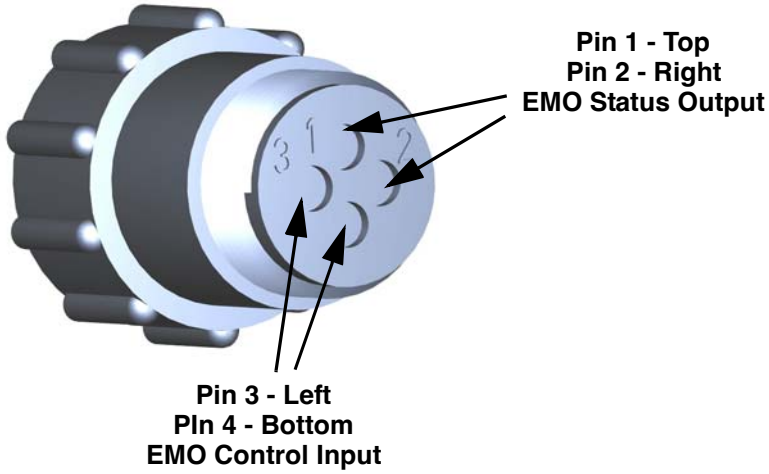


Figure 12-4: J11 Remote EMO Connector - Wire Side View

Appendix E: Water Vapor Cryotrapping

Figure 12-5 and Table 12-1 show the relationship between cryosurface temperature and water vapor partial pressure for different cryotrapping efficiencies.

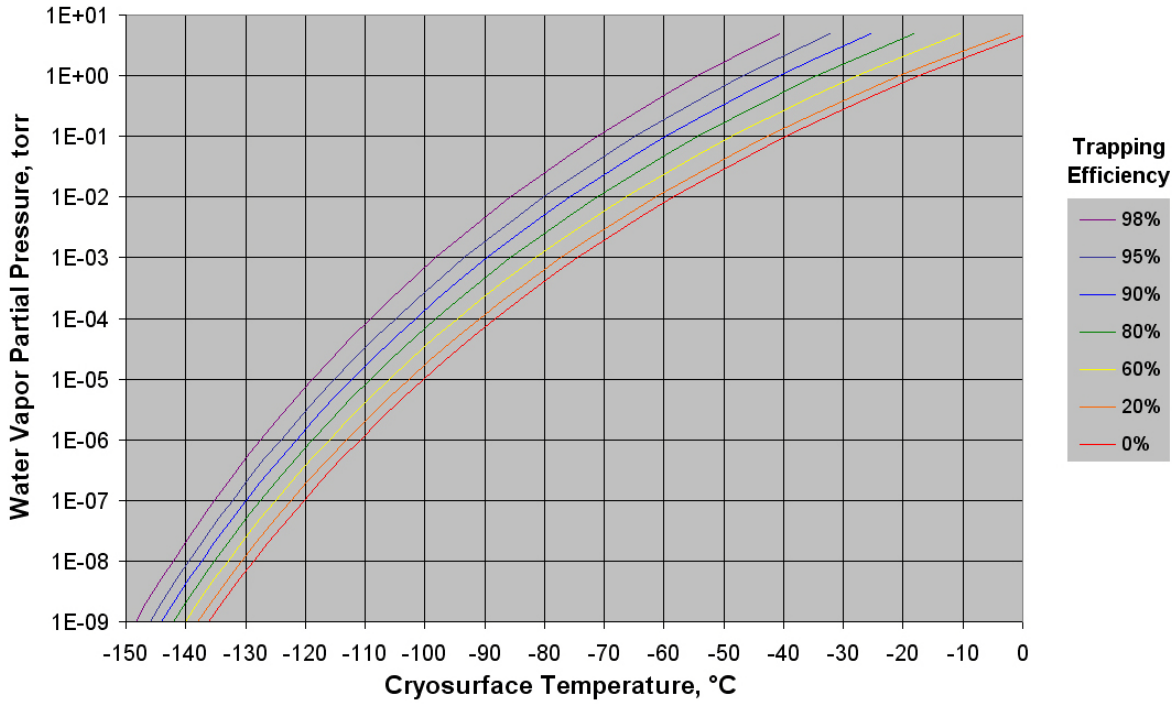


Figure 12-5: Water Vapor Cryotrapping

Cryosurface Pumping Efficiency

For satisfactory pumping results, cryosurfaces should be operated at temperatures cold enough to provide 90% or greater trapping efficiency.

0% efficiency occurs when the cryosurface is in equilibrium with water vapor. At this efficiency, saturation is reached and as many water vapor molecules escape from the cryosurface as stick to it. The right-hand column of Table 12-1 gives the temperatures at which zero pumping occurs at the stated pressure.

To find the best cryosurface temperature for a vacuum application, find the pressure at which the system operates in the left column of Table 12-1 and then follow across to the column showing 90% efficiency. This is the warmest temperature that the cryosurface must be for efficient water vapor pumping.

In general, the deeper the vacuum level, the colder the cryosurface must be in order to trap water vapor at optimum efficiency. For example, for an application requiring a vacuum pressure range of 1×10^{-5} torr, the cryosurface needs to reach a temperature of -112°C or colder to achieve a water vapor trapping efficiency of 90% or better. For an application requiring 5×10^{-7} torr, the cryosurface must be cooled to -124°C to obtain the same efficiency.

The average cryosurface temperature is a convenient number to use when there is a temperature gradient between the coil inlet and coil outlet temperatures. The average cryosurface temperature is simply the average of the coil inlet and coil outlet temperatures. In non-cryopumping applications, such as those used for heat removal, it is the coil outlet temperature that is most important.

Table 12-1: Cryosurface Temperature needed for desire Water Vapor Partial Pressure

Desired Water Vapor Partial Pressure		**Cryosurface Temperature Needed, °C**						
torr	**mbar**	**98%**	**95%**	**90%**	**80%**	**60%**	**20%**	**0%**
5.0E+00	6.7E+00	-40.8	-32.3	-25.4	-18.2	-10.5	-2.3	1.0
2.0E+00	2.7E+00	-48.7	-40.8	-34.4	-27.7	-20.6	-13.0	-9.7
1.0E+00	1.3E+00	-54.3	-46.8	-40.8	-34.4	-27.7	-20.6	-17.3
5.0E-01	6.7E-01	-59.7	-52.6	-46.8	-40.8	-34.4	-27.7	-24.5
2.0E-01	2.7E-01	-66.4	-59.7	-54.3	-48.7	-42.8	-36.5	-33.4
1.0E-01	1.3E-01	-71.2	-64.8	-59.7	-54.3	-48.7	-42.8	-39.7
5.0E-02	6.7E-02	-75.8	-69.7	-64.8	-59.7	-54.3	-48.7	-45.6
2.0E-02	2.7E-02	-81.5	-75.8	-71.2	-66.4	-61.4	-56.1	-53.1
1.0E-02	1.3E-02	-85.6	-80.1	-75.8	-71.2	-66.4	-61.4	-58.4
5.0E-03	6.7E-03	-89.6	-84.3	-80.1	-75.8	-71.2	-66.4	-63.5
2.0E-03	2.7E-03	-94.6	-89.6	-85.6	-81.5	-77.2	-72.7	-69.9
1.0E-03	1.3E-03	-98.2	-93.4	-89.6	-85.6	-81.5	-77.2	-74.4
5.0E-04	6.7E-04	-101.6	-97.0	-93.4	-89.6	-85.6	-81.5	-78.8
2.0E-04	2.7E-04	-106.0	-101.6	-98.2	-94.6	-90.8	-86.9	-84.3
1.0E-04	1.3E-04	-109.1	-104.9	-101.6	-98.2	-94.6	-90.8	-88.2
5.0E-05	6.7E-05	-112.2	-108.1	-104.9	-101.6	-98.2	-94.6	-92.0
2.0E-05	2.7E-05	-116.0	-112.2	-109.1	-106.0	-102.7	-99.3	-96.8
1.0E-05	1.3E-05	-118.8	-115.1	-112.2	-109.1	-106.0	-102.7	-100.3
5.0E-06	6.7E-06	-121.5	-117.9	-115.1	-112.2	-109.1	-106.0	-103.6
2.0E-06	2.7E-06	-125.0	-121.5	-118.8	-116.0	-113.1	-110.1	-107.8
1.0E-06	1.3E-06	-127.5	-124.1	-121.5	-118.8	-116.0	-113.1	-110.8
5.0E-07	6.7E-07	-129.9	-126.7	-124.1	-121.5	-118.8	-116.0	-113.8
2.0E-07	2.7E-07	-132.9	-129.9	-127.5	-125.0	-122.4	-119.7	-117.5
1.0E-07	1.3E-07	-135.2	-132.2	-129.9	-127.5	-125.0	-122.4	-120.2
5.0E-08	6.7E-08	-137.3	-134.5	-132.2	-129.9	-127.5	-125.0	-122.8
2.0E-08	2.7E-08	-140.1	-137.3	-135.2	-132.9	-130.6	-128.2	-126.2
1.0E-08	1.3E-08	-142.1	-139.5	-137.3	-135.2	-132.9	-130.6	-128.6
5.0E-09	6.7E-09	-144.1	-141.5	-139.5	-137.3	-135.2	-132.9	-131.0
2.0E-09	2.7E-09	-146.6	-144.1	-142.1	-140.1	-138.0	-135.9	-133.9
1.0E-09	1.3E-09	-148.4	-146.0	-144.1	-142.1	-140.1	-138.0	-136.1

Appendix F: Feedthroughs

About Feedthroughs

Feedthrough must be selected to match the requirements of the process.

Feedthroughs are used to provide feed and return refrigerant to and from the Polycold Cryochiller cryosurface through the vacuum chamber wall.

One single feedthrough typically incorporates both feed and return lines for the cryosurface.

Typical Brooks Polycold feedthroughs used with the Polycold Cryochiller have a 50mm (2.0 inch) diameter barrel that fits into the vacuum chamber wall. See Figure 12-6. See Figure 12-7 for a close-up of a feedthrough showing the diameter of the barrel of the feedthrough that fits into the hole in the vacuum chamber wall.

P/N 409054-00 has copper tubing. P/N 409053-00 has stainless steel tubing.

Additional feedthrough models are also available from Brooks Polycold, including single-pass feedthroughs for 25mm (1 inch) diameter holes. A total of two such single-pass feedthroughs are required for each cryocoil.

NOTE: *Brooks Automation Polycold feedthroughs are designed to be installed from the inside of the vacuum chamber. This permits removal of the cryosurface when cleaning or servicing the vacuum chamber.*

Table 12-2: Specifications for Polycold Cryochiller Feedthrough

Parameter	Specification
Number	228 [57mm (2.25 inches) ID X 3 mm (0.1.25 inch) section]
Material	Buna-nitrile
Surface	66mm (2.60 inches) Surface roughness not to exceed 0.81 micron (32 micro-inch 0.000032 inch) Must be flat, clean, and free of scratches or deposits.

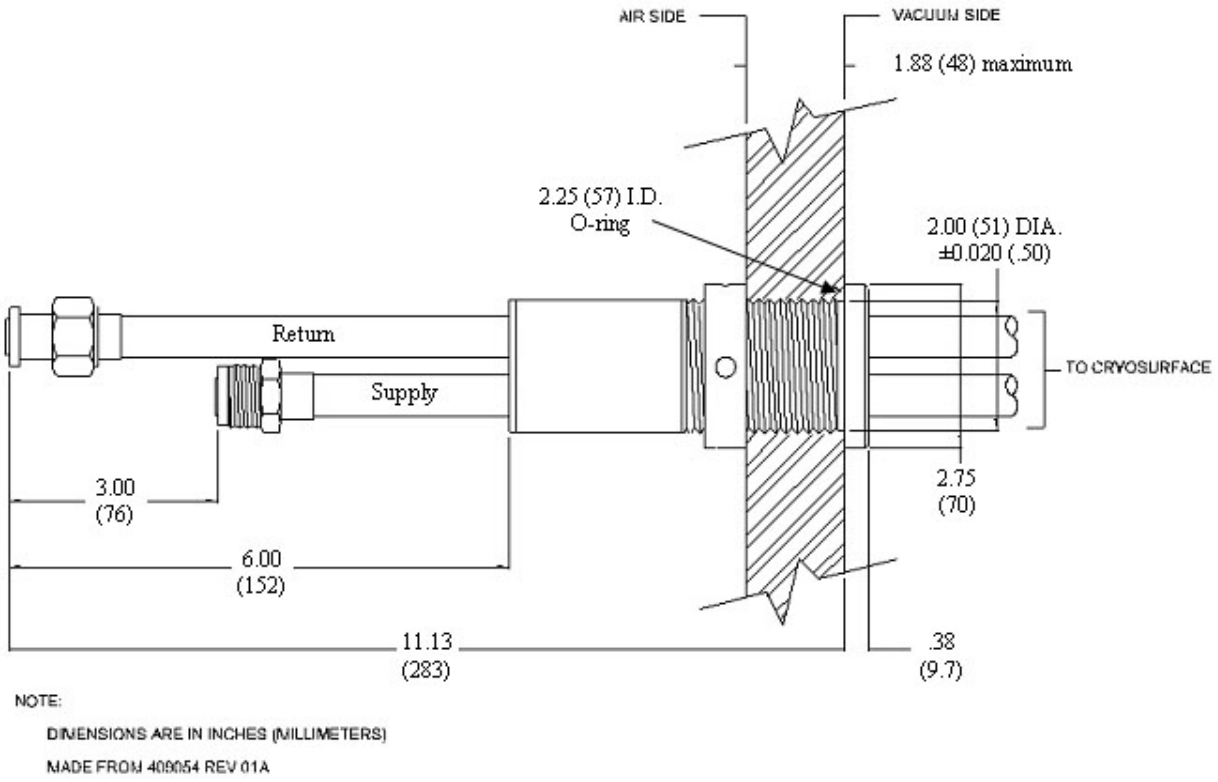


Figure 12-6: Polycold's Two-Inch (50 mm) Feedthrough with Port Requirements

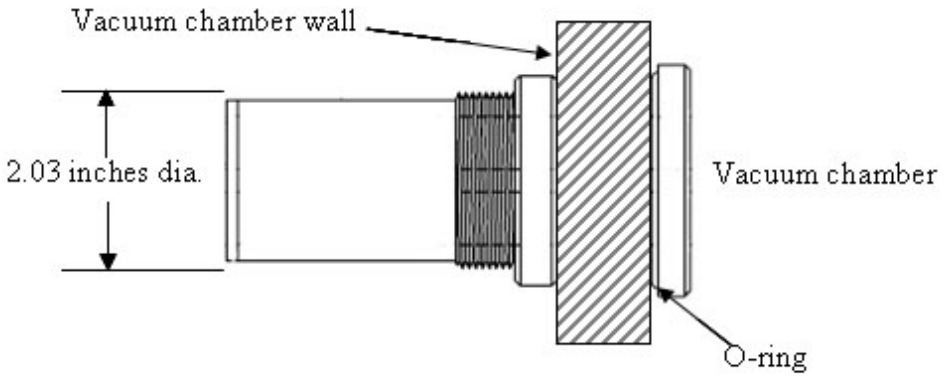


Figure 12-7: Close-up Detail of Feedthrough Connection (Feed and Return Tubes not Shown)

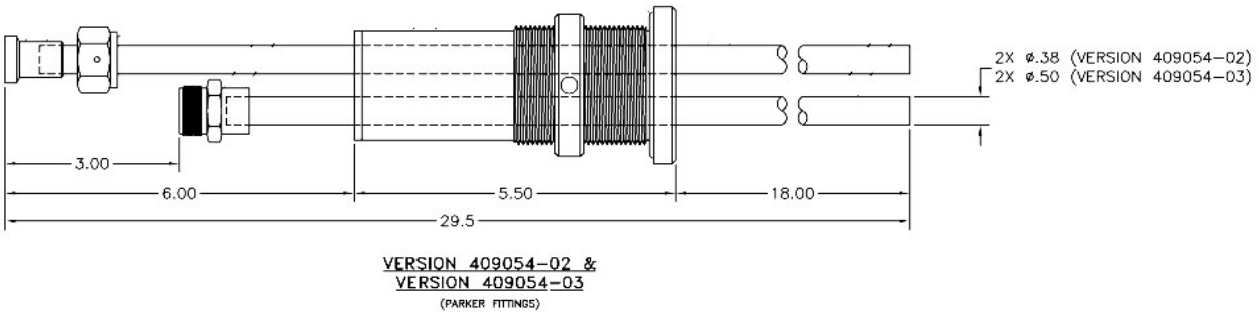


Figure 12-8: Feedthrough; Version -2 and -03

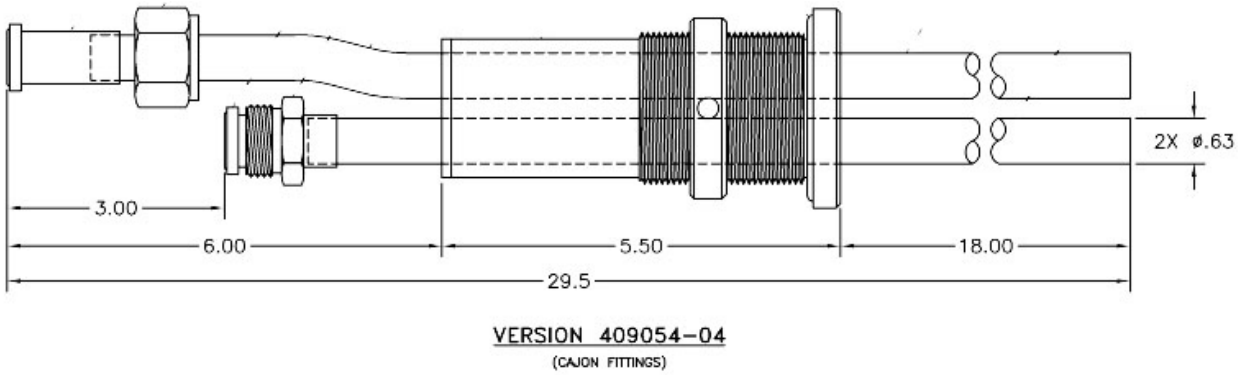


Figure 12-9: .Feedthrough; Version -04

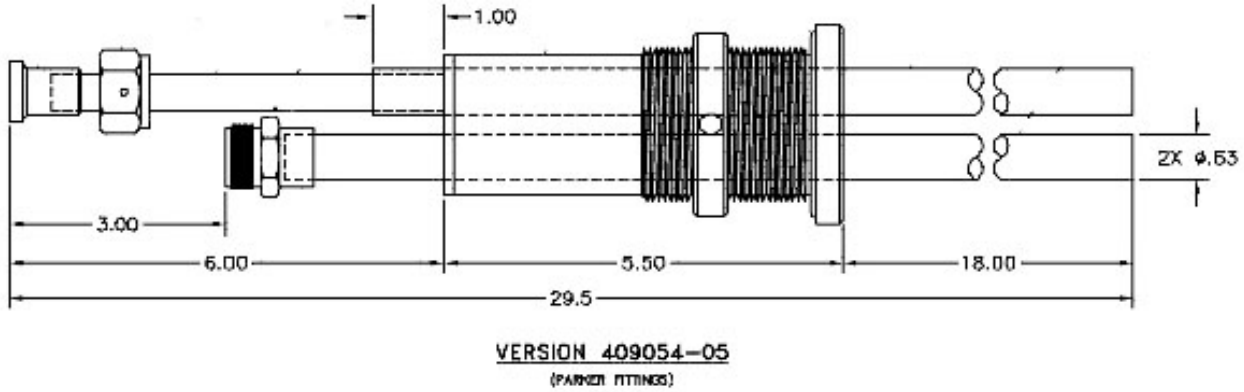


Figure 12-10: .Feedthrough; Version -05

Appendix G: Zero Line Loss Procedure

This procedure is used to pull the refrigerant into the Polycold Cryochiller in order to evacuate the external refrigerant lines to repair a refrigerant line leak. This procedure is also found in “Service Procedure, Zero Line Loss, Polycold Cryochiller”, p/n 185307

Item	Description
Electrical Category	Type 2 - Equipment is energized. Energized circuits are covered and insulated.
Tools and materials:	Standard Hand Tools Open end wrenches or adjustable wrenches as required 1 1/16 inch Crow foot wrenches or deep socket wrenches as required Service menu authorization access code One of the three manifold selections listed below • Service Bypass Line with hand valve, pressure gauge, and (1) 1/4” T adapter and (2) 1/4” evacuation lines • Three-Port Refrigeration Manifold, a ¼” Tee adaptor, and (4) ¼” evacuation lines • Four-Port Refrigeration Manifold and (3) ¼” evacuation lines

NOTICE

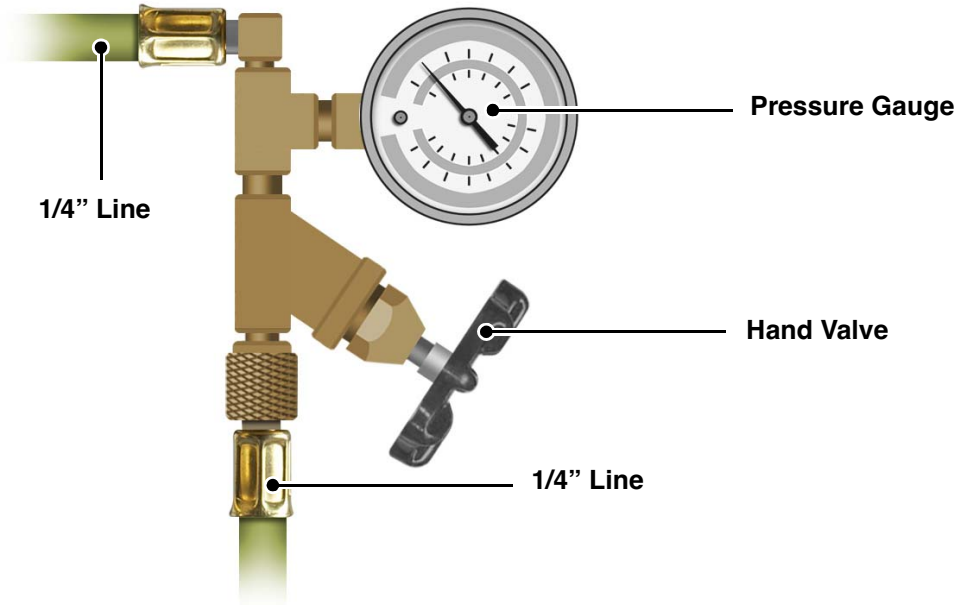
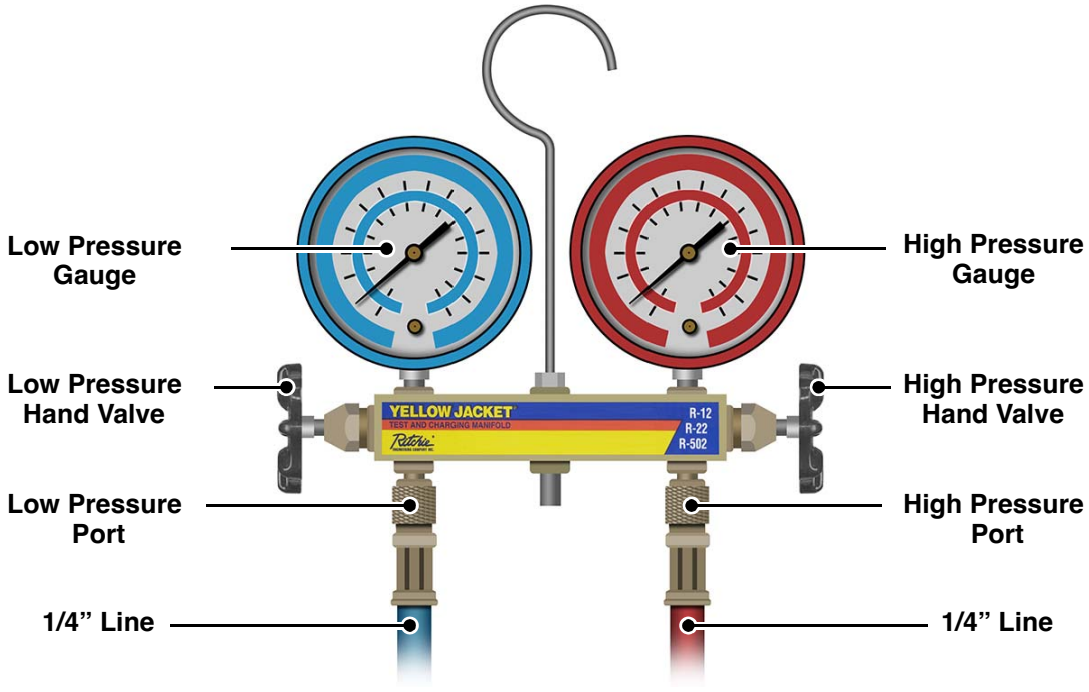
Untrained or improperly equipped personnel performing this procedure may cause damage to the equipment.

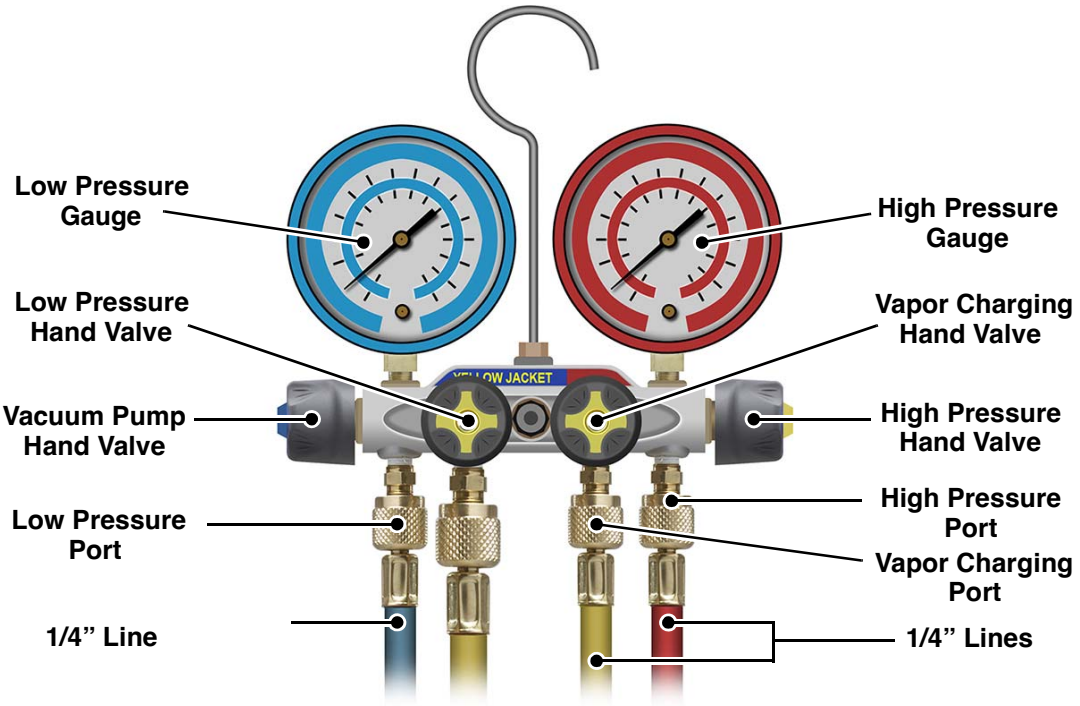
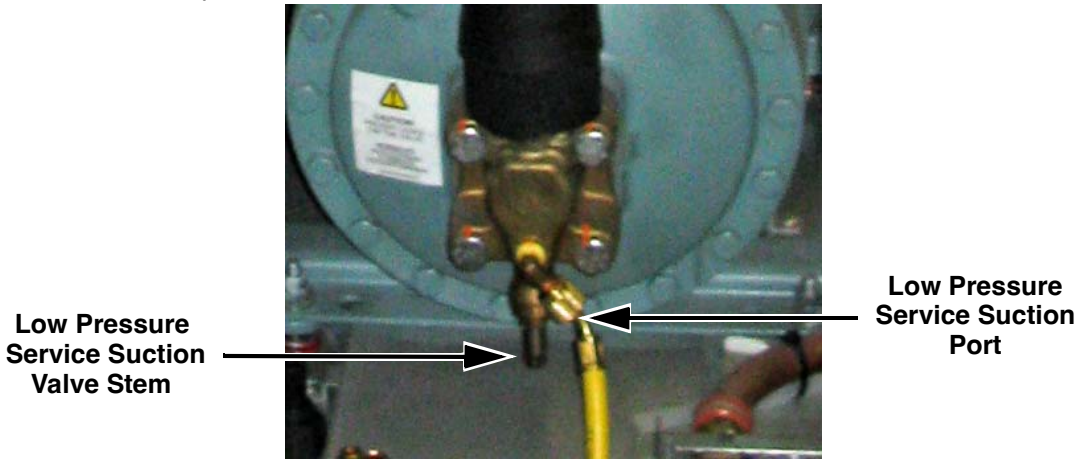
- Only Brooks Automation, Polycold Division, trained personnel should perform this procedure.
- Personnel performing this procedure must read and understand this procedure, the Safety chapter of the Polycold Cryochiller Service Manual, and have the proper tools and supplies ready before starting.
- Personnel performing this procedure must know the applicable regulatory and safety codes, facility safety procedures, safety equipment, and contact information.

Procedure

Step	Action
1.	Set the Polycold Cryochiller to Defrost Mode
2.	Wait for the Polycold Cryochiller to complete the Defrost cycle and indicate that defrost is compete with the Standby and Heat indicators illuminated.

Step	Action
3.	Turn off the Polycold Cryochiller. If the unit has the Rapid Balance Pressure Option, perform a Rapid Balance Pressure Check. Otherwise, wait for at least two hours for the system to come to ambient temperature
4.	Open the valve box. Close the Cold Gas Feed, Hot Gas Feed, and Common Return hand valves. 
5.	If using a **Service Bypass Line**: • Close the hand valve on the service bypass line by turning the handle fully clockwise. If using a **Three or Four-Port Refrigeration Manifold**: • Close all manifold hand valves by turning them clockwise.
6.	Remove the caps from the output end of the Evac Ckt 1 hand valves in the valve box for the circuit being evacuated.

Step	Action
7.	**For Service Bypass Line** Connect the 1/4” service line from the pressure gauge end of the service bypass line to the evacuation port in the valve box for the circuit to be evacuated. 
8.	**For Three Port Refrigeration Manifold** Connect the 1/4” service line from the high pressure port to the evacuation port in the valve box for the circuit to be evacuated. If evacuating a dual circuit unit, connect to both ports using a “T” fitting. 

Step	Action
9.	**For Four Port Refrigeration Manifold** Connect the 1/4” service line from the high pressure gauge port to the evacuation port in the valve box for the circuit to be evacuated. If evacuating a dual circuit unit, connect to both the high pressure gauge port and the vapor charging port to each evacuation port in the valve box. 
10.	**For Service Bypass Line** Connect the 1/4” service line from the hand valve on the service bypass line to the Low Pressure Service Suction Port on the back of the compressor. **For Three or Four Port Refrigeration Manifold** Connect the 1/4” service line from the low pressure port to the Low Pressure Service Suction Port on the back of the compressor. 

Step	Action
11.	Turn on the cryochiller. Set the system control mode to Local. The Remote LED is OFF when system control is set to Local.
12.	Use the HMI keypad and follow the steps to select the ZERO LINE LOSS function. • From the Main Menu, navigate to the **SERVICE MENU** selection. Press the Enter key to select. • Navigate to **AUTHORIZATION CODE**. Press Enter. • Input the **LEVEL 3** authorization code to access the function. • A menu of service options appears. • Scroll down to **ZERO LINE LOSS**. Press Enter. • Scroll down to **CONTINUE**. Press Enter.
13.	Turn on the compressor by the turning the Compressor On/Off toggle switch to **On**.
14.	Open the Evac Ckt 1 hand valve for the refrigerant lines to be evacuated.
15.	**For Service Bypass Line:** • Slowly open the hand valve on the service bypass line to bleed the pressure. • After the pressure equalizes, fully open the valve. **For a standard Three-Port Refrigeration Manifold** • Slowly open the **High Pressure Hand Valve** on the manifold to bleed in the pressure. • After the pressure equalizes, fully open the valve. • Repeat this process for the **Low Pressure Hand Valve**. **For a Four-Port Refrigeration Manifold:** • Slowly open the **High Pressure Hand Valve** on the manifold to bleed in the pressure. • After the pressure equalizes, fully open the valve. • Repeat this process first for the **Vapor Charging Hand Valve** and then for the **Low Pressure Hand Valve**.
16.	Purge the line connected to the Low Pressure Service Suction Port by loosening the fitting (~1/4-turn) just enough to hear gas escape for approximately 2 seconds and then retighten the fitting.
17.	Turn the compressor suction service valve fully in to the front seated position to open the compressor suction to the evacuation line.
18.	Continue with the vacuum extraction until the compound pressure gauge reads 15 inches mercury (50.8 kPag) (7.36 Psig) or lower.

Step	Action
19.	For a **Service Bypass Line:** • Close the service bypass line hand valve. For a **Three-Port Refrigeration Manifold**: • Close the High Pressure Hand Valve. For a **Four-Port Refrigeration Manifold**: • Close both the High Pressure Hand Valve and the Vapor Charging Hand Valve.
20.	Close the Evac Ckt 1 hand valve that are opened for evacuation.
21.	Turn off the compressor by turning the Compressor On/Off toggle switch to Off.
22.	For a **Service Bypass Line**: Observe the compound pressure gauge on the service bypass line for 2 minutes. • If the pressure rises, go to step 4 and close the hand valves tighter and start over from step 3. • If the pressure does not rise after 2 minutes, turn the compressor suction service valve fully out to the back seated position. For a **Three or Four-Port Refrigeration Manifold**: Observe the Low Pressure Gauge on the manifold for 2 minutes. • If the pressure rises, go to step 4 and close the hand valves tighter and start over from step 3. • If the pressure does not rise after 2 minutes, turn the compressor suction service valve fully out to the back seated position.
23.	Confirm that the evacuation port Evac Ckt 1 hand valve is closed.
24.	Press the Enter key on the HMI keypad.
25.	Disconnect all ¼” lines and “T” adapters from the compressor Low Pressure Service Suction Port and Evac Port(s).
26.	Reinstall the caps on the evacuation hand valve and the compressor low pressure service suction port.
27.	Recheck the “packing nut” on the Evacuation Valve for proper tightness to prevent possible leaks.

Appendix H: Rapid Balance Pressure Check

Rapid Balance Pressure Check, sometimes referred to as Stack Warm, is a method to rapidly check the equalized system pressure to confirm proper system charge. Balance pressure is the pressure of the refrigerant when the compressor is at rest and the suction and discharge pressures have equalized to the same pressure.

Rapid BP Check is done by rapidly warming the system and then allowing the suction and discharge pressure transducers to reach equilibrium. Once at equilibrium, the pressure gauge reading is the Balance Pressure. This pressure is very close to the static pressure and very useful for service purposes.

The amount of time that it takes the system to reach the end of the Rapid BP Check is dependent on the state of the system, the load of the system, and the temperature and flow rate of the cooling water. Nominal Rapid BP Check takes approximately 15 minutes. Note that unlike other products, the Polycold MaxCool Cryochiller does not require 48 hours to reach balance pressure.

The vacuum chamber should be in a vacuum state when operating the Rapid BP Check Mode. Operating this feature when the cryosurface is not in a vacuum environment may cause excessive heat loss and the process may not be able to complete.

When Rapid Balance Pressure check is completed, some service functions may be performed. However, charge removal requires a waiting period of a minimum of 12.

Static Pressure versus Rapid Balance Pressure

Static pressure is different from Balance pressure due to the fact that static pressure requires that the unit is at rest and at ambient temperature for 48 hours or longer. Balance Pressure and Static pressure may be different by 5 to 20 psi.

To make Rapid Balance Pressure check more relevant, the user should perform a Rapid Balance Pressure check soon after installation. This value should be recorded for future reference.

Rapid Balance Pressure Check Procedure

1. Verify the vacuum chamber is in a vacuum state, typically 10^{-3} torr or below.
2. Use the HMI keypad to go to the SERVICE MENU and press “Enter”.
3. Scroll to the AUTHORIZATION CODE. Press “Enter”.
4. Enter the authorization code for Security Level 2 (Default Operator Access). Press “Enter”. See Security Levels on page 7-7.
5. Scroll down to “INIT RAPID BP CHECK”. Press “Enter”.
6. The system performs a rapid defrost and stops the Rapid BP Check procedure when the endpoint has been reached.
7. Wait until the suction and discharge pressure transducers reach equilibrium. This typically takes about 5 minutes.
   Note that the transducers may not read the same value when at equilibrium but may have a slight offset due to gauge accuracy.

8. When the transducers are at equilibrium and hold a steady value, take a pressure reading. This is the Balance Pressure.

Appendix I: Disconnect, Packing, and Shipping Instructions

If the Polycold Cryochiller is to be shipped, it must be properly packaged to ensure it arrives undamaged.

NOTE: *The original shipping crates or equivalent must be used when shipping the Cryochiller. If the original crates are lost or damaged, contact Brooks Automation for replacements.*

WARNING

Electrical Hazard

Contact with energized equipment can cause electric shock and result in death or serious injury.

Avoid contact with electrical circuits.

Disconnect electric energy before disassembling electric service.

NOTICE

Refrigerant removal or charging must be performed by Brooks Service personnel or Brooks authorized service providers.

Customers must never attempt to add or remove refrigerant from the system.

Item	Description
Electrical Category	Type 2 - Equipment is energized. Energized circuits are covered or insulated.
840164-XX	Shipping Kit XX designates the kit version for the Polycold Cryochiller
Tools and materials:	Standard tool kit and refrigerant line tools. Moisture, Shock, and Tip indicators as required

Packing Procedure

1. Evacuate the refrigerant from the refrigerant lines and cryosurface by performing the Zero Line Loss procedure. See Appendix G: Zero Line Loss Procedure on page 12-13
2. Carefully disconnect the cryosurface, refrigerant lines, and thermocouples and package them for shipment.
3. Disconnect all external wiring and facilities connections.
4. Lock down the compressor to the frame by installing the double lock-down nuts on each of the (4) compressor bolts.
5. Secure all panels firmly in place with shrink wrap or similar product.
6. Firmly secure the Polycold Cryochiller to a shipping pallet and cover with a cardboard enclosure.
7. Add shipping indicators, if required.

Appendix J: Material Safety Data Sheets - MSDS

Document 825086-00 provides the MSDS information for the blends of refrigerant gas.

Document 825103-00 provides the MSDS information for the compressor oil.

MSDS - Refrigerant Gas

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Petaluma, CA 94954 www.brooks.com

Material Safety Data Sheet

PRODUCT IDENTIFICATION

Product Name:	**INERT-HFC POLYCOLD® Refrigerant (Proprietary)**
Chemical Classification:	Hydro fluorocarbons and Inert Gas Mixture
Product Use:	Refrigerant Gas
Manufacturer's Name:	Brooks Automation Inc.
Address:	3800 Lakeville Highway, Petaluma, CA 94954
Business Phone:	(707) 769-7000
Emergency Phone: Chemtrec North America:	**1-800-424-9300 or 1-703-527-3887**
Preparation Date:	**May 7, 2001**
Revision Date:	**November 01, 2005**

COMPOSITION AND INFORMATION ON INGREDIENTS

Ingredients	CAS No.	EINECS No.	R Phrases
Proprietary blend of HFC (hydro fluorocarbon) refrigerant gases	N/A	N/A	R36/37
Inert gas	N/A	N/A	R36/37

HAZARD IDENTIFICATION

Symptoms of Exposure by Route	
Inhalation:	The most significant route for overexposure is through inhalation of high concentrations of the gas product. Overexposure may cause central nervous system depression and oxygen deficiency. Effects of overexposure may include light-headedness, giddiness, shortness of breath, headaches, and in extreme cases, irregular heartbeats, cardiac arrest, and death. Symptoms of overexposure at lower concentrations may include transient eye, nose, and throat irritation.
Skin Contact:	Contact with rapidly released gas may cause frostbite. Other direct dermal contact may result in skin de-fatting, dryness, irritation, or contact dermatitis. Symptoms of frostbite may include changes in skin color to white or grayish-yellow.
Eye Contact:	Eye contact with rapidly released gas may cause severe frostbite damage to eyes and lids. Eye irritation may occur with exposure to low concentrations.

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(cont.) HAZARD IDENTIFICATION

Ingestion:	Perforation of the stomach lining and nausea may develop if liquid product is ingested.
Other Potential Health Effects:	Inhalation associated with deliberate abuse, or spills occurring in poorly ventilated areas, may result in severe cardiovascular and respiratory effects, and even sudden death.
Carcinogenicity:	OSHA - No NTP - No IARC - No
Health Effects or Risk of Exposure:	Exposure to high concentrations may result from a release or spill in a poorly ventilated area. Inhalation of high-concentrations may result in suffocation from oxygen deprivation or other severe health effects including central nervous system depression, heart attack, and sudden death. Direct skin or eye contact with rapidly released gas may cause frostbite and severe tissue damage.

FIRST-AID MEASURES

Inhalation:	Administer fresh air immediately. Use a bag valve mask or similar device to perform artificial respiration (rescue breathing) if needed. Get medical attention immediately.
Skin Contact:	Wash if needed. If frostbite, freezing, or cryogenic burns occur, warm affected area in warm water. If this is not available, gently wrap affected parts in blankets. Allow circulation to return naturally. Get medical attention immediately.
Eye Contact:	Wash with large amounts of water or normal saline until no evidence of chemical remains (at least 15-20 minutes). Get medical attention immediately. Remove contact lenses if easily possible.
Ingestion:	Get medical attention immediately.

FIRE-FIGHTING MEASURES

Flashpoint:	Not applicable.
Auto-ignition Temperature:	Not applicable.
Flammable Limits (in air by volume, %)	Not applicable.
Fire Extinguishing Media:	Use media appropriate for surrounding materials.

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(cont.) FIRE-FIGHTING MEASURES

Unusual Fire and Explosion Hazards:	CAUTION: Cylinders that are exposed to heat from a fire may rupture or burst and release contents. Although this material is non-flammable, the contents can present health hazards to firefighters if involved in a fire. When involved in a fire, this material may decompose and produce toxic hydrogen fluoride and carbonyl fluoride gases.
Special Fire Fighting Procedures:	Move containers away from fire if possible without personal risk. Keep containers cool well after fire is out. Stay upwind and keep out of low areas. Ventilate closed spaces prior to entry.

ACCIDENTAL RELEASE MEASURES

Spill and Leak Response:	Stop leak immediately if possible without personal risk. Keep people away, isolate area, and deny access. Gases may be heavier than air and spread along the ground and collect in low or confined areas (sewers, basements, tanks). Stay upwind and avoid low areas. Ventilate closed spaces prior to entry. If possible, turn leaking containers so that gas escapes rather than liquid. Water spray may be used to reduce vapor cloud drift.
Environmental Precautions:	Do not allow product to enter drains or watercourses.

HANDLING AND STORAGE

Storage and Handling Practices:	Cylinders should be stored in dry, well-ventilated areas away from sources of heat. Store cylinders away from heavy traffic or equipment operation areas and emergency exits. Confirm that storage and handling is in accordance with all current regulations and standards. Keep separated from incompatible substances (See section 10).
Special Precautions for Handling Gas Cylinders:	Protect cylinders against physical damage. Do not allow temperature of storage areas to exceed 52 °C (125° F).

EXPOSURE CONTROLS – PERSONAL PROTECTION

Ventilation and Engineering Controls:	Provide local exhaust ventilation.
Respiratory Protection:	If a worker exposure to this gas is going to occur, then respiratory protection should be used.
Eye Protection:	Splash goggles, face shields, or safety glasses should be used for protection from rapidly expanding gas.
Hand Protection:	Wear Viton or rubber gloves if contact with gas or liquid may occur.
Body Protection:	A protective suit should be worn to prevent frostbite and skin contamination if contact with liquid or gas may occur.

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PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Odorless gas or liquid
Vapor Density (range of individual components at standard temperature and pressure):	1.4 - 4.2 (Heavier than air).
Specific Gravity:	Not applicable.
Evaporation Rate:	Not available.
Vapor Pressure:	Not available.
Odor Threshold:	Not available.
Appearance and Color:	Colorless gas in normal conditions.
How to Detect This Substance (Warning Properties):	The gas is not visible, however, rapidly released gases may cause the formation of a vapor cloud. The gas may be odorless or have a very slight, sweet odor.
pH:	Not applicable
Freezing Point :	Less than –100° C
Boiling Point :	Less than –128° C

STABILITY AND REACTIVITY

Stability:	Stable at normal temperatures and pressures.
Hazardous Decomposition Products:	Thermal decomposition or burning of gas may produce hydrogen fluoride and carbonyl fluoride.
Materials with Which Substance is Incompatible:	**POWDERED ALUMINUM AND ACTIVE METALS** are not compatible with this gas product and may produce violent reactions. **POLYSTYRENE** is not compatible with this gas product and may produce violent reactions. **ALKALINE EARTH METALS** like calcium, magnesium, sodium, potassium, lithium, and barium are not compatible with this gas and may produce violent reactions. **EARTH METALS** like silver, brass, bronze, and copper may enhance the decomposition of this gas at elevated temperatures. **OXIDIZERS** may produce fire and explosion hazards.
Hazardous Polymerization:	Will not polymerize.

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TOXICOLOGICAL INFORMATION

Toxicity Data:	Low order of toxicity.
Suspected Cancer Agent:	Not a suspected cancer agent.
Irritancy of Product:	Product may cause irritation through all routes of exposure.
Sensitization to the Product:	Weak cardiac sensitization, a potentially fatal disturbance of the heart, is caused by a heightened sensitivity to the action of epinephrine after exposure to gas components.
Reproductive Toxicity Information:	No reproductive toxic effects on humans have been described for the components of this product.
Medical Conditions Aggravated by Exposure:	Cardiovascular, pulmonary, and central nervous system medical conditions may be aggravated by inhalation of this gas.
Recommendations to Physicians:	Do not administer adrenaline due to the sensitizing effect of fluorocarbons on the myocardium. Treatment of overexposure should be directed at the control of symptoms and the clinical condition. Exposure to fluorocarbon pyrolysis products should be considered in the diagnostic evaluation of occupationally related fever of short duration and unknown origin. Signs of exposure include tachycardia, hyperpnea, and pharyngeal congestion; investigation may reveal pulmonary edema and leucocytosis.
Biological Exposure Indices (BEIs):	None.

ECOLOGICAL INFORMATION

Environmental Stability:	Gas components are expected to volatilize rapidly from soil and water surfaces. Vapor phase gases are expected to degrade very slowly in the ambient atmosphere.
Effect of Material on Plants or Animals:	Compounds are not expected to bioconcentrate in organisms. Specific toxic effects are not known.
Effect of Chemical on Aquatic Life:	Bioconcentration in aquatic life is expected to be low.

DISPOSAL CONSIDERATIONS

Preparing Wastes for Disposal:	Dispose in accordance with all applicable regulations.

TRANSPORTATION INFORMATION

Proper Shipping Names	
For Shipments of Cylinders:	Refrigerant gases, n.o.s., 2.2, UN 1078, (contains hydrofluorocarbons, inert gas).
For Shipments of Refrigeration Units:	Units contain less than 25 pounds (12 kg) of non-flammable, non-toxic refrigerant gas. In accordance with Section 173.307 (a) (4) (i) of 49 CFR, units are not subject to the requirements of Hazardous Materials Regulations.

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(cont.) TRANSPORTATION INFORMATION

U.N. Hazard Class Number:	2.2 (Non-Flammable Gas)
U.N. Identification Number:	UN 1078 for shipments of cylinders.
Packing Group:	Not applicable.
North American Emergency Response Guidebook Number (2000):	126
Marine Pollutant:	Not applicable.
Canada Transportation of Dangerous Goods Regulations:	This material is considered a dangerous good. Use the above information to prepare Canadian shipments.

REGULATORY INFORMATION

U.S. SARA Reporting Requirements:	None.
U.S. SARA Threshold Planning Quantity:	Not applicable.
U.S. CERCLA Reportable Quantity (RQ):	Not applicable.
Canadian DSL/NDSL Inventory Status:	Not applicable.
U.S. TSCA Inventory Status:	Hydrofluorocarbon gas constituents are listed on the TSCA inventory.
U.S. State Regulatory Information:	This product is subject to state worker and community Right-to-Know Acts.
California Safe Drinking Water and Toxic Enforcement Act (Proposition 65):	Product ingredients are not listed.
Labeling:	
Refrigeration Units:	**CAUTION:** THIS UNIT HAS INTERNAL SYSTEMS WITH LIQUID AND GAS UNDER PRESSURE. Store and use in a well-ventilated area where temperatures will not exceed 52° C (125° F). Contact the manufacturer or a certified technician for the repair and maintenance of internal refrigeration systems.

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(cont.) REGULATORY INFORMATION

Cylinders:	**CAUTION: LIQUID AND GAS UNDER PRESSURE. CAN CAUSE RAPID SUFFOCATION. MAY CAUSE FROSTBITE.** Store and use with adequate ventilation. Do not get liquid in eyes, on skin or clothing. Cylinder temperature should not exceed 52°C (125°F). Use in accordance with the Material Safety Data Sheet. **FIRST AID:** If inhaled, administer fresh air immediately. Administer oxygen if breathing is difficult. Contact a physician. In case of frostbite, obtain immediate medical attention. **DO NOT REMOVE THIS PRODUCT LABEL.**
R phrases:	R 36/37
S phrases:	2, 46, 51
EINECS Number:	Refer to Page 1, Section 2.
Canadian WHMIS Classification:	Class A: Compressed Gases

OTHER INFORMATION

Uses and Restrictions:	Only use product in accordance with its intended use. Cylinders should never be refilled without permission from the owner.
U.K. Legislation:	Control of Substances Hazardous to Health as amended.

End of MSDS

MSDS - POE Solest Oil LT-32

SOLEST LT-32

MATERIAL SAFETY DATA SHEET

Material Safety Data Sheet
SOLEST LT-32

Prepared according to 29CFR 1910.1200.

1	Chemical Product and Company Identification

The Lubrizol Corporation
29400 Lakeland Boulevard
Wickliffe, Ohio 44092
Tel: (440) 943-4200

Product Trade Name	SOLEST LT-32
CAS Number	Not applicable for mixtures.
Synonyms	None.
Generic Chemical Name	Mixture.
Product Type	Multipurpose.
Preparation/Revision Date	04 May 2011
Transportation Emergency Phone No.	FOR TRANSPORT EMERGENCY call CHEMTREC: (+1) 703-527-3887 (outside the U.S.), 1-800-424-9300 (in the U.S.)
MSDS No.	3862567-2301925-5036121-102103

2	Hazards Identification

Appearance	Clear to yellow liquid.
Odor	Mild
Principal Hazards	Caution. • May cause skin irritation.

See Section 11 for complete health hazard information.

3	Composition/Information on Ingredients

Hazardous Ingredients	This material contains no ingredients requiring disclosure under regulatory hazard criteria for this jurisdiction. See Section 11 for additional details.

4	First Aid Measures

Eyes	Flush with water at least 30 minutes. Get medical attention if eye irritation develops or persists.
Skin	Wash with soap and water. Remove contaminated clothing. If skin irritation occurs, get medical attention. Launder contaminated clothing before reuse.
Inhalation	Remove exposed person to fresh air if adverse effects are observed.
Oral	DO NOT INDUCE VOMITING. Get immediate medical attention.
Additional Information	Note to physician: Treat symptomatically.

5	Fire Fighting Measures

Flash Point	246 °C, 475 °F COC (Typical)
Extinguishing Media	CO2, dry chemical, or foam. Water can be used to cool and protect exposed material.
Firefighting Procedures	Recommend wearing self-contained breathing apparatus. Water may cause frothing. Use water to cool containers exposed to fire.
Unusual Fire & Explosion Hazards	See section 10 for additional information.

6	Accidental Release Measures

Spill Procedures	Personal Protective Equipment must be worn, see Personal Protection Section for PPE recommendations. Ventilate area if

SOLEST LT-32

spilled in confined space or other poorly ventilated areas. Prevent entry into sewers and waterways. Pick up free liquid for recycle and/or disposal. Residual liquid can be absorbed on inert material.

7	Handling and Storage

Pumping Temperature	Not determined.
Maximum Handling Temperature	Not determined.
Handling Procedures	Keep away from potential sources of ignition. Keep containers closed when not in use. Avoid breathing dust, fume, gas, mist, vapors or spray. Wash thoroughly after handling. Launder contaminated clothing before reuse. Empty container contains product residue which may exhibit hazards of product. Dispose of packaging or containers in accordance with local, regional, national and international regulations.
Maximum Storage Temperature	Not determined.
Storage Procedures	Store in a cool, dry location. See section 10 for incompatible materials.
Loading Temperature	Not determined.

8	Exposure Controls/Personal Protection

Exposure Limits	None established
Other Exposure Limits	None known.
Engineering Controls	Use with adequate ventilation.
Gloves Procedures	Neoprene.
Eye Protection	Safety Glasses.
Respiratory Protection	Use NIOSH/MSHA approved respirator with an organic vapor cartridge if exposure limit is exceeded. Use self-contained breathing apparatus for entry into confined space, for other poorly ventilated areas and for large spill clean-up sites. Consult with an industrial hygienist to determine the appropriate respiratory protection for your specific use of this material. A respiratory protection program compliant with all applicable regulations must be followed whenever workplace conditions require the use of a respirator.
Clothing Recommendation	Long sleeve shirt is recommended. Do not wear rings, watches or similar apparel that could entrap the material and cause a skin reaction. Launder contaminated clothing before reuse.

9	Physical and Chemical Properties

Flash Point	246 °C, 475 °F COC (Typical)
Upper Flammable Limit	Not determined.
Lower Flammable Limit	Not determined.
Autoignition Point	Not determined.
Explosion Data	Material does not have explosive properties.
Vapor Pressure	Not determined.
pH	Not determined.
Specific Gravity	0.98 (20 °C)
Bulk Density	8.21 Lb/gal, 0.98 Kg/L
Water Solubility	Insoluble.
Percent Solid	Not determined.
Percent Volatile	Not determined.
Volatile Organic Compound	Not determined.
Vapor Density	Not determined.
Evaporation Rate	Not determined.
Odor	Mild
Appearance	Clear to yellow liquid.
Viscosity	34.8 Centistokes (40 °C) 6 Centistokes (100 °C)
Odor Threshold	Not determined.
Boiling Point	Not determined.
Pour Point Temperature	Not determined.
Melting / Freezing Point	Not determined.

The above data are typical values and do not constitute a specification. Vapor pressure data are calculated unless otherwise noted.

10	Stability and Reactivity

Stability	Material is normally stable at moderately elevated temperatures and pressures.
Decomposition Temperature	Not determined.
Incompatibility	Strong acids. Strong bases.
Polymerization	Will not occur.

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Thermal Decomposition	Smoke, carbon monoxide, carbon dioxide, aldehydes and other products of incomplete combustion.
Conditions to Avoid	High temperatures.

11	**Toxicological Information**

– ACUTE EXPOSURE –

Eye Irritation	Not expected to cause eye irritation. Based on data from components or similar materials.
Skin Irritation	May cause mild skin irritation. Does not meet Canadian D2B or EU R38 criteria. Based on data from components or similar materials.
Respiratory Irritation	No data available to indicate product or components may cause respiratory irritation under normal workplace conditions and good industrial hygiene practices.
Dermal Toxicity	The LD50 in rabbits is > 2000 mg/Kg. Based on data from components or similar materials.
Inhalation Toxicity	No data available to indicate product or components may be a toxic inhalation hazard.
Oral Toxicity	The LD50 in rats is > 10,000 mg/Kg. Based on data from components or similar materials.
Dermal Sensitization	No data available to indicate product or components may be a skin sensitizer.
Inhalation Sensitization	No data available to indicate product or components may be respiratory sensitizers.

– CHRONIC EXPOSURE –

Chronic Toxicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Carcinogenicity	No data available to indicate any components present at greater than 0.1% may present a carcinogenic hazard.
Mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.
Reproductive Toxicity	No data available to indicate either product or components present at greater than 0.1% that may cause reproductive toxicity.
Teratogenicity	No data available to indicate product or any components contained at greater than 0.1% may cause birth defects.

– ADDITIONAL INFORMATION –

Other	No other health hazards known.

12	**Ecological Information**

– ENVIRONMENTAL TOXICITY –

Freshwater Fish Toxicity	Not determined.
Freshwater Invertebrates Toxicity	Not determined.
Algal Inhibition	Not determined.
Saltwater Fish Toxicity	Not determined.
Saltwater Invertebrates Toxicity	Not determined.
Bacteria Toxicity	Not determined.
Miscellaneous Toxicity	Not determined.

– ENVIRONMENTAL FATE –

Biodegradation	Adequate data is not available to estimate the biodegradation potential of this material.
Bioaccumulation	Less than 1.0% of the components display no potential to bioconcentrate.
Soil Mobility	Not determined.

13	**Disposal Considerations**

Waste Disposal	This material, if discarded, is not a hazardous waste under RCRA Regulation 40 CFR 261. Treatment, storage, transportation, and disposal must be in accordance with applicable Federal, State/Provincial, and Local regulations.

14	**Transport Information**

ICAO/IATA I	Not regulated.
ICAO/IATA II	Not regulated.
IMDG	Not regulated.
IMDG EMS Fire	Not applicable.
IMDG EMS Spill	Not applicable.
IMDG MFAG	Not applicable.
MARPOL Annex II	Not determined.
USCG Compatibility	Not determined.
U.S. DOT Bulk	Not regulated.
DOT NAERG	Not applicable.
U.S. DOT (Intermediate)	Not regulated.
U.S. DOT Intermediate NAERG	Not applicable.

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U.S. DOT Non-Bulk	Not regulated.
U.S. DOT Non-Bulk NAERG	Not applicable.
Canada	Not regulated.
Mexico	Not regulated.
Bulk Quantity	85000 KG, 187391 lbs.
Intermediate Quantity	11000 KG, 24251 lbs.
Non-Bulk Quantity	400 KG, 882 lbs.

Review classification requirements before shipping materials at elevated temperatures.

15	Regulatory Information

-- Global Chemical Inventories --

USA	All components of this material are on the US TSCA Inventory or are exempt.
Other TSCA Reg.	None known.
EU	May require notification under EC Seventh Amendment Directive 92/32/EEC.
Japan	May require notification in Japan.
Australia	All components are in compliance with chemical notification requirements in Australia.
New Zealand	May require notification before sale under New Zealand regulations.
Canada	This material contains one or more components that are on the Non-Domestic Substances list (NDSL). This material or products containing this material may be exported to Canada in limited quantities.
Switzerland	May require notification before sale in Switzerland.
Korea	May require notification before sale in Korea.
Philippines	All components are in compliance with the Philippines Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990 (R.A. 6969).
China	All components of this product are listed on the Inventory of Existing Chemical Substances in China.
Taiwan	May require notification before sale in Taiwan.

-- Other U.S. Federal Regulations --

SARA Ext. Haz. Subst.	This product does not contain greater than 1.0% of any chemical substance on the SARA Extremely Hazardous Substances list.
SARA Section 313	This product does not contain greater than 1.0% (greater than 0.1% for carcinogenic substance) of any chemical substances listed under SARA Section 313.

SARA 311 Classifications

Acute Hazard	No
Chronic Hazard	No
Fire Hazard	No
Reactivity Hazard	No

CERCLA Hazardous Substances None known.

-- State Regulations --

Cal. Prop. 65 This product does not intentionally contain any chemicals known by the State of California to cause cancer and/or birth defects. Moreover, we do not routinely analyze its products for impurities which may be such chemicals.

-- Product Registrations --

U.S. Fuel Registration	Not applicable.
Finnish Registration Number	Not Registered
Swedish Registration Number	Not Registered
Norwegian Registration Number	Not Registered
Danish Registration Number	Not Registered
Swiss Registration Number	Not Registered
Italian Registration Number	Not Registered

-- Other / International --

Miscellaneous Regulatory Information	Not determined.

16	Other Information

US NFPA Codes

Health	Fire	Reactivity	Special
1	1	0	N/E

(N/E) - None established

HMIS Codes

Health	Fire	Reactivity
1	1	0

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Precautionary Labels	Caution. • May cause skin irritation.
Revision Indicators	This MSDS has no revisions since 4 May 2011

As the conditions or methods of use are beyond our control, we do not assume any responsibility and expressly disclaim any liability for any use of this product. Information contained herein is believed to be true and accurate but all statements or suggestions are made without warranty, expressed or implied, regarding accuracy of the information, the hazards connected with the use of the material or the results to be obtained from the use thereof. Compliance with all applicable federal, state, and local regulations remains the responsibility of the user.

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Glossary

After Cooler: Component in the refrigeration unit that removes heat from the refrigerant vapor after it exits the compressor

ANSI: American National Standards Institute.

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers

AWG: American wire gauge

Balance pressure: The pressure in the refrigeration unit (or cryopump) when the suction and discharge sides of the compressor are equal and the system is at room temperature. This is the same as the charge pressure.

CE: Conformité Européene The CE Marking identifies that the product or machine is complying with all of the safety requirements established by the European Union.

Charge pressure: The pressure in the refrigeration unit (or cryopump) when the suction and discharge sides of the compressor are equal and the system is at room temperature. This is the same as the balance pressure.

Coldest liquid: The portion of the refrigerant circuit that obtains the lowest temperature prior to evaporation.

Compressor: component in the refrigeration unit that raises the refrigerant pressure and causes the refrigerant to move through the circuit

Condenser: A component in the refrigeration unit that removes heat from the refrigerant vapor after it exits the compressor.

Copper Gas Line: Refrigerant line that is made from copper

Cryopump: The Polycold cryogenic refrigeration system that captures water molecules in a vacuum chamber. It consists of a refrigeration unit, a refrigerant line, and a cryosurface (with cryogenic feed-through).

Cryosurface: The coil or baffle in the vacuum chamber that captures water molecules by freezing them to its surface.

Cylinder Unload: A solenoid that deactivates one of the three compressor cylinders to save power under certain conditions.

Defrost: The rapid heating process used to remove captured water vapor from the cryocoil.

DeviceNet: A system control protocol consisting of software and hardware. Uses its own command format to gather data and command certain actions on the system.

EC: Conformité Européene Early version of the CE Marking. See CE above.

EEC: European Economic Community

EMC: Electromagnetic Compatibility

EN: European norm (or standard)

Ethernet: A serial communication protocol for communication and configuring the XC Cryochller from a host or service computer. Consists of a family of computer networking technologies for local area networks. Data is sent in packets with error checking so that damaged data can be resent.

Feed line: The copper tube in the refrigerant line that carries refrigerant from the refrigeration unit to the cryosurface.

Field replacement charge:

A refrigerant mixture that replaces the refrigerant in the cryopump.

GUTS: Brooks acronym standing for Guaranteed Up-Time Service.

Human Machine Interface (HMI):

The user interface used in the XC Cryochiller

IEC: International Electrotechnical Commission

I/O: Input / output.

Liquid line: A portion of the refrigerant circuit containing high pressure refrigerant just after it has been cooled by the water-cooled condenser.

MSDS: Material Safety Data Sheet

Manifold: Service manifold gauge set

NEC: National Electrical Code

NPT: National Pipe Thread

OFHC: Oxygen-free high thermal conductivity

Polycold stack: The upper portion of the refrigeration unit that is insulated with foam.

Profibus: A communication protocol designed to control process equipment. Consists of hardware and software. Uses its own command format to gather data and command certain actions on the system.

Recharge: Procedure for replacing the refrigerant in a refrigeration unit

Refrigerant: A proprietary mixture of refrigerants made by Brooks Polycold Systems Inc.

Refrigerant circuit: The path of the refrigerant that goes from the refrigeration unit, through the feed line, through the cryosurface, through the return line, and back to the refrigeration unit.

Refrigerant expansion tank:

A tank inside the refrigeration unit that maintains the gaseous refrigerant at a safe pressure when the unit is not at operating temperature.

Refrigerant Line: feed and return lines that carry refrigerant to and from the cryocooler

Refrigeration unit: The machine containing the compressor, condenser, and stack that cools the refrigerant mixture to cryogenic temperatures.

Return Line: The copper tube in the refrigerant line that carries refrigerant from the cryosurface to the refrigeration unit.

RS-232: A serial communication protocol that can command and configure the Polycold Cryochiller using the system commands.

SAE: Society of Automotive Engineers.

TC: Thermocouple.

Top-off charge: A refrigerant mixture that can be added to the refrigerant in the Polycold Cryochiller

Transformer Tap: Jumper or connection configuration that allows for different input voltages to be used on the system and generate the appropriate internal voltages.

TÜV: Technical Supervision Society verifies compliance with EN and IEC standards

UL: Underwriters Laboratories verifies compliance with NEC standards

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