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**Brooks Automation**  
**Polycold Systems**  
**Polycold Fast Cycle**  
**Water Vapor Cryopump**  
**Customer Instruction Manual**  
**For Vacuum Chamber Applications**

Serial # \_\_\_\_\_

<b>Model Type</b>	<b>Size</b>		<b>Refrigerant</b>
<input type="checkbox"/> PFC	<input type="checkbox"/> 550	<input type="checkbox"/> 670	<input type="checkbox"/> HC
<input type="checkbox"/> PFC/PFC	<input type="checkbox"/> 551	<input type="checkbox"/> 672	<input type="checkbox"/> LT
<input type="checkbox"/> PFC/P	<input type="checkbox"/> 552	<input type="checkbox"/> 1100	
	<input type="checkbox"/> 660	<input type="checkbox"/> 1101	
	<input type="checkbox"/> 661	<input type="checkbox"/> 1102	
	<input type="checkbox"/> 662		

**Options**

- CE Mark
- High Liquid Temperature Alarm
- Isolated Interface
- GVE Remote
- Temperature Module

Option #: \_\_\_\_\_

Set Point A: \_\_\_\_\_

Set Point B: \_\_\_\_\_

2<sup>nd</sup> Temp. Meter \_\_\_\_\_

**Cool° Solutions®**

# Polycold Fast Cycle Water Vapor Cryopump Customer Instruction Manual

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# Polycold Fast Cycle Water Vapor Cryopump Customer Instruction Manual

## Limited Warranty Terms

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

Polycold® Systems cryogenic cooling products, including water vapor cryopumps (PFC, PCT, FLC, FI), chillers (PGC, PGCL), cryocoolers (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**

<b>Product</b>	<b>New Product Warranty</b>	<b>Repair Service Warranty</b>	<b>Certified Refurbished Cryogenic Cooling Products Warranty</b>
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 (PFC, PCT, FLC, FI), chillers (PGC, PGCL), cryocoolers (P), and accessories	24 Months	12 Months	12 months

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# Polycold Fast Cycle Water Vapor Cryopump Customer Instruction Manual

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# **1**

# **Introduction**

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## **Overview**

This Introduction provides a brief description of Brooks Automation Product, highlighting its features, subsystems, operation, specifications, and some safety precautions.


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## 1.1 General Precautions


Review the instruction manual before performing any procedure including the routine operation of Polycold's *Cool Solutions*® Fast Cycle Water Vapor Cryopump.

### 1.1.1 General precautions to follow at all times


	<b>⚠ WARNING</b>
	<b>GENERAL HAZARD</b> Failure to review this manual could result in death or serious injury. Review this manual before performing any procedure including routine operation of Polycold's <i>Cool Solutions</i> ® Fast Cycle Water Vapor Cryopump.

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> United States federal law requires a certified refrigeration technician (Type 2, High Pressure) for any procedure that could release refrigerant to the atmosphere. This includes installing the cryopump, some inspection procedures, disconnecting the refrigerant lines, some troubleshooting procedures, repair, and disposal of the unit. A qualified refrigeration technician must do all refrigeration work.

**NOTE:** *When installing or servicing this equipment outside the USA, comply with applicable local requirements.*


	<b>⚠ WARNING</b>
	<b>ELECTRICAL</b> Failure to have a qualified electrician do all electrical work could result in death or serious injury. A qualified electrician must do all electrical work.





	<b>⚠ DANGER</b>
	<p><b>GENERAL HAZARD</b> Do not bypass or change the setting of any protective device. The repeated resetting of a protective device may void the warranty and, if not avoided, will cause death or serious injury. Review this manual before performing any procedure including routine operation of Polycold's <i>Cool Solutions</i>® Fast Cycle Water Vapor Cryopump. Reset protective devices only as defined throughout this manual.</p>

### 1.1.1.1 Specific Hazards and How to Avoid Them


Refrigeration unit (or cryopump, once installed) contains pressurized gas.


	<b>⚠ WARNING</b>
	<p><b>FLAMMABLE MATERIAL (1101, 1100, 670, 661, 660, 551, and 550 ONLY)</b> Do not open the refrigerant circuit to the atmosphere. Do not change the settings of the valves or loosen any fittings. Opening the refrigerant circuit or changing valve settings along with the failure to following instructions in this manual could result in death or serious injury. Review this manual before performing any procedure including routine operation of Polycold's <i>Cool Solutions</i>® Fast Cycle Water Vapor Cryopump. Inspect the refrigerant circuit and change valve settings only as defined throughout this manual.</p>

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> Do not connect the refrigeration unit to an existing cryosurface unless it meets specification. Doing so could cause minor or moderate injury. See <a href="#">section 3.5 Cryosurface &amp; Cryogenic Feed-through Specification</a> for more information.</p>


	<b>⚠ DANGER</b>
	<p><b>GENERAL HAZARD</b> Do not bypass or change the settings of any protective device on the refrigeration unit. Resetting of a protective device may void your warranty and, if not avoided, will cause death or serious injury. Review this manual before performing any procedure including routine operation of Polycold's <i>Cool Solutions</i>® Fast Cycle Water Vapor Cryopump. Do not bypass or change the settings of any protective devices on the refrigeration unit.</p>

Refrigerant is harmful to the environment and to human health. Refrigerant may also be flammable. (This warning does not apply to PFC- 552, 662, 672, and 1102).


	<b>⚠ WARNING</b>
	<p><b>CHEMICAL HAZARD</b> Do not release refrigerant to the atmosphere. Opening the refrigerant circuit or changing valve settings along with the failure to following instructions in this manual could result in death or serious injury. Review this manual before performing any procedure including routine operation of Polycold's <i>Cool Solutions</i>® Fast Cycle Water Vapor Cryopump. Do not release refrigerant to the atmosphere.</p>


	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> Failure to review this manual may result in minor or moderate injury. See the enclosed Material Safety Data Sheet (MSDS) section for additional information and protective measures for Polycold's <i>Cool Solutions</i>® Fast Cycle Water Vapor Cryopump.</p>

Hazardous voltages exist at all times after the power is connected.

	<b>⚠ WARNING</b>
	<b>ELECTRICAL</b> Failure to have a qualified electrician do all electrical work could result in death or serious injury. Do not reach inside the refrigeration unit. A qualified electrician must do all electrical work.

Extreme temperatures (cold & hot) exist while the refrigeration unit is operating and for at least an hour after the unit is turned off.

	<b>⚠ CAUTION</b>
	<b>EXTREME TEMPERATURES EXIST</b> Extreme temperatures (cold & hot) exist while the refrigeration unit is operating and for at least an hour after the unit is turned off. Contact with a cold or hot surface may result in minor or moderate injury. Do not reach inside Polycold's <i>Cool Solutions</i> ® Fast Cycle Water Vapor Cryopump's refrigeration unit.

	<b>⚠ CAUTION</b>
	<b>EXTREME TEMPERATURES EXIST</b> Extreme temperatures (cold & hot) exist while the refrigeration unit is operating and for at least an hour after the unit is turned off. Contact with a cold or hot surface may result in minor or moderate injury. Do not touch any uninsulated part of the refrigerant circuit when the unit is operating. This includes the solenoid and hand valves, any uninsulated part of the refrigerant line or feedthrough, and the cryosurface. Also, do not reach inside Polycold's <i>Cool Solutions</i> ® Fast Cycle Water Vapor Cryopump's refrigeration unit.



**⚠ CAUTION**


**GENERAL HAZARD**

Moving or repositioning the refrigerant line may result in minor or moderate injury.

Do not attempt to move or position the refrigerant line. The insulation hardens when cold and may crack.


## 1.2 Emergency Shut-Down Procedures

### Refrigerant Leak

	<b>⚠ WARNING</b>
	<b>CHEMICAL HAZARD</b> Do not release refrigerant to the atmosphere. Opening the refrigerant circuit or changing valve settings along with the failure to following instructions in this manual could result in death or serious injury. Review this manual before performing any procedure including routine operation of Polycold's <i>Cool Solutions</i> ® Fast Cycle Water Vapor Cryopump. Do not release refrigerant to the atmosphere.

1. For all leaks: Follow the instructions in the MSDS, especially if the leak is large.
2. For a leak on the refrigerant line or cryosurface: If the leak is not too large, limit the amount of refrigerant lost. Follow the instructions in [section 8.2 How to Disconnect the Refrigerant Line](#).

### Electrical Problem

	<b>⚠ WARNING</b>
	<b>ELECTRICAL</b> Failure to have a qualified electrician do all electrical work could result in death or serious injury. Do not reach inside the refrigeration unit. A qualified electrician must do all electrical work.

1. Turn off the unit.
2. Turn the power disconnect switch to the OFF position
3. Disconnect the refrigeration unit from your electrical supply, if necessary.

---

### 1.3 The Polycold Fast Cycle Water Vapor Cryopump and its Applications

The Polycold Fast Cycle Water Vapor Cryopump (PFC) is a cryogenic refrigeration system that captures volatile molecules by freezing them onto a cold surface. It consists of a refrigeration unit, a refrigerant line, and a cryosurface with cryogenic feedthrough. The refrigeration unit can pump cold or hot refrigerant in a continuous loop through the refrigerant line and cryosurface. The refrigerant is actually a proprietary mixture of refrigerants made by Brooks Polycold Systems Inc.

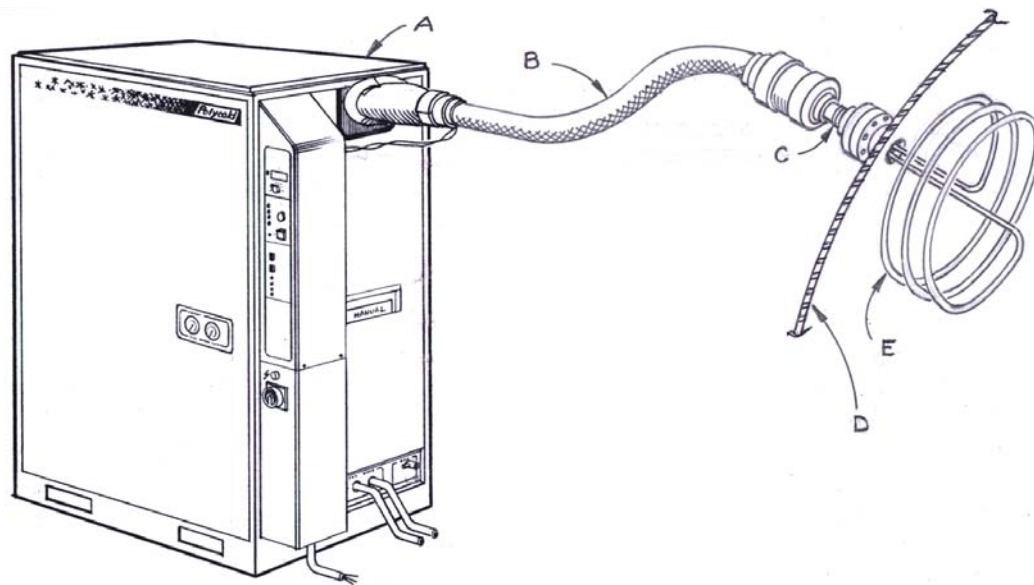
The primary application of the PFC is to capture water vapor in a vacuum chamber after opening the high vacuum valve. For this application, the cryosurface is normally a coil. The coil can be quickly cooled and defrosted to correspond with vacuum chamber cycles. See [Figure 1-1](#).

The PFC can also be used to control backstreaming. See [Figure 1-2](#). For this application, the cryosurface is a baffle. “Fast Cycle” refers to the faster interchange between cool and defrost. However, quick cooling and defrosting is not normally required or desired for this application.

**NOTE:** *Backstreaming will contaminate the system because it is the process of hot vapor migrating and condensing on cold surfaces. When the vacuum pump is used, the pump oil heats up and travels opposite of the pumping direction and condenses the system resulting in system contamination.*

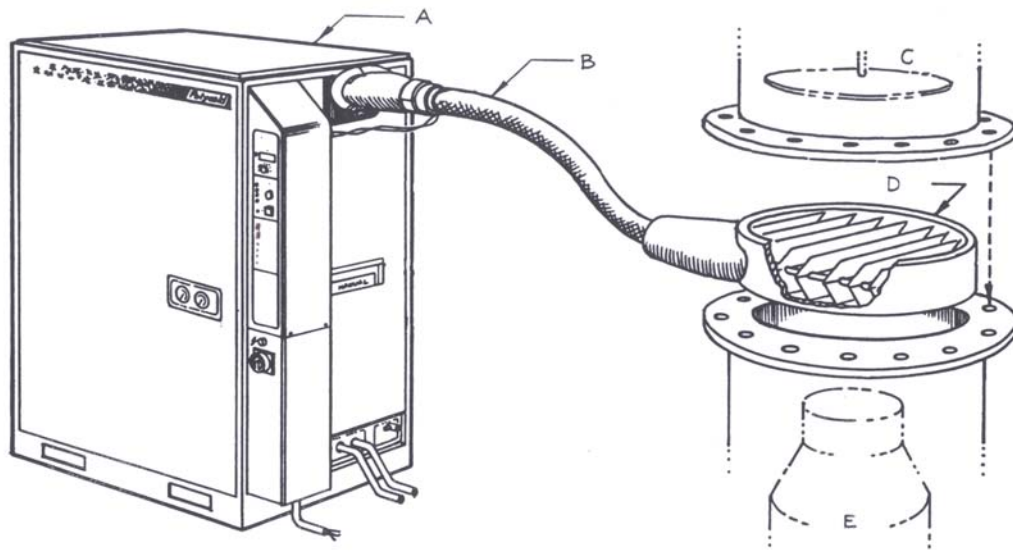
The PFC/PFC is the same as a PFC except that the PFC/PFC has two refrigerant circuits. Each refrigerant circuit services a separate cryosurface. Both cryosurfaces can be quickly defrosted.

The PFC/P also has two refrigerant circuits. Each refrigerant circuit services a separate cryosurface. However, only the first refrigerant circuit can be quickly defrosted.



*Figure 1-1: PFC cryopump—primary application*

- A. Refrigeration unit
- B. Refrigerant line
- C. Cryogenic feedthrough
- D. Vacuum chamber wall
- E. Cryosurface



*Figure 1-2: PFC cryopump—secondary application*

- A. Refrigeration unit
- B. Refrigerant line
- C. High vacuum valve
- D. Cryobaffle
- E. High vacuum pump



## 1.4 Refrigeration Unit Features

See [Figure 1-3](#) and [Figure 1-4](#).

### Couplings for the Refrigerant Line

- A. #1 Return
- B. #1 Feed

### Low Voltage Box

- C. The EXTERNAL TC port allows thermocouples on the refrigerant line to be connected to the TC SELECT switch. See [section 3.3.5 Connect the COIL IN & COIL OUT Thermocouples](#) for more information.
- D. The TEMPERATURE module displays the temperatures of various thermocouples that will help monitor the cryopump. See [Figure 3-23](#) and [section 3.8.2 Additional Instructions for Remote Temperature Indication](#) for more information.
- E. The SYSTEM CONTROL module will help troubleshoot the cryopump if a protective device has shut it off. See [section 7.1 What to Do If the Cryopump Stops Running](#) for more information.
- F. The PFC CIRCUIT 1 module controls the refrigerant circuit. See [section 4.1 What the Cryopump Does in STANDBY, COOL, and DEFROST](#) for more information.
- I. The REMOTE connector permits remote control of the unit and provides status information to a remote location. See [section 3.8 How to Install the Remote Control \(Optional\)](#) for more information.

### High Voltage Box

- J. The power disconnect switch disconnects the main power when it is in the OFF (O) position. The switch must be in the OFF (O) position to open the high voltage box.

### Utility Panel

- K. REFRIGERANT connections (EVACUATION VALVE and PRESSURE RELIEF OUTLET)
- L. COOLING WATER connections

### Other

- G. Pocket for manual

H. Nameplate (above the REMOTE connector)

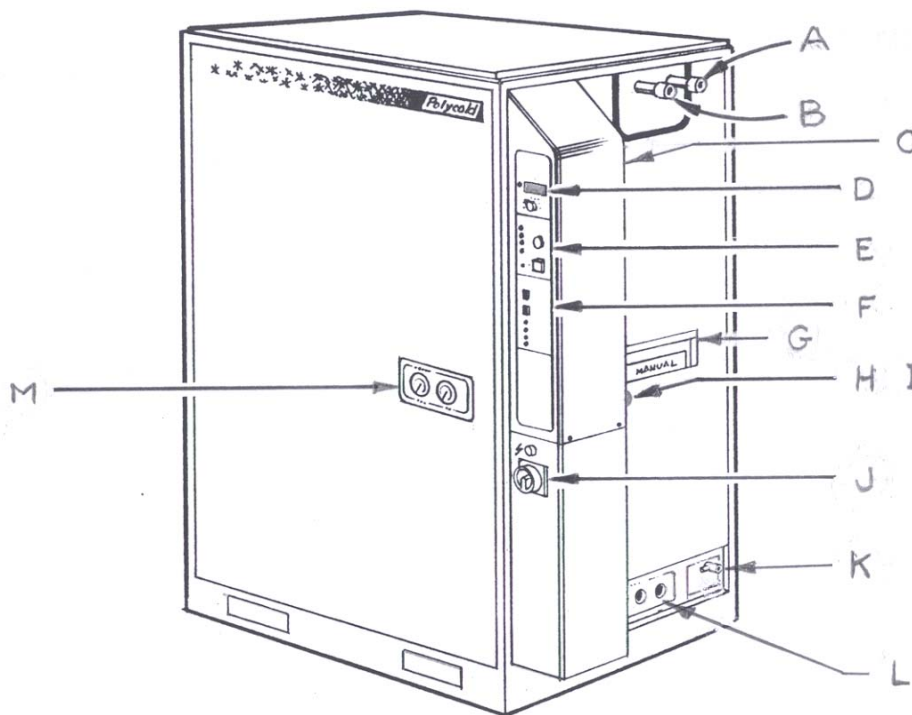
M. COMPRESSOR PRESSURE gauges

**For PFC/PFC or PFC/P**

N. #2 Return

O. #2 Feed

P. The PFC CIRCUIT 2 or COOLING CIRCUIT 2 module controls a second refrigerant circuit. See section 4.1 “What the Cryopump does in STANDBY, COOL, & DEFROST” for more information.



*Figure 1-3: PFC features*

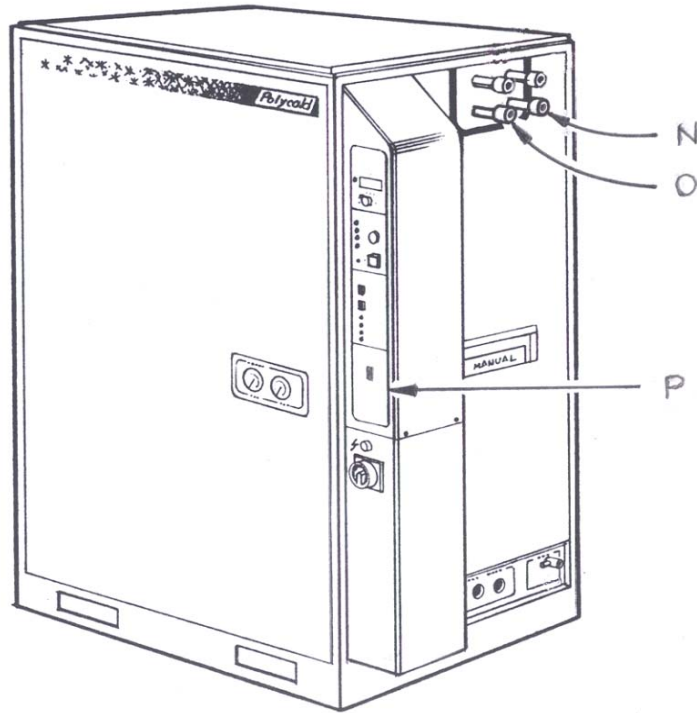


Figure 1-4: PFC/PFC & PFC/P—additional features

## 1.5 Location of Isolation & Solenoid Valves

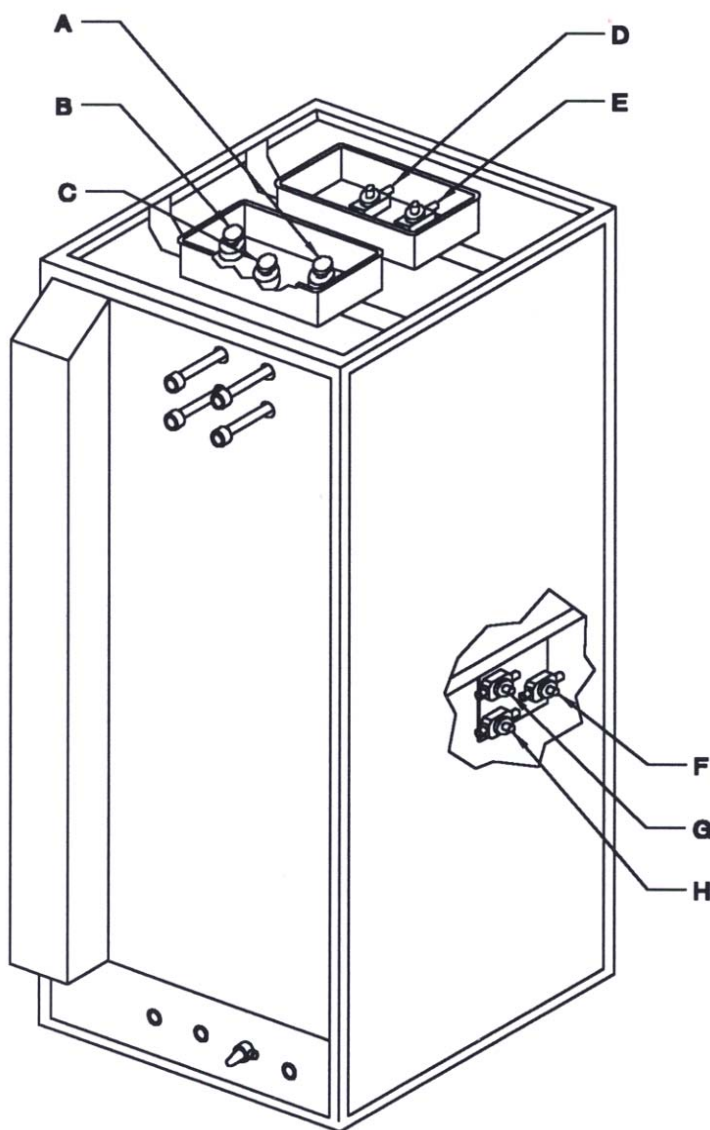


Figure 1-5: Location of isolation & solenoid valves

**NOTE:** Two valve box shown in this figure. Some units have a single box.

- A. Cold gas feed isolation valve
- B. Hot gas feed isolation valve
- C. Common return isolation valve
- D. #2 Cool solenoid valve (PFC/PFC or PFC/P only)

- E. #1 Cool solenoid valve
- F. Buffer tank solenoid valve (660s & 1100s only)
- G. Defrost solenoid valve
- H. #2 Defrost solenoid valve (PFC/PFC only)

## 1.6 Refrigeration Unit Data

Refrigeration Unit	Dimensions Width x Depth x Height in (mm)	Weight or Mass lb (kg)	Maximum Sound Pressure Level dB(A)†
550, 551, 552	37.5 x 26 x 72.5 (953 x 660 x 1842)	900 (408)	71
660, 661, 670, 672	37.5 x 26 x 72.5 (953 x 660 x 1842)	1055 (478)	72
662	37.5 x 26 x 72.5 (953 x 660 x 1842)	1050 (476)	72
1100, 1101	41.5 x 28 x 66.5 (1054 x 711 x 1689)	1200 (544)	81
1102	41.5 x 28 x 66.5 (1054 x 711 x 1689)	1200 (544)	73

† Notes regarding maximum sound pressure level:

Units were tested in a manufacturing environment while under maximum load in the COOL mode. Measurements were made on each side of the unit at a distance of 39 inches (1.0 m) and at a height of 63 inches (1.6 m).

Measurements taken from each side of the unit did not vary significantly. However, measurements did vary with the specific acoustics of the environment in which the unit was placed. For example, the maximum sound pressure level of an 1100 in an anechoic chamber is 67 dB(A).

The abbreviation dB(A) means decibels with an “A” weighting.

## 1.7 Recommended Items to Keep in Stock

Description	Polycold Part Number
Refrigerant Charge (2 each)	<p>940027-12 for 550-HC 940027-13 for 550-LT 940070-12 for 551-HC 940079-12 for 552-HC</p> <p>940027-15 for 660-HC 940070-15 for 661-HC 940079-15 for 662-HC</p> <p>940027-19 for 1100-LT 940027-35 for 1100-HC 940070-19 for 1101-LT 940070-35 for 1101-HC 940079-35 for 1102-HC</p> <p><b>NOTE:</b> <i>Part numbers are different if requesting shipment in special tanks.</i></p>
Tape, pipe insulation (flexible Armaflex elastomeric thermal insulation tape)	060120-00
Adhesive, pipe insulation (glue used for Armaflex pipe insulation)	060121-00
Sheet, pipe insulation (foam like sheet with a smooth skin on one side which forms the outer exposed insulation surface)	060105-00
Tube, pipe insulation, smaller diameter	<p>060123-08 for PFC-1100, 1101, and 1102</p> <p>060123-04 for 550, 551, 552, 660, 661, 662, 670, 672 PFC/PFC-1100, PFC/PFC-1101, and PFC/PFC-1102</p>

Description	Polycold Part Number
Tube, pipe insulation, larger diameter	060123-05 for PFC-1100, 1101, and 1102  060123-07 for 550, 551, 552, 660, 661, 662, 670, 672 PFC/PFC-1100, PFC/PFC-1101, and PFC/PFC-1102
Panel fasteners	840156-00
O-ring removal tool for 550, 551, 552, 660, 661, 662 and, PFC/PFC-1100, PFC/PFC-1101, and PFC/PFC-1102	810004-00
O-rings, Parker CPI UltraSeal couplings for 550s, 551s, 552s, 660s, 661s, 662s and, PFC/PFC-1100s, PFC/PFC-1101s, and PFC/PFC-1102s only	840151-00
Gaskets, Cajon VCR couplings for PFC-1100s, PFC-1101s, and PFC-1102s only	840152-00
Gaskets, COOL solenoid valve (XUJ) copper gaskets for flare solder adapter fittings (flared at one end and used to solder connections on the other end)	389038-01
COOL solenoid valve (XUJ) 1 each for PFC 2 each for PFC/PFC or PFC/P	380061-00
DEFROST solenoid valve service kit (B6S1) 1 each for PFC 2 each for PFC/PFC or PFC/P  <b>NOTE:</b> <i>This is also the BUFFER valve on 660s, 661s, and 662s.</i>	380090-00
BUFFER solenoid valve service kit (B9S1) for 1100s, 1101s, and 1102s only	380091-00
Compressor oil, Zerol 150 1 gallon (3.8 L)	840050-00
Gasket set, compressor	810002-00
Gasket, compressor suction valve	389031-00



Description	Polycold Part Number
Gasket, compressor discharge valve	389032-00 for 550s, 551s, and 552s 389033-00 for 660s, 661s, 662s, 670s, and 672s 1100s, 1101s, and 1102s
Fuses, 1 A, 600 V, time-delay (slow fuse) for 575 V compressor only	335042-04
Filter drier assembly, liquid line	452085-02 for 550s, 551s, and 552s 452085-03 for 660s, 661s, 662s, 670s, and 672s 452166-00 for 1100s, 1101s, and 1102s
Discharge thermostat, high limit, 275°F (135°C)	327032-00
Discharge thermostat, high-high limit, 300°F (149°C)	327031-00
Fuses, 1 A, SYSTEM CONTROL board	335043-10
Relay, SYSTEM CONTROL board	333019-01
Relay, PFC module board	333019-02
Type T thermocouple wire 20 AWG (0.50 mm <sup>2</sup> cross-sectional area)	320201-01
Angle valve, 1/4 inch NPT, 1/4 inch flare	380000-00
1/4 inch flare nuts	200000-00
1/4 inch bonnets	238001-00
<b>NOTE:</b> <i>Some items may be combined in kits at a reduced price.</i>	

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## Overview

This chapter describes safety guidelines for the Brooks Automation Product. All personnel involved in the operation or maintenance of the Product must be familiar with the safety precautions outlined in this chapter.

**NOTE:** *These safety recommendations are basic guidelines. If the facility where the Product is installed has additional safety guidelines they should be followed as well, along with the applicable national and international safety codes.*

## Chapter Contents

2.1 Safety Hazards and Safeguards . . . . .	2-2
2.2 Danger, Warning, and Caution Alerts . . . . .	2-3
2.3 Safety Training Guidelines . . . . .	2-6
2.4 Potential Hazards During Maintenance and Servicing . . . . .	2-8
2.5 Lock-Out and Tag-Out Instructions (LOTO) . . . . .	2-17
2.6 Safety Interlocks . . . . .	2-19
2.7 Circuit Breaker and Fuse Protection . . . . .	2-20

## **2.1 Safety Hazards and Safeguards**

This chapter summarizes safety concerns (hazards, precautions, and ergonomics) associated with the operation and service of Polycold's *Cool Solutions*® Fast Cycle Water Vapor Cryopump.

The Fast Cycle Water Vapor Cryopump has been designed to conform to all known safety requirements applicable to our products. Under normal operation the Fast Cycle Water Vapor Cryopump presents no hazard to its operator or other personnel. Tool secured access panels shield operators and other personnel working in the area of the equipment from the operation or possible failure of the components that compose the equipment.

Only qualified service personnel are authorized to open or remove the panels and must be in accordance with the safety instructions presented in this chapter and throughout the manual. In service and repair operations, the direct refrigeration and heating equipment may potentially expose personnel to the following hazards:

- Electrical shock
- Hazardous Materials
- Lifting Hazards
- Cold Surfaces
- Hot Surfaces

The information and instructions provided in this chapter and throughout this manual are intended to help service personnel work with the equipment in a safe, effective, and efficient manner. The emergency and safety procedures are provided to help service personnel develop safe practices and establish safe conditions for working with Polycold's *Cool Solutions*® Fast Cycle Water Vapor Cryopump.

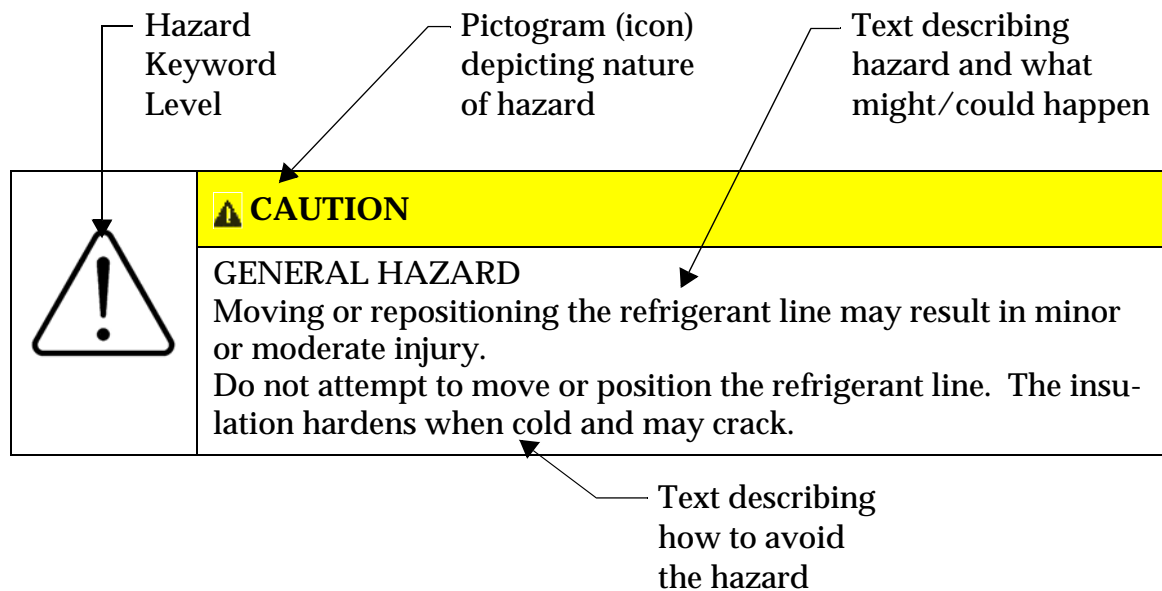
## 2.2 Danger, Warning, and Caution Alerts

Danger, Warning, and Caution alerts are integral parts of these instructions:

**NOTE:** *Note: Information in this section is for users in the USA and for users complying with SEMI S2 requirements.*

- DANGER is used to indicate an imminently hazardous situation that, if not avoided, will result in death or serious injury.
- WARNING is used to indicate a potentially hazardous situation that, if not avoided, could result in death or serious injury.
- CAUTION is used to indicate a potentially hazardous situation that, if not avoided, may result in minor or moderate injury.
- CAUTION is also used when failure to follow instructions or precautions can result in damage to the equipment.

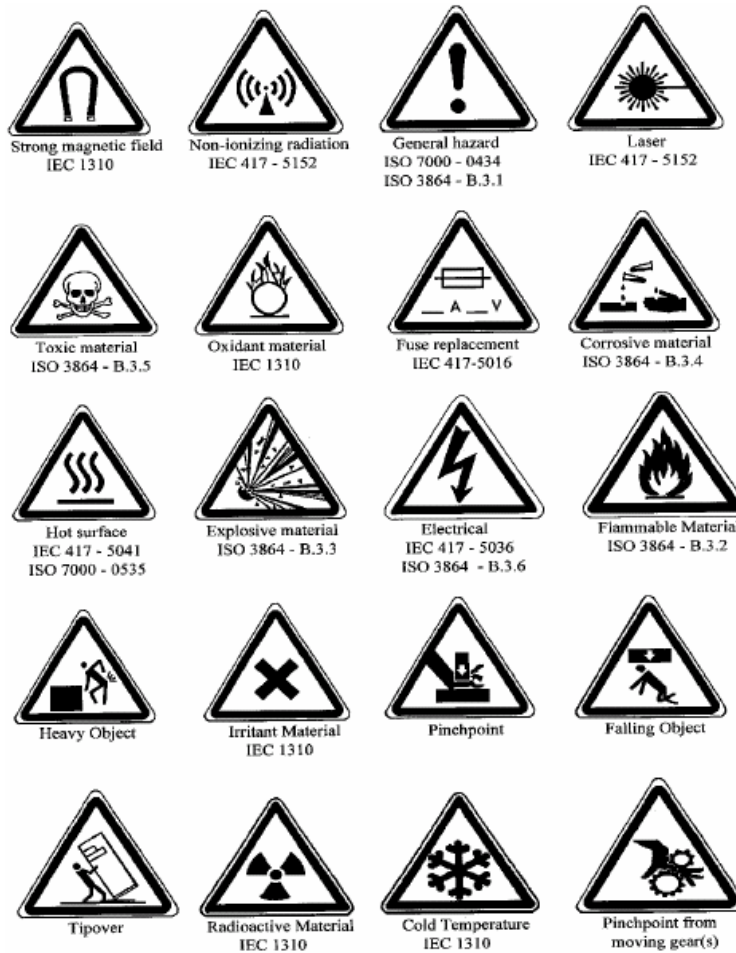
Danger, Warning, and Caution alerts must be read carefully, understood thoroughly, and observed at all times. If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Pictorial hazard alerts affixed to the direct refrigeration and heating equipment and its components are in accordance with ANSI, FDA, SEMI, and (where applicable) IEC standards. Pictorial hazard alerts follow the format described below:



*Table 2-1: Warning Label Legend*

	<b>‡ SAFETY ALERT SYMBOL</b>
DANGER - White Lettering / Red Background (Safety Red: per ANSI Z535.4 - 15 parts Warm Red, 1 part Rubine Red, 1/4 part Black)	White Triangle / Red Exclamation Point
WARNING - Black Lettering / Orange Background (Safety Orange: per ANSI Z535.4 - 13 parts Yellow, 3 parts Warm Red, 1/4 part Black)	Black Triangle / Orange Exclamation Point
CAUTION - Black Lettering / Yellow Background (Safety Yellow: per ANSI Z535.4 - Pantone 108C)	Black Triangle / Yellow Exclamation Point

This page includes pictogram representations used on semiconductor manufacturing equipment. This information is provided for customers using this equipment for semiconductor process equipment. Other users may refer to this information as well. Some of these pictograms will be found on Polycold's *Cool Solutions*® Fast Cycle Water Vapor Cryopump equipment. Actual label configurations and placement will be found in this chapter. Please note, for purposes of clarity, most illustrations depicting hazardous exposures show components in their most hazardous state (i.e., covers removed, safety interlocks, and other safeguards defeated) as they might appear during a major service activity. Most tasks do not require that the hazards be exposed to this degree.



*Figure 2-1: Typical Warning Labels*

## **2.3 Safety Training Guidelines**

The safety information in this chapter is a summary of the safety information that is to be successfully conveyed to service personnel as part of their training on Polycold's *Cool Solutions*® Fast Cycle Water Vapor Cryopump. The training program is intended to ensure that any person who undertakes the service of the Fast Cycle Water Vapor Cryopump can demonstrate competence to perform the required tasks safely. Accordingly, training required for each task includes, but is not limited to, the following:

- A review of applicable safety standards and procedures, such as those presented in this chapter.
- A review of maintenance and safety recommendations applicable to vendor supplied equipment.
- An explanation of the purpose of a subsystem and its operation.
- An explanation of the specific tasks and responsibilities of each person (operator, service personnel, etc.) assigned to the Fast Cycle Water Vapor Cryopump equipment.
- The person(s) (identified by name, location, and telephone number) to be contacted when required actions are beyond the training and responsibility of the person being trained.
- Identification of the recognized hazards associated with each task.
- Identification of, and appropriate responses to, unusual operating conditions.
- Explanation of the functions and limitations of all safeguards and their design characteristics.
- Instructions for the functional testing (or other means of assurance) for proper operation of safeguarding devices.

Safe use and service of the Fast Cycle Water Vapor Cryopump equipment also requires the following:

- Service personnel should understand the operation of process-related hardware interlocks, and the sequences of hardware operation that are executed automatically, as explained in this chapter.
- The equipment should not be used without assuring correct operation of all connected facilities, especially fugitive emissions exhaust.
- Service personnel should always assume that high voltage is present unless they have personally turned it off and locked it out.
- The equipment should not be operated without all guards and safety devices in place.



- The equipment should be shutdown, locked-out, and not be operated while it is being maintained.
- Users should not attempt to defeat, modify, or disable any of the equipment's safety interlock switches.
- Only Polycold Systems trained service personnel should perform installation, assembly, operation, disassembly, service, or maintenance of the Fast Cycle Water Vapor Cryopump equipment.
- All safety related incidents or near misses should be reported to a supervisor or to Brooks Polycold Systems Inc.
- The user should carefully review and understand manufacturer provide material safety data sheets (MSDS) for materials used by this equipment.

### **Definition of Electrical Work Types**

The following are the four types of electrical work in SEMI S2-0200:

**Type 1-** Equipment is fully deenergized.

**Type 2-** Equipment is energized. Energized circuits are covered or protected.

**NOTE:** *Type 2 work includes tasks where the energized circuits are or can be measured by placing probes through suitable openings in the covers or insulators.*

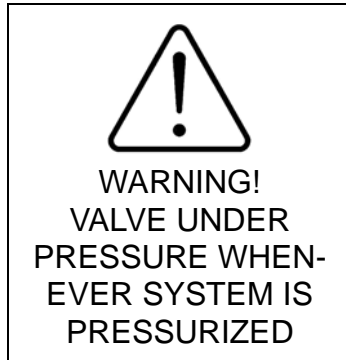
**Type 3-** Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are no greater than 30 volts rms, 42.4 volts peak, 60 volts dc or 240 volt-amps in dry locations.

**Type 4-** Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are greater than 30 volts rms, 42.4 volts peak, 60 volts dc or 240 volt-amps in dry locations. Potential exposures to radio-frequency currents exist; refer to SEMI S2-0200, Table A5-1 of Appendix 5 for a listing of these values.

## **2.4 Potential Hazards During Maintenance and Servicing**

*NOTE: This section applies to users wishing to comply with SEMI S2 requirements.*

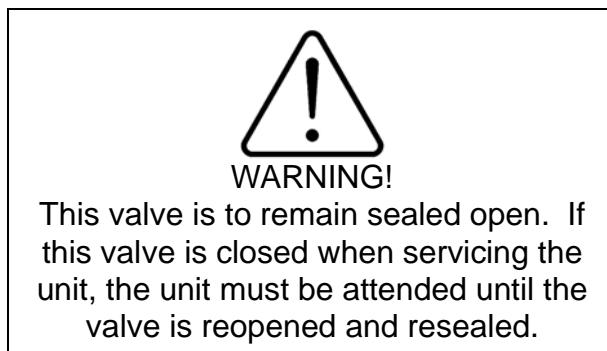
1



2



3



4



5

This valve is only open when the valve stem is in the middle position (mid-seated)

6

PRIMARY REFRIGERANT  
EXPANSION

407020 REV 01      XQS23689

8

R2000 SERIES

9





(CE Marked Units Only)

10

24 V AC  
PUSH TO RESET


11

 	<b>⚠ CAUTION</b>
	Extreme Temperatures. Can cause burns or frostbite. Do not touch exposed piping.

12




13

	<b>⚠ WARNING</b>
	<b>FLAMMABLE MATERIAL (1101, 1100, 670, 661, 660, 551, and 550 ONLY)</b> Do not open the refrigerant circuit to the atmosphere. Do not change the settings of the valves or loosen any fittings. Opening the refrigerant circuit or changing valve settings along with the failure to following instructions in this manual could result in death or serious injury. Review this manual before performing any procedure including routine operation of Polycold's <i>Cool Solutions</i> ® Fast Cycle Water Vapor Cryopump. Inspect the refrigerant circuit and change valve settings only as defined throughout this manual.

SEE OTHER SIDE

LINE IDENTIFICATION



**CAUTION!**  
**PRESSURIZED GAS**

DO NOT REMOVE BLANK-OFF FITTINGS FROM COUPLINGS UNTIL YOU HAVE READ THE INSTALLATION INSTRUCTIONS IN THE MANUAL.

ALWAYS USE SILVER PLATED STAINLESS STEEL GASKETS/ O-RINGS WHEN CONNECTING THE REFRIGERANT LINES.  
SAVE BLANK-OFF FITTINGS FOR USE WHENEVER THE LINES ARE DISCONNECTED.

407040-01 REV. 01A

SEE OTHER SIDE

**CAUTION**

THIS CRYOGENERATOR HAS BEEN FULLY CHARGED AT THE FACTORY WITH A PROPRIETARY MIXTURE OF REFRIGERANTS.

**DO NOT OPEN THE REFRIGERANT CIRCUIT TO THE ATMOSPHERE**

DISCHARGE OF REFRIGERANT MAY CAUSE PERSONAL INJURY DUE TO HIGH PRESSURES OR CRYOGENIC TEMPERATURES.

REFER TO THE MANUAL WHENEVER YOU NEED TO CONNECT OR DISCONNECT REFRIGERANT LINES.

SEE OTHER SIDE

LINE IDENTIFICATION



**CAUTION!**  
**PRESSURIZED GAS**

DO NOT REMOVE BLANK-OFF FITTINGS FROM COUPLINGS UNTIL YOU HAVE READ THE INSTALLATION INSTRUCTIONS IN THE MANUAL.

ALWAYS USE SILVER PLATED STAINLESS STEEL GASKETS/ O-RINGS WHEN CONNECTING THE REFRIGERANT LINES.  
SAVE BLANK-OFF FITTINGS FOR USE WHENEVER THE LINES ARE DISCONNECTED.

407040-02 REV. 01A

SEE OTHER SIDE

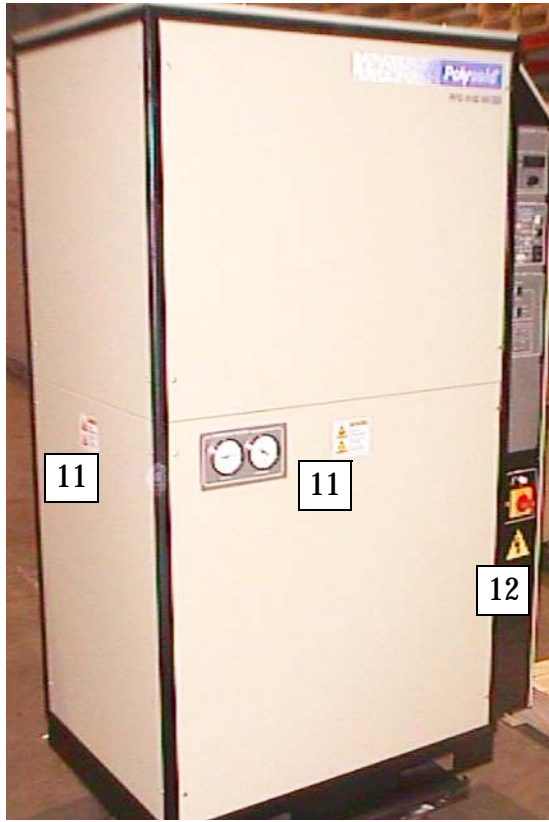
**CAUTION**

THIS CRYOGENERATOR HAS BEEN FULLY CHARGED AT THE FACTORY WITH A PROPRIETARY MIXTURE OF REFRIGERANTS.

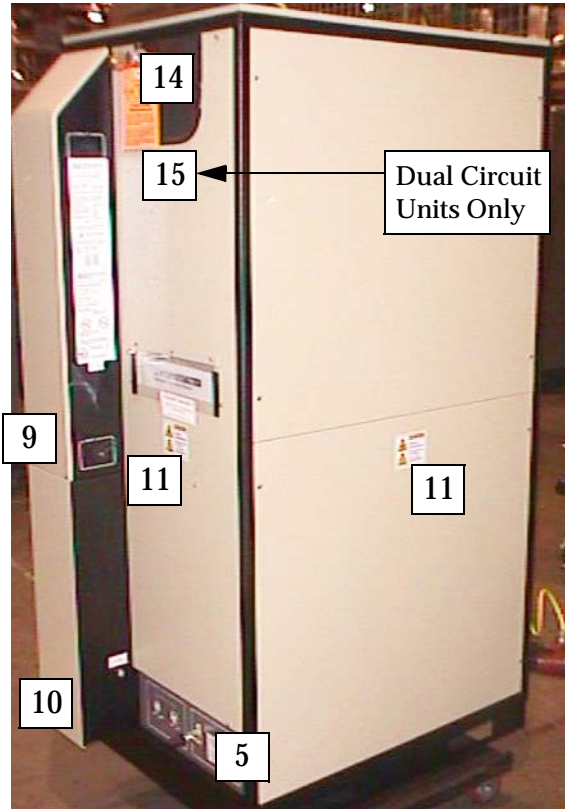
**DO NOT OPEN THE REFRIGERANT CIRCUIT TO THE ATMOSPHERE**

DISCHARGE OF REFRIGERANT MAY CAUSE PERSONAL INJURY DUE TO HIGH PRESSURES OR CRYOGENIC TEMPERATURES.

REFER TO THE MANUAL WHENEVER YOU NEED TO CONNECT OR DISCONNECT REFRIGERANT LINES.

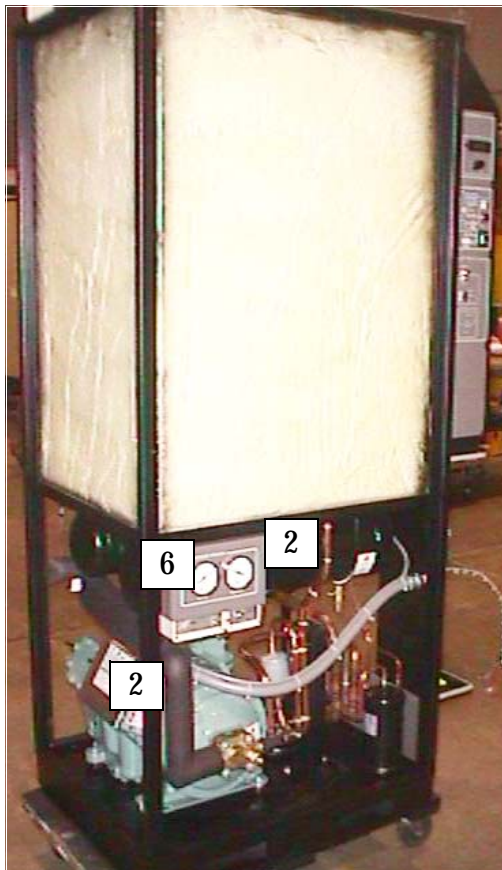


Exterior, Left Front Oblique

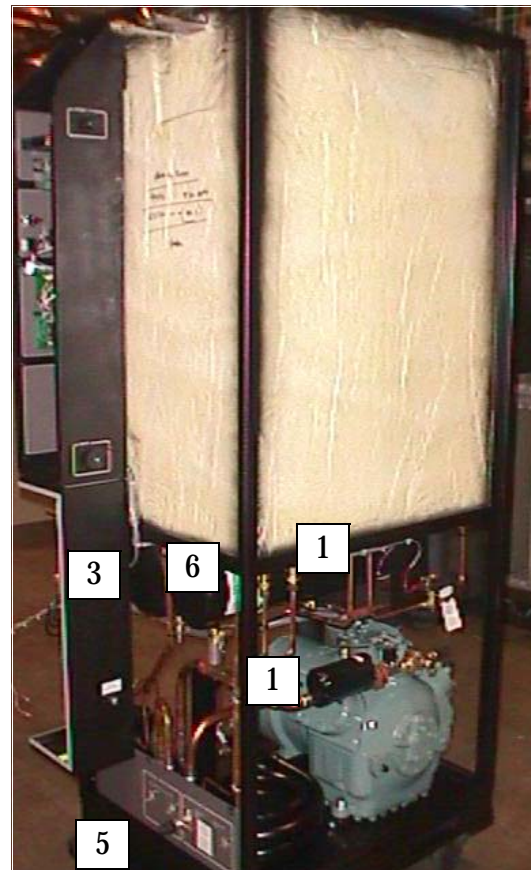


Exterior, Right Rear Oblique

Figure 2-2: Exterior Label Placement



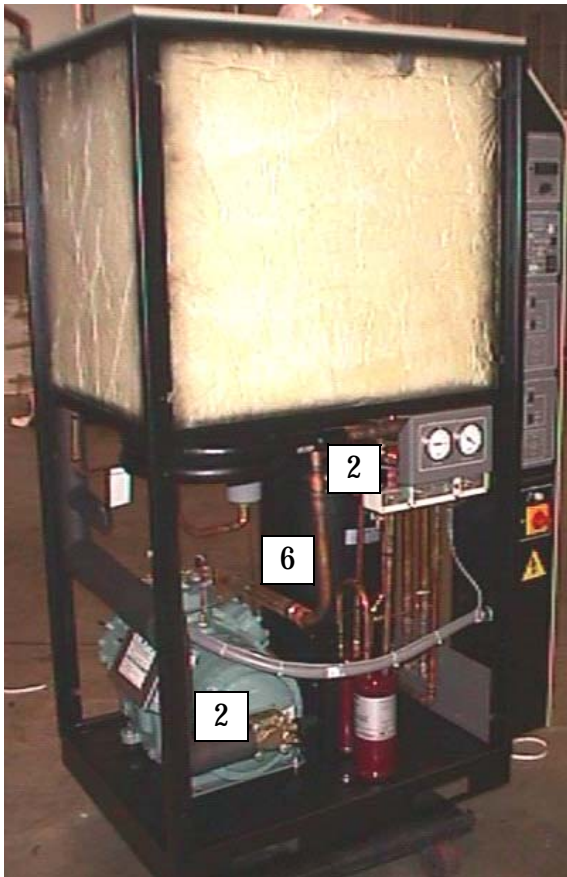
Interior, Left Front Oblique



Interior, Right Rear Oblique

*Figure 2-3: Interior Label Placement 550s, 552s, 660s, 662s, 670s, 672s (670 shown)*



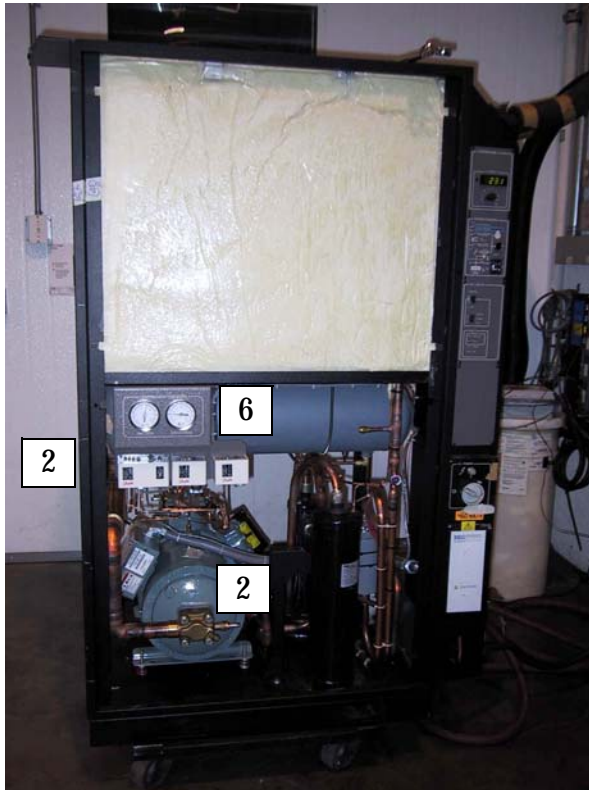


Interior, Left Front Oblique

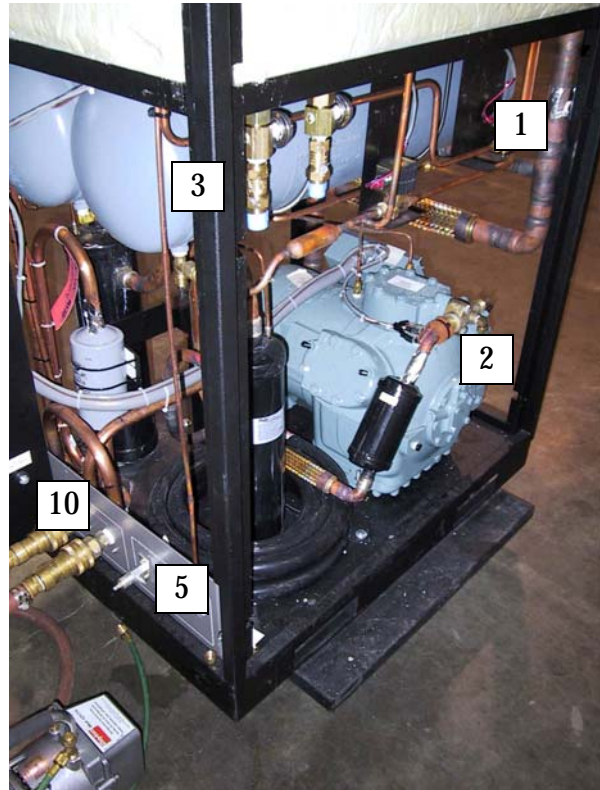


Interior, Right Rear Oblique

*Figure 2-4: Interior Label Placement 1100*



Interior, Left Front Oblique




Interior, Right Rear Oblique

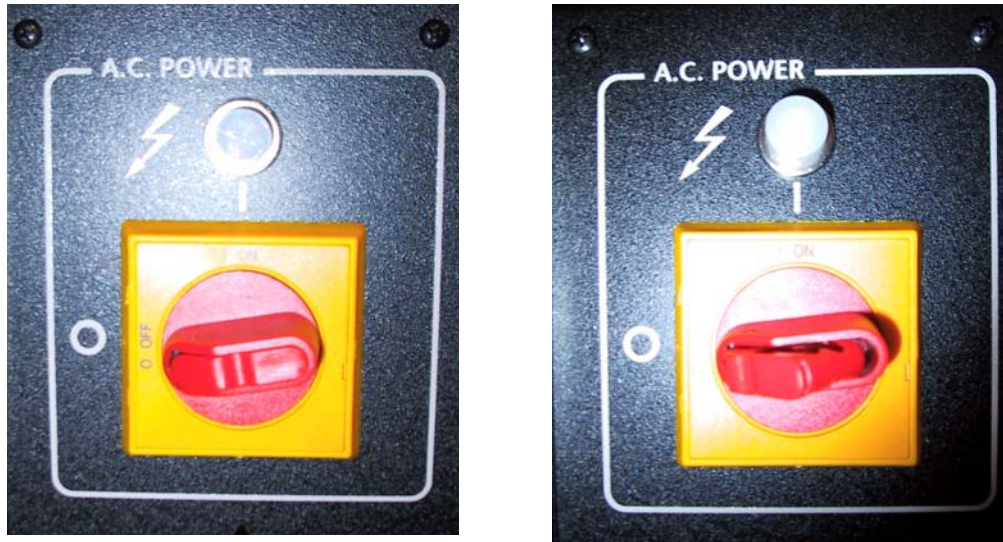
*Figure 2-5: Interior Label Placement 1102*

## 2.5 Lock-Out and Tag-Out Instructions (LOTO)

**NOTE:** *A lock-out refers to disconnecting the power supply from the unit, and reapplying safe power in order to avoid possible personnel electrocution.*

	<b>⚠ WARNING</b>
	<b>ELECTRICAL HAZARD</b> Contact could cause electric shock and result in death or serious injury. After performing LOTO of the Power Disconnect Switch, Line Voltage is still present at input terminals of the Power Disconnect Switch. To remove electrical power to the input terminals of the Power Disconnect Switch, refer to end-user's Facility Power LOTO instructions.

1. Shut down the system as described in [section 8.1 How to Shut Down or Ship the Cryopump](#).
2. Switch the Power Disconnect switch (refer to figure below) to the OFF position.
3. Pull out the Tag (shown in lower right picture below) on Power Disconnect Switch and place a pad lock in the opening keep the power off and locked.
4. Using an appropriate test meter, verify no electrical potential exists on secondary side of Power Disconnect Switch.
5. It is now safe to work in this area, refer to the Type 3 Electrical Work instructions before proceeding.



*Figure 2-6: Power Disconnect Switch in OFF position –  
Unlocked (Left), Locked (Right) (Customer supplied lock out device not shown.)*

## **2.6 Safety Interlocks**

The PFC safety interlock circuitry design is a positive logic, hardware based, fault tolerant device (approved by an authorized testing agency and NRTL approved for use as a safety device), providing operator notification, requiring manual reset, and which places the equipment in a safe standby condition upon activation. An exception to this is the compressor discharge safety interlock that uses negative logic. The risk associated with this variance has been deemed to be acceptable since other interlocks (which use positive logic) are expected to be activated if abnormally high discharge temperatures occur.

## 2.7 Circuit Breaker and Fuse Protection

Table 2-2: PFC Circuit Breaker and Fuse Protection

	Reference Designation	Protection Provided	Rated Voltage and Amperage	*Amperage Interrupting Capacity
<b>High Voltage Box</b>	CB1	Over Current	460V 1A	
	CB2	Over Current	460V 1A	
	CB3	Over Current	24VAC 5A	
<b>High Voltage Box- 575V Compressor</b>	FU1	Over Current	600V 1A	Not Applicable
	FU2	Over Current	600V 1A	Not Applicable
	CB1	Over Current	24VAC 5A	
<b>System Control Printed Circuit Board</b>	F1	Over Current	24VAC 1A	Not Applicable
<p><b>NOTE:</b> <i>*Amperage Interrupting Capacity refers to the maximum current that the electrical component is rated for. If the current is too high the contacts will “arc” exceeding capacity and possibly weld (fuse) together. In some locations this is also known as “AC breaking capacity.”</i></p>				

# 3

# Installation

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## Overview

This chapter provides complete installation procedures for the Brooks Automation Product including: unpacking, assembly, facilities connections, initial setup, and initial check-out.

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### 3.1 How to Install the Cryosurface


#### 3.1.1 If the Cryosurface is a Coil

##### Tools and materials needed

- spanner wrench†
- high vacuum lubricant—must have an appropriate low vapor pressure (for optional use on the feed-through's O-ring)

† Shipped with Polycold's standard 2-inch (50 mm) feed-through.

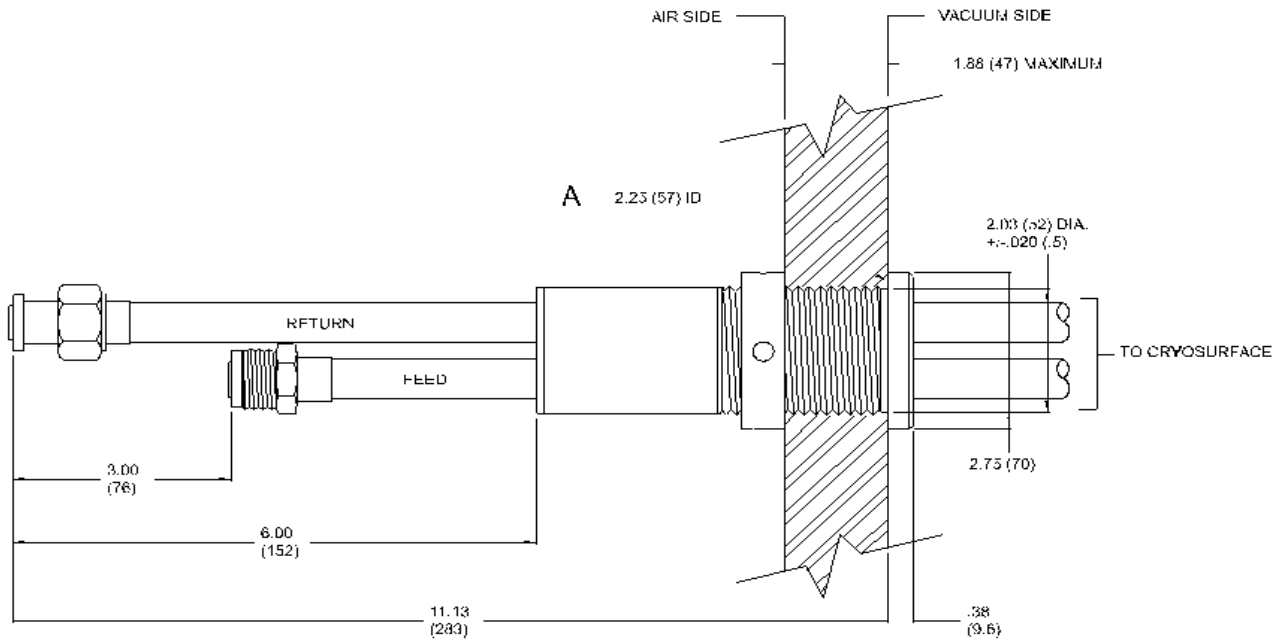
This section assumes the purchase of a cryocoil and standard 2-inch (50 mm) feed-through from Brooks Polycold Systems Inc. If not, see [section 3.5 Cryosurface & Cryogenic Feed-through Specification](#). Then continue with the installation.

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> Do not connect the unit to an existing cryosurface without first verifying that the cryosurface meets specification. The cryopump's working pressure may exceed your cryosurface's working pressure, which may damage your vacuum system components and may result in minor or moderate injury. (Reservoir type cryosurfaces are not suitable.) Verify all components meet specifications before connection.

##### 3.1.1.1 Ensure that the Feed-through Port is Compatible

Check the feed-through port thickness, hole diameter, and sealing surface. Ensure that the feed-through port is compatible with the feed-through. (See [Figure 3-1](#) below.)

**NOTE:** *Polycold's 2-inch (50 mm) feed-through is designed to be installed from inside the vacuum chamber. This allows removal of the cryocoil when cleaning or servicing the vacuum chamber.*



NOTE:

DIMENSIONS ARE IN INCHES (MILLIMETERS)

MADE FROM 408054 REV 01A

*Figure 3-1: Polycold's 2-inch (50 mm) Feed-through with Port Requirements*

O-ring number 228: 2.25 inches (57 mm) ID x 0.125 inches (3 mm) section

O-ring material: Buna-nitrile

O-ring surface: 2.60 inches (66 mm) surface roughness not to exceed 32 micro-inch (32/1000000 inch or 0.81 micron) — must be flat, clean, and free of scratches or deposits.

### 3.1.1.2 Put the Cryocoil into the Vacuum Chamber

1. Insert the feed-through into the feed-through port. Tighten the feed-through nut finger-tight and position the cryocoil. If the cryocoil has fasteners, secure them at this time.
2. Verify that no moving parts will hit the cryocoil. Make sure the cryocoil does not touch the vacuum chamber wall or anything else in the vacuum chamber. The cryocoil should be at least 5/8 inch (16 mm) away from the vacuum chamber wall.
3. Hold the feed-through in place and tighten the nut with a wrench. 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.

4. Install a 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.

### 3.1.1.3 Check Vacuum Chamber for Leaks


Check the feed-through port and seals used to install the cryocoil to ensure that the vacuum chamber is free of leaks.

### 3.1.2 If the Cryosurface Is a Baffle

#### Tools and materials needed:

high vacuum lubricant—must have an appropriate low vapor pressure (for optional use on an O-ring seal)

**NOTE:** *Note: This section assumes the purchase of a cryobaffle from Brooks Polycold Systems Inc. If not, see [section 3.5 Cryosurface & Cryogenic Feed-through Specification](#). Then continue with the installation.*

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> Do not connect the unit to an existing cryosurface without first verifying that the cryosurface meets specification. The cryopump's working pressure may exceed your cryosurface's working pressure, which may damage your vacuum system components and may result in minor or moderate injury. (Reservoir type cryosurfaces are not suitable.) Verify all components meet specifications before connection.</p>

### 3.1.2.1 Inspect All Vacuum Sealing Surfaces

Surfaces must be clean and free from scratches or other imperfections that might result in vacuum leaks. Protect these surfaces at all times. Remove any contaminants by wiping it with a clean cloth moistened with alcohol.

### **3.1.2.2 Mount the Cryobaffle**

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


### **3.1.2.3 Confirm Cryobaffle is Thermally Isolated**

1. Shield the cryobaffle from any radiation source greater than 50°C.
2. Ensure that there isn't any part of the cryobaffle in direct contact with the vacuum chamber.

### **3.1.2.4 Check the Vacuum Chamber for Leaks**

## 3.2 How to Install the Refrigeration Unit

### 3.2.1 Inspect the Unit

	<b>⚠ WARNING</b>
	<b>HIGH PRESSURE RUPTURE</b> If a high pressure circuit is ruptured equipment damage could occur. In addition, cuts and eye injury from flying objects could result in death or serious injury. Review this manual before performing any procedure including routine operation of Polycold's <i>Cool Solutions</i> ® Fast Cycle Water Vapor Cryopump. Inspect the refrigerant circuit and entire unit before continuing.

#### 3.2.1.1 Check All Items Received

Notify the carrier immediately if there is reason to suspect an item was damaged during shipping. Contact Polycold's local sales representative or Polycold's shipping department if there are any questions about what has been received. Spare parts are normally shipped in the compressor compartment of the unit.

#### 3.2.1.2 Check Unit's Balance Pressure

Locate the COMPRESSOR PRESSURE gauges on the front of the unit. Record the pressure of the discharge gauge.

Refrigeration unit's balance pressure: \_\_\_\_\_ psig

The unit's balance pressure should be in the appropriate range. (See [Table 3-1](#).) If not, contact Polycold's local sales representative or Brooks Polycold Systems Inc. for assistance.

**NOTE:** *Some refrigeration units cannot be shipped with the refrigerant charge in them. If the unit does not contain a refrigerant charge, a separate refrigerant charge with instructions for charging the unit should have been received.*


*Table 3-1: Acceptable Balance Pressures for Refrigeration Units†*

<b>Refrigeration Unit</b>	<b>*Balance Pressure psig (bar)</b>
550-HC	110-125 (7.6-8.6)
550-LT	110-130 (7.6-9.0)
551-HC	139-152 (9.6-10.5)
552-HC	135-155 (9.3-10.7)
660-HC	140-175 (9.7-12.1)
661-HC	155-175 (10.7-12.1)
662-HC	160-190 (11.0-13.1)
670-HC	140-175 (9.7-12.1)
672-HC	160-190 (11.0-13.1)
1100-HC	160-200 (11.0-13.8)
1100-LT	155-170 (10.7-11.7)
1101-HC	165-185 (11.4-12.8)
1101-LT	150-170 (10.3-11.7)
1102-HC	175-200 (12.1-13.8)
<p><b>NOTE:</b>  <i>†These pressures are for the refrigeration units only. The balance pressure may drop 5-10 psig (35-70 kPa) after installing the refrigerant line and cryosurface and opening the isolation valves.</i>  <i>*Balance Pressure refers to the pressure of the unit when it is turned off and fully warmed up to room temperature. It is the balance of pressure on both sides (suction and discharge) of the compressor. Under operating conditions (when the compressor is running) the unit creates a pressure difference between sides of the compressor.</i></p>	

### 3.2.2 Position the Unit

**Tools and materials needed:**

- Forklift
- Two 9/16-inch wrenches
- Phillips screwdriver

	<b>⚠ WARNING</b>
	<b>TIP OVER</b> Failure to properly lift this device could result in death or serious injury. Use forklift slots to properly lift this device.

#### 3.2.2.1 PED information for PFC-552, -662, -672 and 1102 systems.

The following is a representative label of the unit label and typical information provided on the unit nameplate. Due to changes in our manufacturing process the specific information on your unit may differ.

# POLYCOLD SYSTEMS

## HELIX TECHNOLOGY CORPORATION

3800 Lakeville Highway  
Petaluma, CA 94954 USA

+1 707.769.7000  
service@polycold.com

### CRYOGENIC REFRIGERATION UNIT

MODEL:

SERIAL #: XXXXX

MANUFACTURING DATE: 23 November 2005

### ALLOWABLE PRESSURES (PS)

LOW (SUCTION) SIDE: 300.0 psi (20.7 bar)

HIGH (DISCHARGE) SIDE: 430.0 psi (29.6 bar)

### TEST PRESSURES (PT)

LOW (SUCTION) SIDE: 430.0 psi (29.6 bar)

HIGH (DISCHARGE) SIDE: 615.0 psi (42.4 bar)

### AMBIENT OPERATING TEMPERATURE (TO)

MINIMUM: 40°F (4.4°C)

MAXIMUM: 100°F (37.8°C)

PED 97/23/EC

CATEGORY II

*Figure 3-2: Typical Unit Label and Nameplate*

### 3.2.3 Place the Unit

(See [Figure 3-3](#).)

1. The refrigeration unit should be installed in an environment that meets the following conditions:
  - Indoors
  - Above ground
  - A well ventilated area
  - A room temperature of 40-100° F (4-38 C)
  - A relative humidity of 20-80%, no condensation



2. The refrigeration unit has a PRESSURE RELIEF OUTLET on the utility panel. This port has a 3/4 inch female NPT fitting. It allows the venting of refrigerant escaping from a pressure relief valve to another location. To install the unit to ASHRAE requirements, see [section 3.2.6 How to Install the Refrigeration Unit to Meet ASHRAE Requirements](#).
3. The unit must remain vertical. However, placement of the unit may be at any elevation relative to the cryosurface. The cryopumping system is not gravity-sensitive.

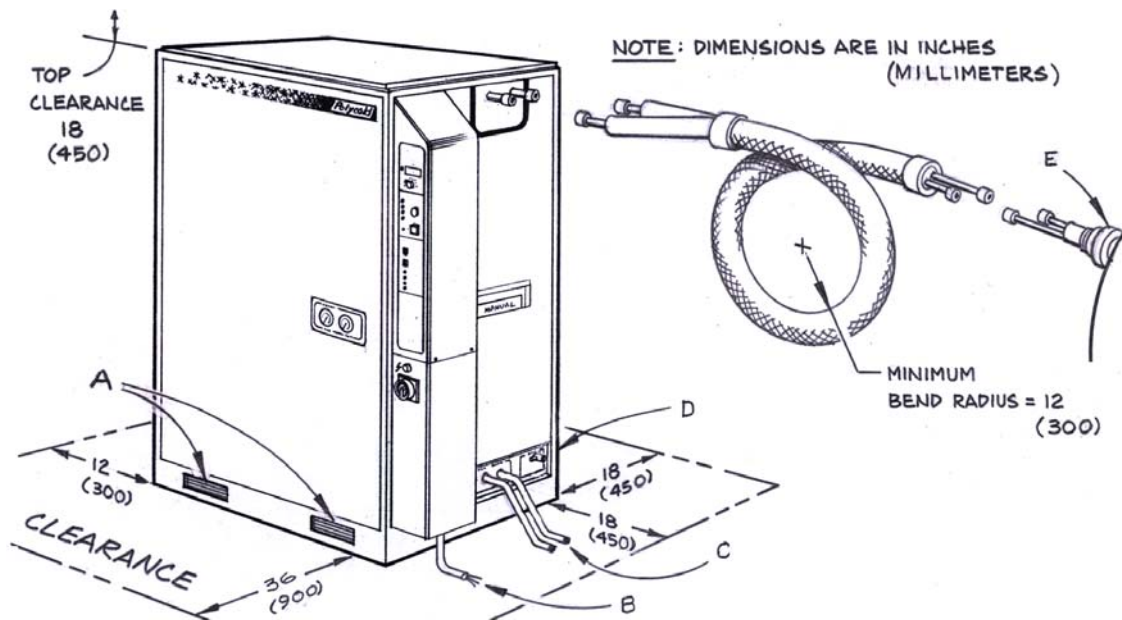


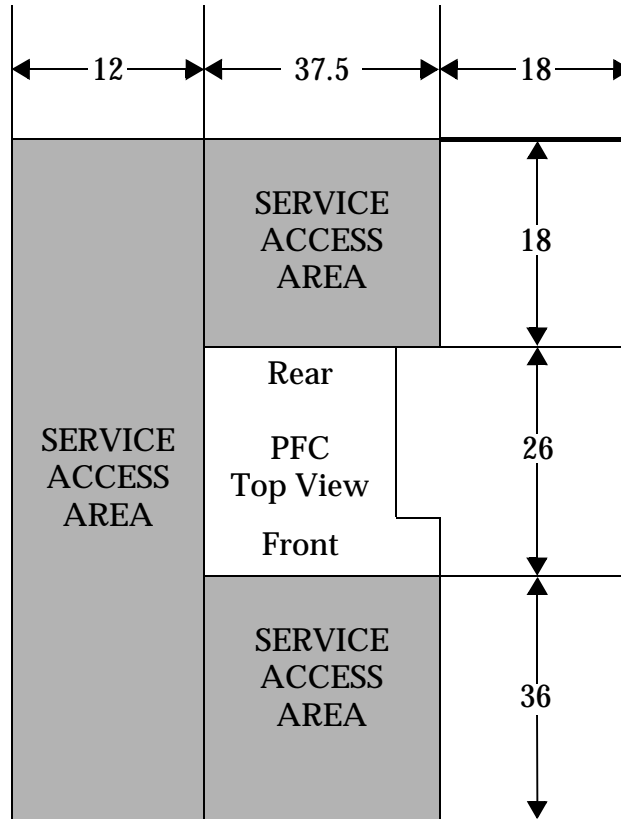
Figure 3-3: Unit Placement Considerations

- A. Forklift slots
  - B. Electrical supply port
  - C. Cooling water connections
  - D. Pressure relief outlet (not shown)
  - E. Feed-through port
1. The minimum space requirements for inspection and service are as follows (see [Figure 3-4](#)):
    - 36 inches (900 mm) in the front
    - 18 inches (450 mm) on the top, rear, and right side

- 12 inches (300 mm) on the left side

The couplings, electrical hook-up, and cooling water connections are on the right side of the unit.

2. The standard refrigerant line is about 8 feet (2.4 m) long. It has a minimum bend radius of 12 inches (300 mm).



*Figure 3-4: PFC Footprint (not to scale)*

- The PFC requires 18 inches of clear area at the back of the system and 36 inches at the front. (See [Table 3-2](#).) This is needed for access to switches, settings, and for safety reasons.
- Service and maintenance are also slowed if the unit is installed in a confined area. For this reason we recommend that the unit be installed with as much clear service access area as the facility will allow.
- Multiple units may be placed side by side as long as the rear of the unit is accessible.
- When units are placed facing one another a 36 inch service area is required.

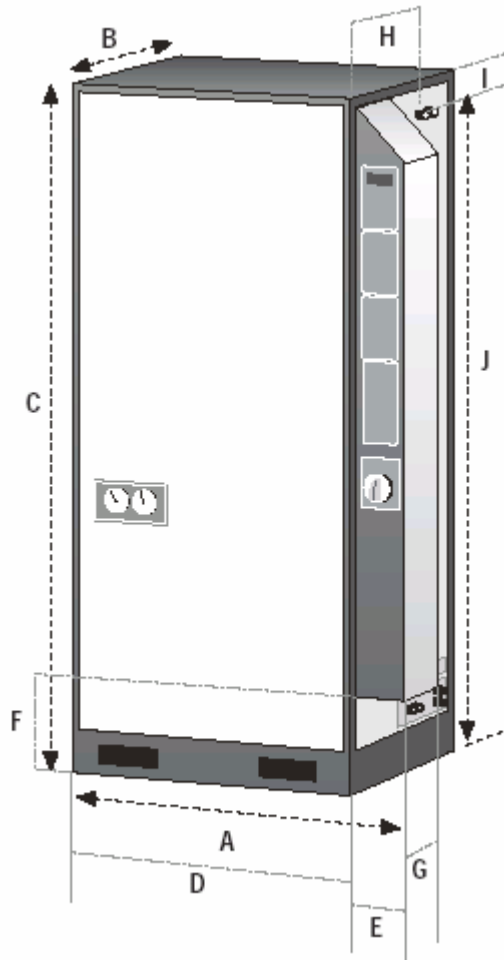
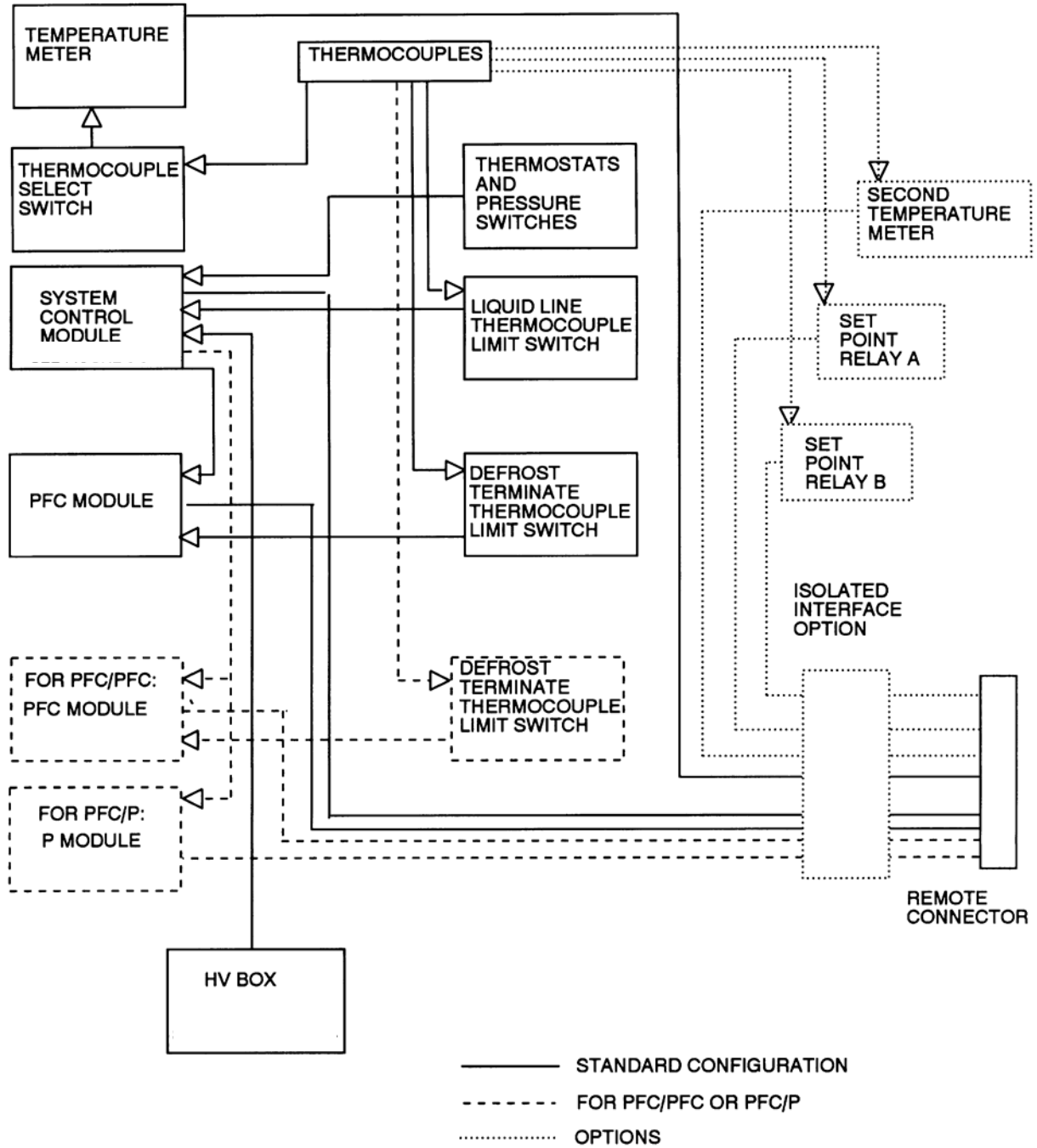


Figure 3-5: PFC 550, 551, 552, 660, 661, 662, 670, 672, 1100, 1101, and 1102

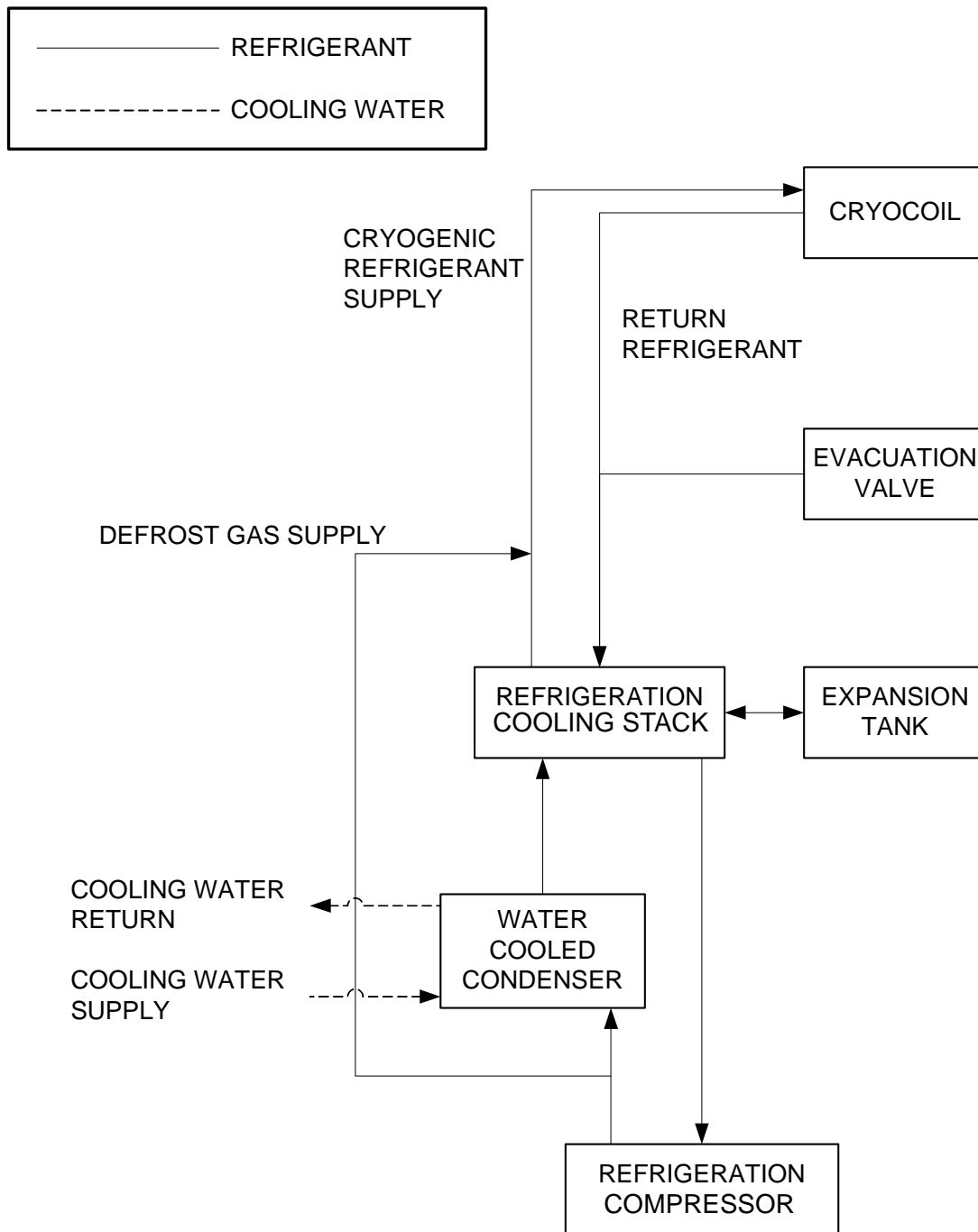
*Table 3-2: PFC Dimensions*

<b>Model</b>	<b>A mm / inches</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>	<b>H</b>	<b>I</b>	<b>J</b>	<b>Weight kg./lb.</b>	<b>Standard Refriger- ant Line</b>
550	953	660	1842	812	140	254	203	432	114	1727	408	8 ft.
551	37.5	26	72.5	32	5.5	10	8	17	4.5	68	900	
552												
660	953	660	1842	812	140	254	203	432	114	1727	478	8 ft.
661	37.5	26	72.5	32	5.5	10	8	17	4.5	68	1055	
670 672												
662	953	660	1842	812	140	254	203	432	114	1727	476	8 ft.
	37.5	26	72.5	32	5.5	10	8	17	4.5	68	1050	
1100	1054	711	1689	914	140	102	203	457	114	1562	544	8 ft.
1101	41.5	28	66.5	36	5.5	4	8	18	4.5	61.5	1200	
1102												



3-19-97 CB

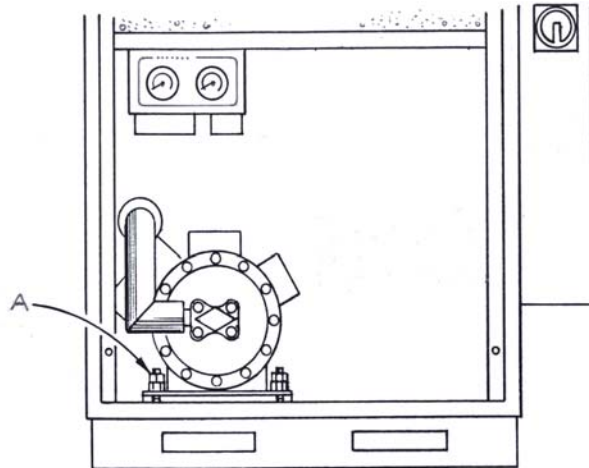
Figure 3-6: Electrical Block Diagram



*Figure 3-7: System Block Diagram*

### 3.2.3.1 Remove the Compressor Hold-Down Nuts

Remove the front and lower back panels from the unit. Use two 9/16-inch wrenches to remove the compressor hold-down nuts. (See [Figure 3-8](#).) Keep these nuts with the unit they will need to be reinstalled if the unit is moved.




*Figure 3-8: Location of Compressor Hold-down Nuts*

Compressor hold-down nuts (2 nuts—4 places)

### 3.2.4 Connect the Electrical Power

#### Tools and materials needed:

Qualified electrician with tools and materials

	<b>⚠ WARNING</b>
	<b>ELECTRICAL</b> Hazardous voltages exist. Failure to have a qualified electrician do all electrical work could result in death or serious injury. Make sure the power source is off. Do not reach inside the refrigeration unit. A qualified electrician must do all electrical work. Electrical work must be completed according to local codes. Use copper conductors only.

### **3.2.4.1 Check and Protect the Electrical Supply**

Check the nameplate on the Polycold *Cool Solutions*® Fast Cycle Water Vapor Cryopump unit. If the nominal voltage does not exist, check the control voltage after connecting the electrical supply. (See [section 3.2.4.2 How to Check the Control Voltage and Change the Transformer Taps.](#))

The unit should have its' own electrical supply. (See [section Table 3-3: Electrical Supply and Protection Requirements.](#))

### **3.2.4.2 How to Check the Control Voltage and Change the Transformer Taps**

#### **3.2.4.2.1 How to Check the Control Voltage**

##### **Tools and materials needed:**

Voltmeter that can measure 30 V(ac)

1. Turn off the refrigeration unit. Turn the power disconnect switch to the OFF position.
2. Loosen the two lower screws on the side of the low voltage box panel. Slide the panel straight up to remove it. (See [Figure 3-22.](#))
3. Locate the SYSTEM CONTROL printed circuit board that is behind the SYSTEM CONTROL panel.
4. Connect the voltmeter. (See [Figure 3-9.](#))
  - Connect one lead to a screw holding the heat sink. (The voltage regulator is inside the heat sink.)
  - Connect the other lead to a fuse terminal.
5. Make certain the refrigeration unit's ON/OFF switch is in the OFF position. Turn the power disconnect switch to the ON position.
6. The acceptable voltage range is 22.5–26.5 V. If the control voltage is not acceptable, see [section 3.2.4.2.2 How to Change the Transformer Taps.](#)



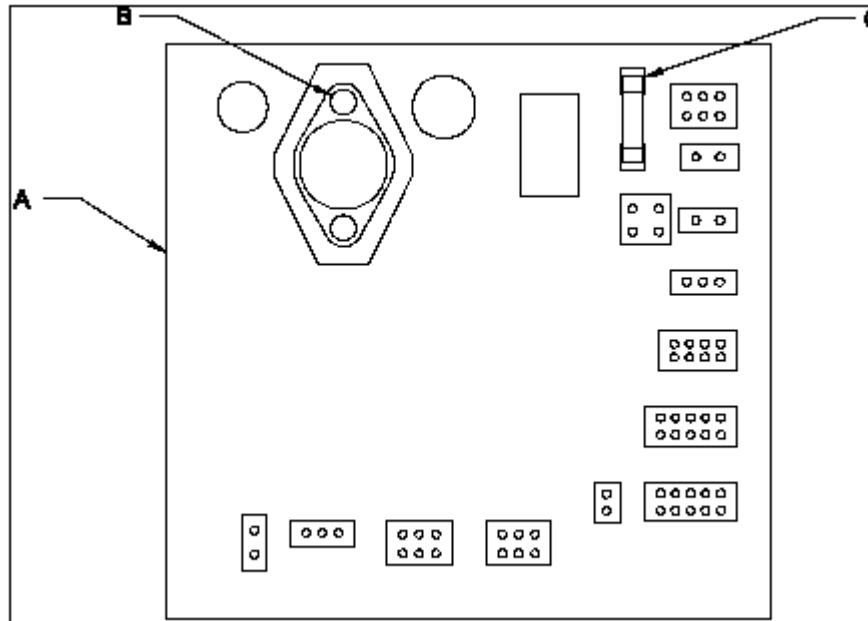


Figure 3-9: Control Voltage Check—Voltmeter Connections

- A. SYSTEM CONTROL printed circuit board
- B. Screw holding the heat sink
- C. Fuse terminal

#### 3.2.4.2.2 How to Change the Transformer Taps

1. Make certain the refrigeration unit's ON / OFF switch is in the OFF position.
2. Turn the power disconnect switch to the OFF position. Remove the high voltage box panel.
3. Refer to the "Transformer Connections" table in [Figure 10-2](#).

**NOTE:** Before changing taps, verify that the transformer connections are set for the proper line voltage.

- If the control voltage is greater than 26.5 V, move power connection "B" to the next higher tap. (For example, if "B" is connected to tap 3, move it to tap 4.)

- If the control voltage is less than 22.5 V, move power connection “B” to the next lower tap, with tap 3 being the lowest selection. (For example, if “B” is connected to tap 6, move it to tap 5.)
4. Reinstall the high voltage box panel.
  5. Check the control voltage with the new transformer setting following the instructions in [section 3.2.4.2.1 How to Check the Control Voltage](#).
  6. If the control voltage is within the acceptable range, record the new transformer connections in the manual.
  7. If the control voltage is still not within the acceptable range, repeat the procedure above, moving power connection “B” to the next available tap.
  8. If none of the available tap settings yield a control voltage within the acceptable range, contact Polycold Service for assistance.

*Table 3-3: Electrical Supply and Protection Requirements*

Model Characteristics				Electrical Characteristics					
Unit	Nominal Compressor Voltage	Common Worldwide Voltage-Phase-Frequency	Transformer Tap Setting and ID Label	Acceptable Voltage Range Low-High	MCC Amps	LRA Amps	RLA mps	Fuse Size Amps	Power Input kVA
550 HC	230V	200-3-50 200-3-60 208/230-3-60	200-3-50/60	180-220@50Hz 187-220@60Hz	44	160		60	
		208/230-3-60 220-3-50 230-3-60	230-3-50/60	207-230@50Hz 207-253@60Hz					
	460V	380-3-50	380-3-50	342-418@50Hz	22	80		25	
		400-3-50 415-3-50	400-3-50	360-440@50Hz					
		440-3-50 460-3-60	460-3-50/60	414-460@50Hz 414-506@60Hz					
		480-3-60	480-3-60	432-528@60Hz					
	575V	575-3-60	575-3-60	518-632@60Hz	17.6	64		20	

*Table 3-3: Electrical Supply and Protection Requirements*

Model Characteristics				Electrical Characteristics					
Unit	Nominal Compressor Voltage	Common Worldwide Voltage-Phase-Frequency	Transformer Tap Setting and ID Label	Acceptable Voltage Range Low-High	MCC Amps	LRA Amps	RLA mps	Fuse Size Amps	Power Input kVA
550L T	230V	200-3-50 200-3-60 208/230-3-60	200-3-50/60	180-220@50Hz 187-220@60Hz	44	160		60	
		208/230-3-60 220-3-50 230-3-60	230-3-50/60	207-230@50Hz 207-253@60Hz					
	460V	380-3-50	380-3-50	342-418@50Hz	22	80		25	
		400-3-50 415-3-50	400-3-50	360-440@50Hz					
		440-3-50 460-3-60	460-3-50/60	414-460@50Hz 414-506@60Hz					
480-3-60	480-3-60	432-528@60Hz							
575V	575-3-60	575-3-60	518-632@60Hz	17.6	64		20		
660 HC 670 HC	230V	200-3-50 200-3-60 208/230-3-60	200-3-50/60	180-220@50Hz 187-220@60Hz	44	160	32.0	60	11.5
		208/230-3-60 220-3-50 230-3-60	230-3-50/60	207-230@50Hz 207-253@60Hz					
	460V	380-3-50	380-3-50	342-418@50Hz	22	80	16.0	25	
		400-3-50 415-3-50	400-3-50	360-440@50Hz					
		440-3-50 460-3-60	460-3-50/60	414-460@50Hz 414-506@60Hz					
480-3-60	480-3-60	432-528@60Hz							
575V	575-3-60	575-3-60	518-632@60Hz	17.6	64	12.8	20		

*Table 3-3: Electrical Supply and Protection Requirements*

Model Characteristics				Electrical Characteristics					
Unit	Nominal Compressor Voltage	Common Worldwide Voltage-Phase-Frequency	Transformer Tap Setting and ID Label	Acceptable Voltage Range Low-High	MCC Amps	LRA Amps	RLA mps	Fuse Size Amps	Power Input kVA
1100 HC	230V	200-3-50 200-3-60 208/230-3-60	200-3-50/60	180-220@50Hz 187-220@60Hz	62	228	53.7	80	19.3
		208/230-3-60 220-3-50 230-3-60	230-3-50/60	207-230@50Hz 207-253@60Hz					
	460V	380-3-50	380-3-50	342-418@50Hz	31	114	26.8	35	
		400-3-50 415-3-50	400-3-50	360-440@50Hz					
		440-3-50 460-3-60	460-3-50/60	414-460@50Hz 414-506@60Hz					
480-3-60	480-3-60	432-528@60Hz							
575V	575-3-60	575-3-60	518-632@60Hz	25	90	21.6	30		
1100 LT	230V	200-3-50 200-3-60 208/230-3-60	200-3-50/60	180-220@50Hz 187-220@60Hz	62	228	44.3	80	15.9
		208/230-3-60 220-3-50 230-3-60	230-3-50/60	207-230@50Hz 207-253@60Hz					
	460V	380-3-50	380-3-50	342-418@50Hz	31	114	22.1	35	
		400-3-50 415-3-50	400-3-50	360-440@50Hz					
		440-3-50 460-3-60	460-3-50/60	414-460@50Hz 414-506@60Hz					
480-3-60	480-3-60	432-528@60Hz							
575V	575-3-60	575-3-60	518-632@60Hz	25	90	18.1	30		

*Table 3-3: Electrical Supply and Protection Requirements*

Model Characteristics				Electrical Characteristics					
Unit	Nominal Compressor Voltage	Common Worldwide Voltage-Phase-Frequency	Transformer Tap Setting and ID Label	Acceptable Voltage Range Low-High	MCC Amps	LRA Amps	RLA mps	Fuse Size Amps	Power Input kVA
551 HC 552 HC	460V	380-3-50	380-3-50	342-418@50Hz	22	80		25	
		400-3-50 415-3-50	400-3-50	360-440@50Hz					
		440-3-50 460-3-60	460-3-50/60	414-460@50Hz 414-506@60Hz					
		480-3-60	480-3-60	432-528@60Hz					
	575V	575-3-60	575-3-60	518-632@60Hz	17.6	64		20	
661 HC 662 HC 672 HC	460V	380-3-50	380-3-50	342-418@50Hz	22	80		25	
		400-3-50 415-3-50	400-3-50	360-440@50Hz					
		440-3-50 460-3-60	460-3-50/60	414-460@50Hz 414-506@60Hz					
		480-3-60	480-3-60	432-528@60Hz					
	575V	575-3-60	575-3-60	518-632@60Hz	17.6	64		20	
1101 HC 1102 HC	460V	380-3-50	380-3-50	342-418@50Hz	31	114		35	
		400-3-50 415-3-50	400-3-50	360-440@50Hz					
		440-3-50 460-3-60	460-3-50/60	414-460@50Hz 414-506@60Hz					
		480-3-60	480-3-60	432-528@60Hz					
	575V	575-3-60	575-3-60	518-632@60Hz	25	90		30	
1101 LT	460V	380-3-50	380-3-50	342-418@50Hz	31	114		35	
		400-3-50 415-3-50	400-3-50	360-440@50Hz					
		440-3-50 460-3-60	460-3-50/60	414-460@50Hz 414-506@60Hz					
		480-3-60	480-3-60	432-528@60Hz					
	575V	575-3-60	575-3-60	518-632@60Hz	25	90		30	

Leg to Leg voltages must be balanced to within 2% of each other.

**NOTE:** *RLA is the current drawn by the compressor at rated load. It may also be referred to as the maximum full load amps. Maximum recommended fuse size. A Bussman FRS-R dual element, current limiting fuse or equivalent is recommended to protect the branch circuit. Actual protection must comply with local codes. "Worse Case low Volts" refers to the lowest amount of voltage available. Typically power fluctuates by 10% within a given area, so the lowest voltage amount would be 90% of the nominal voltage.*

Gould TRS, Littlefuse FLSR.

MCA=minimum Circuit Ampacity = should be at least 125% RLA

**NOTE:** *This value is to assist the customer electrician to determine the dimensions of the electrical system.*


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.

**NOTE:** *Compressors are provided with over current and over temperature protection which comply with UL and NEC definitions of inherent thermal protection.*

$$\text{kVA} = \text{Test Volts} * \text{RLA} * 1.732 / 1000$$

$$\text{kW} = \text{kVA} * \text{Power Factor. } 90\% \text{ in this case}$$


### 3.2.4.3 Connect the Unit to the Electrical Supply

	<b>⚠ WARNING</b>
	<b>ELECTRICAL</b> Hazardous voltages exist. Failure to have a qualified electrician do all electrical work could result in death or serious injury. Make sure the electrical supply is <u>not</u> energized. Do not reach inside the refrigeration unit. A qualified electrician must do all electrical work. Electrical work must be completed according to local codes.

(See [Figure 3-10](#) and [Figure 3-11](#).)

1. Turn the power disconnect switch to the OFF position. Unscrew the fasteners and remove the high voltage box panel.


2. Refer to [Table 3-3](#) and all local codes to determine the proper type and size wires. Four wires will be needed—one for each phase and one for the ground. A neutral wire is not needed.
3. Remove the plug from one of the holes in the bottom of the high voltage box. Attach wire fittings as required. Feed customer installed wires through this hole.
4. Ground the unit according to local codes. Polycold has provided two ground studs. The internal ground stud is inside the high voltage box. For 1100s, the external ground stud is on the frame to the right of the utility panel. For all 550s, 660s, and 670s the external ground stud is on the frame to the left of the utility panel.

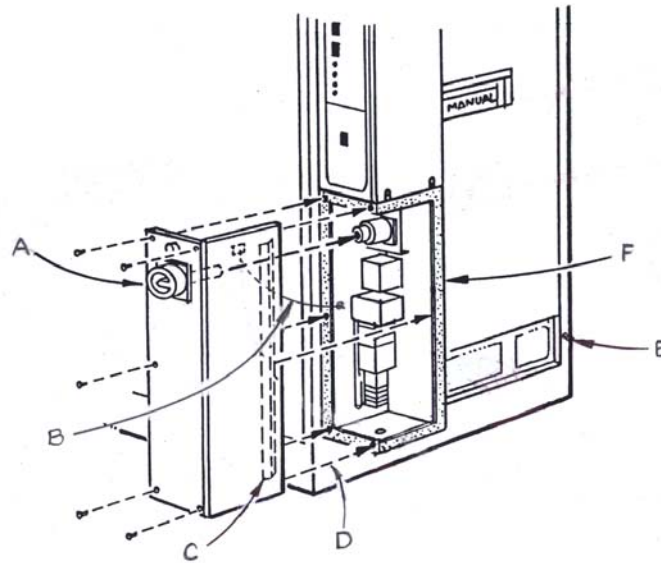
	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> If the internal ground stud is not used damage to the equipment can result. Verify that the nut holding the washers and terminal lugs is tight.

5. Route your other three wires along the wire guides. Secure a wire in terminals L1, L2, and L3 of the power disconnect switch. It does not matter which wire goes to which terminal; the compressor is not phase sensitive. Press the wire guides down to hold the wires in place.

**NOTE:** *For additional information, refer to [Section 11](#).*

6. Reinstall the high voltage box panel. Make sure its ground and lamp wires and its tab fit inside the seal.

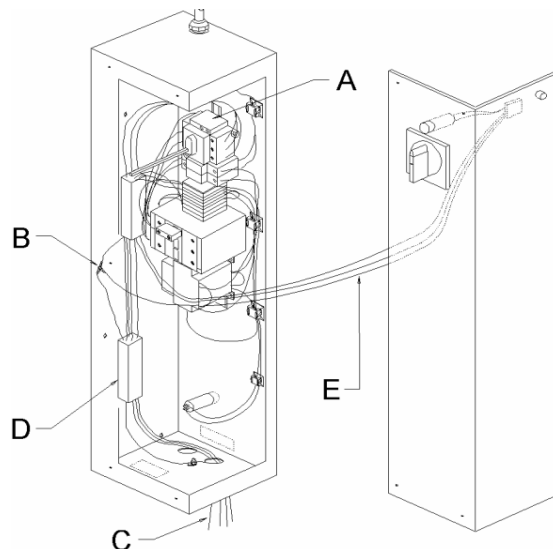
	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> Do not turn on the unit at this time; damage to the equipment can result. Cooling water must be connected before the unit is turned on.



*Figure 3-10: High Voltage Box Panel Removal; External Ground Stud Locations*

- A. Power disconnect switch
- B. Ground and lamp wires (attached to panel)
- C. Tab
- D. External ground stud for all 550s, 660s, and 670s (not shown)
- E. External ground stud for all 1100s
- F. High voltage box





*Figure 3-11: High Voltage Box Component Locations*


- A. Power disconnect switch
- B. Internal ground stud
- C. Customer installed wires
- D. Wire guides
- E. Ground and lamp wires

### 3.2.5 Connect the Cooling Water

#### **Tools and materials needed:**

For 550, 551, 552, 660, 661, 662, 670, and 672: 1/2-inch (15 mm) standard pipe size

For 1100, 1101, and 1102: 3/4-inch (20 mm) standard pipe size

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b>          If cooling water has not been connected damage to the equipment can result.          Verify that cooling water has been connected before turning on the unit.</p>

**3.2.5.1 Ensure Cooling Water is Adequate**

Measure the inlet water temperature. It must be 55-85°F (13-29°C). Make sure the minimum flow rate for the water’s temperature is adequate. See [Table 3-4](#).

**NOTE:** *Cooling water may be warmer in the summer than in the winter.*

Cooling water should be clean. Polycold recommends filtering cooling water if it is very dirty or has abrasives in it. Any chemical impurities in the cooling water must be compatible with copper.

*Table 3-4: Cooling Water Flow Requirements*

Refrigeration Unit	Water Inlet Temperature °F (°C)	Minimum Flow Rate gpm (L/min)	Pressure Drop Inside the Unit psi (kPa)	Pressure Drop in Supply Line† psi/ft (kPa/m)	Heat Rejection Btu/Hour (kW)
550, 551, 552	55 (13) (Min)	1.3 (4.9)	0.3 (2.1)	no data	23,900 (7.0)
	65 (18)	1.7 (6.4)	0.6 (4.1)	no data	23,900 (7.0)
	75 (24)	2.6 (9.8)	1.3 (9.0)	no data	23,900 (7.0)
	85 (29) (Max.)	5.2 (19.7)	5.3 (36.6)	0.06 (1.4)	23,900 (7.0)
660, 661, 662, 670, 672	55 (13) (Min)	1.8 (6.8)	0.5 (3.4)	no data	33,400 (9.8)
	65 (18)	2.4 (9.1)	0.8 (5.5)	no data	33,400 (9.8)
	75 (24)	3.6 (13.6)	1.8 (12.4)	no data	33,400 (9.8)
	85 (29) (Max.)	7.3 (27.6)	7.6 (52.4)	0.11 (2.5)	33,400 (9.8)

Table 3-4: Cooling Water Flow Requirements

Refrigeration Unit	Water Inlet Temperature °F (°C)	Minimum Flow Rate gpm (L/min)	Pressure Drop Inside the Unit psi (kPa)	Pressure Drop in Supply Line† psi/ft (kPa/m)	Heat Rejection Btu/Hour (kW)
1100, 1101, 1102	55 (13) (Min)	3.6 (13.6)	1.6 (11.0)	no data	65,500 (19.2)
	65 (18)	4.8 (18.2)	2.8 (19.3)	no data	65,500 (19.2)
	75 (24)	7.2 (27.3)	6.3 (43.4)	no data	65,500 (19.2)
	85 (29) (Max.)	14.3 (54.1)	24.8 (171)	0.15 (3.4)	65,500 (19.2)
<p><b>NOTE:</b> †For 550s, 660s, and 670s these numbers assume a 1/2-inch (15 mm) standard pipe size. For 1100s, these numbers assume a 3/4-inch (20 mm) standard pipe size. The maximum working pressure of the unit's cooling water circuit is 200 psig (1380 kPa).</p>					

### 3.2.5.2 Connect a Supply Line and a Drain Line to Refrigeration Unit

Use the correct size pipe, see “Tools and Materials Needed” at the beginning of this section. For 550, 551, 552, 660, 661, 662, 670, and 672 the COOLING WATER connections have 1/2-inch female NPT fittings. For 1100, 1101, and 1102 the COOLING WATER connections have 3/4-inch female NPT fittings.

Connect the supply line to the port marked IN. Connect the drain line to the port marked OUT. The cooling water must flow in this direction to properly cool the unit. (See [Figure 3-12](#).)

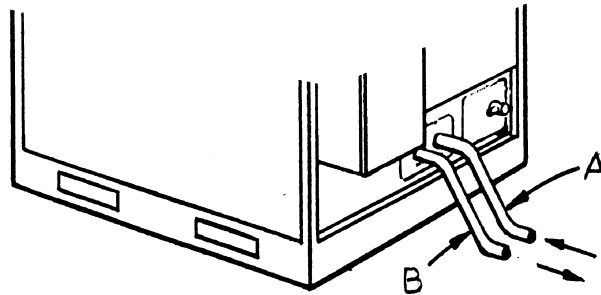
### 3.2.5.3 Estimate the Correct Flow Rate

Ensure that the minimum flow rate is achieved. (See [Table 3-4](#).)

To determine the correct flow rate, check both the liquid line temperature and the water outlet temperature when the unit is in COOL. (This will be checked in [section 3.4.4 Evaluate the Cryopump](#).)

**Optional:** Install pressure gauges to the cooling water supply and drain lines at the unit. Measure the cooling water pressures. Make sure pressure drops correspond to the flow rate needed for the cooling water temperature.

**NOTE:** *If using a rotameter type flow meter, its inherent restriction may reduce the actual flow rate attainable while it is attached.*



*Figure 3-12: Cooling Water Supply and Drain Lines Location*

- A. Supply line
- B. Drain line

### **3.2.6 How to Install the Refrigeration Unit to Meet ASHRAE Requirements**

The following information helps to comply with ANSI / ASHRAE 15-1994 “Safety Code for Mechanical Refrigeration”. ANSI is the acronym for the American National Standards Institute. ASHRAE is the acronym 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 back of the low voltage box.


**NOTE:** *Polycold 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 as a guide.*

- The cryopump is a “direct (refrigeration) system”. It is only intended to be installed above ground in an industrial environment.
- 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.
- Some models have a PRESSURE RELIEF OUTLET with a 3/4-inch female NPT fitting. This port allows the direct refrigerant escaping from a pressure relief valve to be moved to another location. See section 9.7.8 of ANSI / ASHRAE 15-1994 for location requirements. See [Table 3-5](#) for piping requirements.
- All models have this PRESSURE RELIEF OUTLET, except models PFC- 552, 672, and 1102 manufactured after March 2003. These models use a refrigerant that does not require pressure relief outlet plumbing.

*Table 3-5: Pressure Relief Piping Requirements to Comply with ANSI/ASHRAE 15-1994*

<b>Refrigeration Unit</b>	<b>Recommended Discharge Capacity<sup>1</sup> (lb air / min)</b>	<b>Maximum Length of 1/2 inch Diameter Pipe<sup>2</sup> (feet)</b>	<b>Maximum Length of 3/4 inch Diameter Pipe<sup>3</sup> (feet)</b>
550, 551,	4.75	113	458
660, 661, 670	4.75	113	458
1100, 1101	7.7	42	174
<p><b>NOTE:</b></p> <p><sup>1</sup> <i>The discharge capacity is recommended by Polycold based on actual relief requirements from the refrigeration system. 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 for 550s, 660s, and 670s; 30.3 pounds of air per minute for 1100s.</i></p> <p><sup>2</sup> <i>Maximum length of piping is based on the recommended discharge capacity using standard wall steel pipe and pressure relief devices set at 300 psig (2070 kPa).</i></p> <p><sup>3</sup> <i>Not required on models PFC- 552, 662, 672, and 1102.</i></p>			

### 3.3 How to Connect the Cryosurface to the Refrigeration Unit

	<b>⚠ Attention</b>
	Information in this section is for trained technicians familiar with installing Polycold Fast Cycle Water Vapor Cryopumps. If you are not trained on these procedures, contact the Polycold factory or your nearest service representative. Failure to properly install this product may result in refrigerant leaks or other problems that are not covered by our warranty.

#### 3.3.1 Connect the Refrigerant Line

**Tools and materials needed:**

- Step ladder
- Torque wrench (optional)

For Parker CPI UltraSeal couplings (standard fitting):

- Silver-plated stainless steel O-rings†
- 1 inch open end wrench
- 15/16 inch open end wrench


For Cajon VCR couplings (optional fitting):

- Silver-plated stainless steel gaskets or unplated nickel gaskets†
- 1-3/16 inch open end wrench
- 1-1/16 inch open end wrench

†Shipped with the unit.

**NOTE:** *This section assumes the purchase of a refrigerant line from Brooks Polycold Systems Inc. If not, see [section 3.6 Refrigerant Line Specification](#) before continuing.*

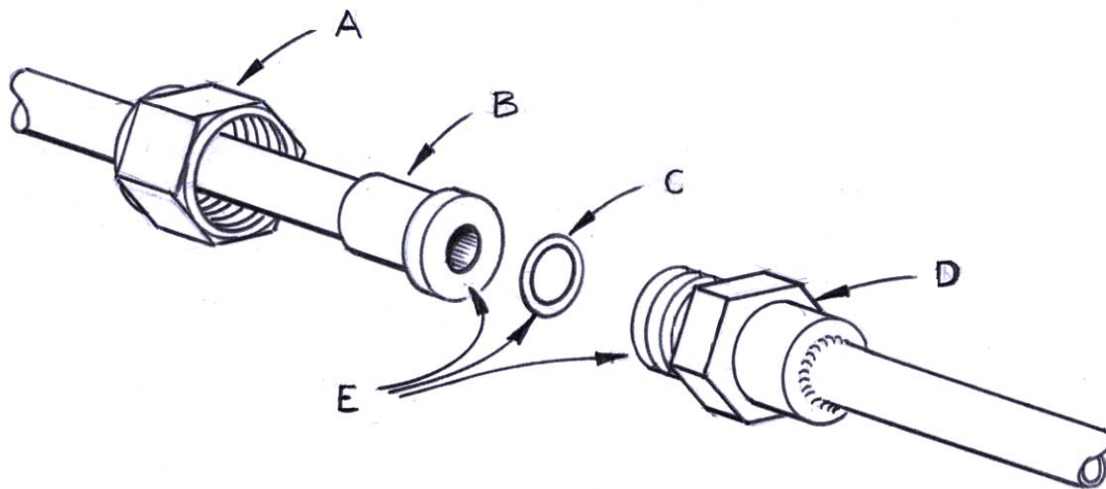
For PFC/PFC or PFC/P: This section assumes that both refrigerant circuits will be connected at the same time. At times, only one refrigerant circuit may be connected. Thus, when ready to connect the second refrigerant circuit, the refrigerant mixture must be drawn back into the unit. (This is because both refrigerant circuits are connected inside the unit.) See [Step 1](#) and [Step 2](#) in [section 8.2 How to Disconnect the Refrigerant Line](#) for instructions.

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b></p> <p>A common source for leaks is improper connection of the couplings. Internal leaks can result in damage to 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. It can also mask a leak during the leak-checking procedures. 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 CPI UltraSeal couplings. See <a href="#">Step 4</a> in <a href="#">section 8.2 How to Disconnect the Refrigerant Line</a> for instructions.</p>

### 3.3.1.1 Inspect the Couplings

Remove any dirt or foreign materials from the sealing surfaces. Make certain there are no scratches (particularly radial scratches) or dents in the sealing surfaces. (See [Figure 3-13](#) and [Figure 3-14](#).) Contact a Polycold sales representative or the Polycold service department if a sealing surface is damaged.

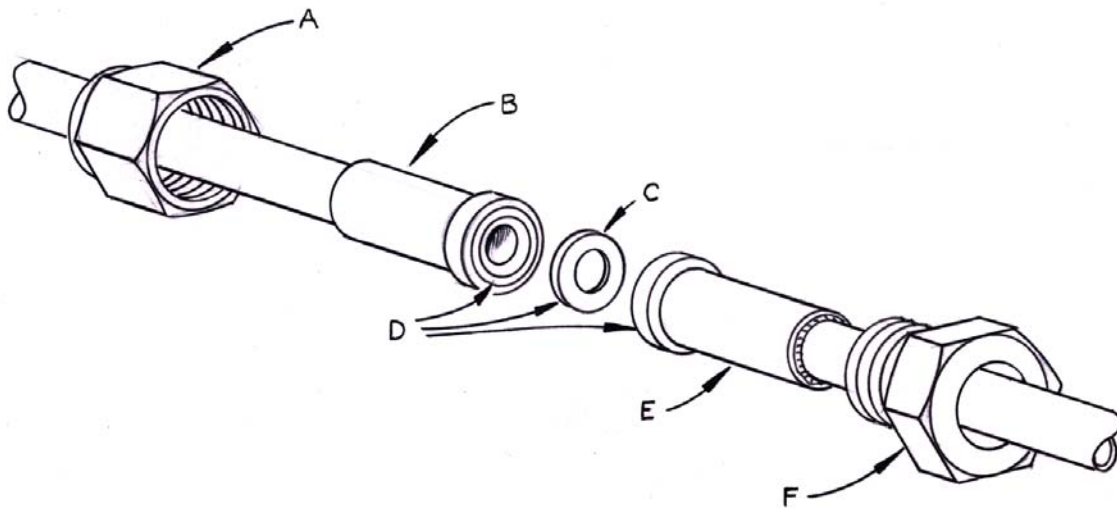
**NOTE:** *Parker CPI UltraSeal couplings are standard on a 550, 660, 670, or PFC/PFC-1100. Cajon VCR couplings are standard on a PFC-1100.*



*Figure 3-13: Parker CPI UltraSeal coupling (standard fitting)*

- A. Nut
- B. Gland
- C. Silver-plated stainless steel O-ring
- D. Male coupling
- E. Sealing surfaces





*Figure 3-14: Cajon VCR Coupling (optional fitting)*


- A. Female Nut
- B. Gland
- C. Silver-plated stainless steel gasket or unplated nickel gasket
- D. Sealing surfaces
- E. Gland
- F. Male nut

### 3.3.2 Position the Refrigerant Line

(See [Figure 3-15](#).)

**NOTE:** *The refrigerant line is made of soft refrigeration copper and has a minimum bend radius of 12 inches (300 mm). It is suitable for being bent once to fit the existing layout.*

1. Bend the refrigerant line so that the couplings are even when they get to the unit (For example, the feed and return lines should have the same bend radius.)

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> Do not repeatedly bend the refrigerant line. Do not twist the refrigerant line. Do not bend the refrigerant line within 6 inches (150 mm) of the couplings. Improper handling can result in damage to the line or equipment. Handle the refrigerant line carefully.

2. It may be helpful to connect the refrigerant line to the cryosurface first. If so, tighten the couplings only finger-tight until finishing the positioning of the refrigerant line. (See [section 3.2.1.2 Check Unit's Balance Pressure](#).)

**NOTE:** *For PFC/PFC or PFC/P: The upper set of couplings is for the first refrigerant circuit. The lower set of couplings is for the second refrigerant circuit.*

### 3.3.2.1 Attach the Refrigerant Line to the Cryosurface

For Parker CPI UltraSeal couplings (standard fitting): Insert an O-ring into the male coupling's groove. Place the gland against the O-ring and male coupling. Make certain the O-ring does not drop out of the groove. Slide the nut forward and finger-tighten the coupling. While keeping the male coupling stationary with the 15/16-inch wrench, tighten the nut with the 1-inch wrench. Each wrench must have a length of at least 12 inches (300 mm). Tighten until resistance increases sharply and no further tightening occurs. During the tightening procedure, the metal o-ring will be crushed into the o-ring groove. Tighten each coupling to 40-60 foot-pounds (54-80 Nm).

For Cajon VCR couplings (optional fitting): Place a gasket into the female nut. Assemble the components and finger-tighten the coupling. Use both wrenches to tighten each coupling to 40-60 foot-pounds (54-80 Nm).

**NOTE:** *These 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.*

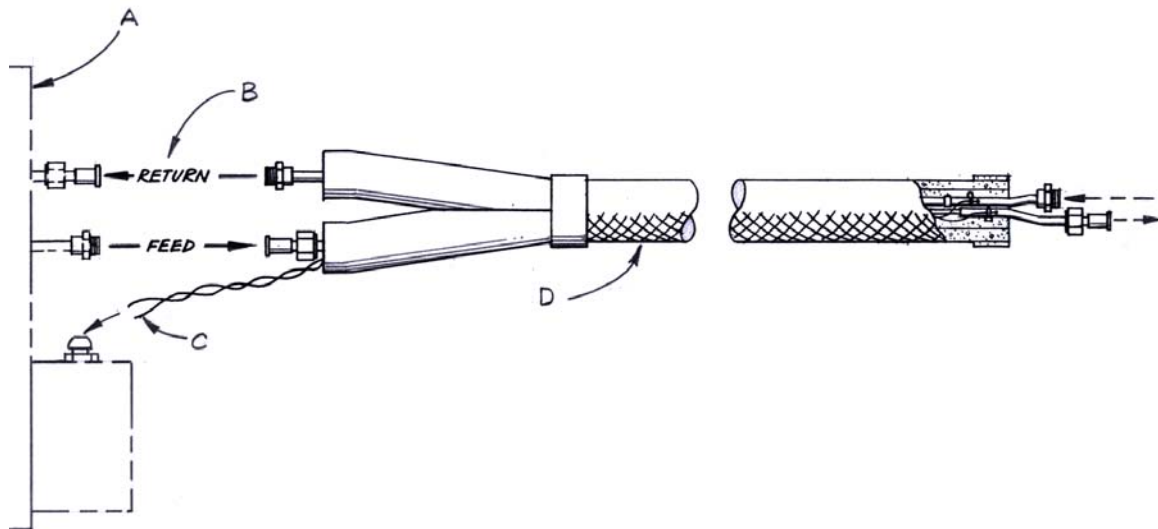


Figure 3-15: Refrigerant line connection

- A. Refrigeration unit (top view)
- B. Direction of refrigerant flow
- C. Thermocouple wires (2)
- D. Refrigerant line

### 3.3.2.2 Verify that the Isolation Valves are Closed, and Remove the Blank-off Fittings

1. Remove the top panel of the unit. The isolation valves are in the box closest to the couplings. Loosen the screws to open the valve box lid. Locate the red hand valves labeled COLD GAS FEED, COMMON RETURN, and HOT GAS FEED. Turn each hand valve clockwise to make certain it is closed. (See [Figure 3-16](#).)
2. Slowly remove the blank-off fittings from the couplings on the unit. A brief hiss may be heard. However, if refrigerant continues to escape from the unit, quickly reinstall the blank-off fittings and make certain the isolation valves are closed.
3. Keep the blank-off fittings with the unit. They will need to be reinstalled after the refrigerant line is disconnected.

**NOTE:** *The isolation valves are used to hold the refrigerant mixture in the unit during shipping or whenever the cryosurface or refrigerant line is disconnected. These valves cannot be operated when they are at cryogenic temperatures.*

### 3.3.2.3 Attach the Refrigerant Line to the Unit

Remove the rubber O-rings from the couplings. Assemble the couplings following the instructions in [section 3.2.1.2 Check Unit's Balance Pressure](#) above.

### 3.3.2.4 Support the Refrigerant Line

Support the refrigerant line at midlength. If a longer refrigerant line is installed, support it every 3 feet (1 m). Make sure the insulation is not crushed with the support. Use supports that are at least 4 inches (100 mm) wide such as tape, hangers, clamps, or cradles.

**NOTE:** *The brand or type of tape, hangers, clamps, or cradles depends on what is available and acceptable at the installation site. Do not use supports that make direct contact with the exposed tubes or couplings.*

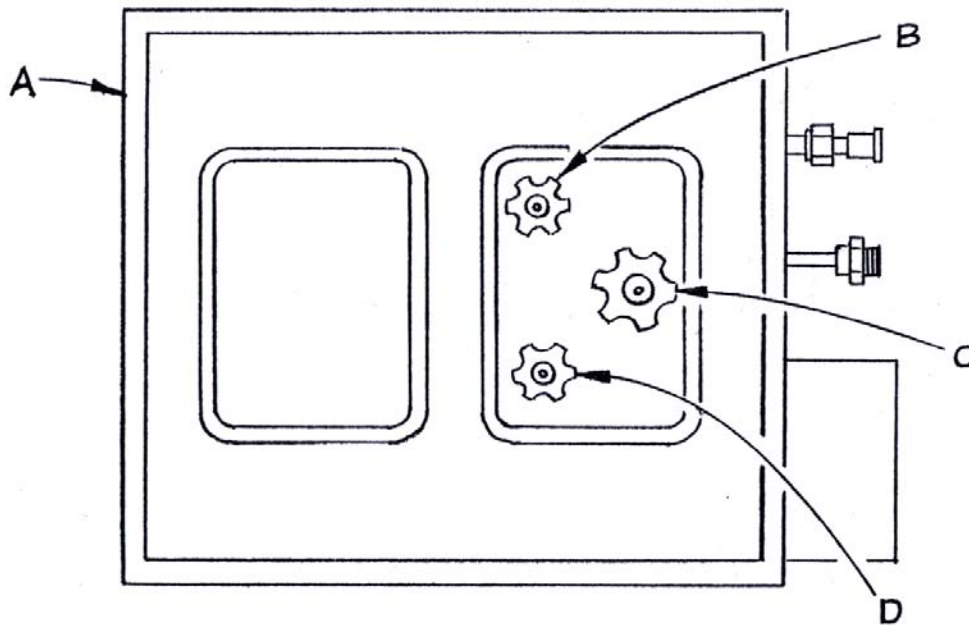


Figure 3-16: Isolation Valves Location

**NOTE:** Two valve boxes shown in the previous figure. Some units have a single box.

- A. Refrigeration unit (top view with panel removed)
- B. Cold gas feed isolation valve
- C. Common return isolation valve
- D. Hot gas feed isolation valve

### 3.3.3 Check the Refrigerant Line & Cryosurface for Leaks

#### Tools and materials needed:

- Cylinder of refrigerant gas R-22 or R-134a (mandatory for installations in Europe)
- Cylinder of dry nitrogen gas (dry referring to a 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
- 5/8 inch end wrench
- 15/16 inch end wrench
- 1/4 inch ratchet valve wrench

**NOTE:** *If these materials are not obtainable, contact the Polycold service department for an alternate method to check for leaks.*

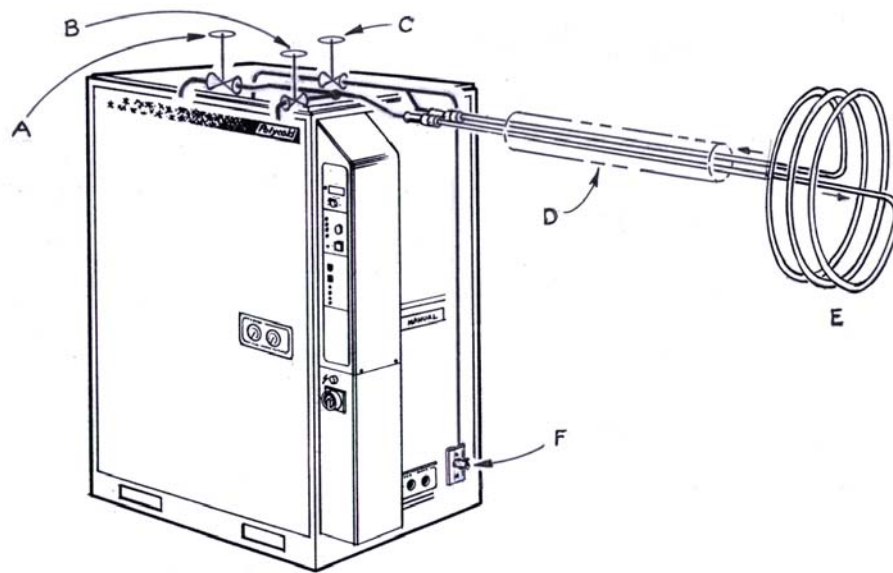
### 3.3.3.1 Pressurize the Refrigerant Line and Cryosurface

(See [Figure 3-17](#) and [Figure 3-18](#))

1. Make certain the manifold's valves are closed. Connect the manifold's suction (low pressure) hose to the EVACUATION VALVE on the unit. Midseat the EVACUATION VALVE to open it. (Midseat the EVACUATION VALVE by turning the valve stem three complete rotations in the counter-clockwise direction.)
2. Connect the refrigerant cylinder to the manifold's center port. Pressurize the refrigerant line and cryosurface to 10-20 psig (70-140 kPa). Once pressurized, close the valve and disconnect refrigerant cylinder.
3. Connect the nitrogen cylinder to the manifold's center port. Increase the pressure in the refrigerant line and cryosurface to 150 psig (1030 kPa).

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> Do not pressurize the refrigerant line and cryosurface above 335 psig (2310 kPa). The pressure relief valve may leak if it is activated. Improper pressurization can result in damage to the line or equipment. Make sure the procedure in this section, <a href="#">section 3.3.3.1 Pressurize the Refrigerant Line and Cryosurface</a>, is followed carefully.</p>

**NOTE:** *For PFC/PFC or PFC/P: [section 3.3.3.1 Pressurize the Refrigerant Line and Cryosurface](#) will pressurize both refrigerant circuits.*



*Figure 3-17: Evacuation Valve, Refrigerant Line & Cryosurface Relationship*

(Schematic only—actual valve locations not shown)

- A. Cold gas feed isolation valve (closed)
- B. Hot gas feed isolation valve (closed)
- C. Common return isolation valve (closed)
- D. Refrigerant line
- E. Cryosurface
- F. Evacuation valve

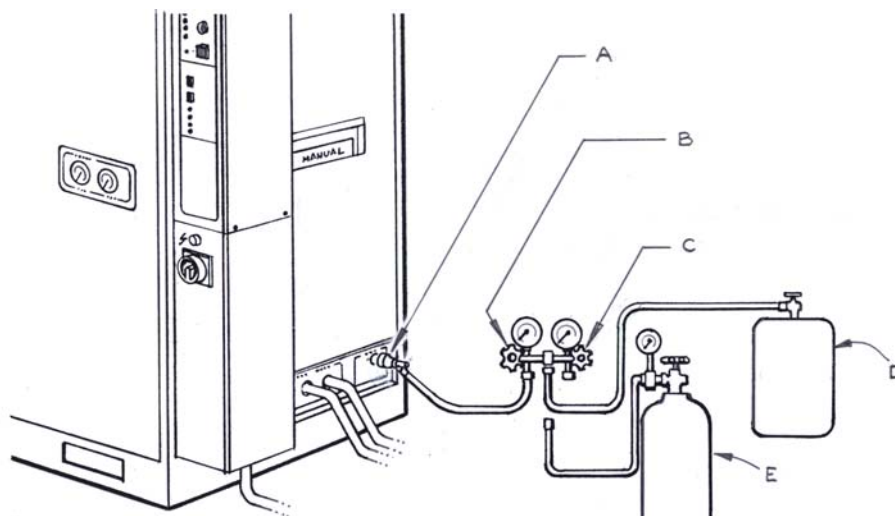


Figure 3-18: Refrigerant Line & Cryosurface—Leak-check Charging Set-up

- A. Evacuation valve; pressure relief outlet (not shown)
- B. Manifold suction valve
- C. Manifold discharge valve (closed)
- D. Cylinder of R-22 or R-134a
- E. Cylinder of dry nitrogen gas

### 3.3.3.2 Check for Refrigerant Leaks

1. With the halogen leak detector, carefully check each connection that was made. This includes the Parker CPI UltraSeal or Cajon VCR couplings, the EVACUATION VALVE, and any brazed joint that may have been made. The Parker and Cajon couplings have two small access holes on each nut to help find leaks. With a finger cover one hole and put the sensor at the other hole. (See [Figure 3-19](#).)
2. If no leaks are found, check the pressure on the manifold to verify that it is still at 150 psig (1030 kPa). If the pressure has not changed, go on to [section 3.3.4 Evacuate the Refrigerant Line and Cryosurface](#).

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



### 3.3.3.3 Pinpoint and Repair Any Leaks

If a leak is found with the halogen leak detector, pinpoint its location with leak detector soap. A bubble that forms in about 2 minutes represents a leak equivalent to 1.5 ounces (43 grams) per year.

**NOTE:** *Note: Avoid making bubbles when applying the leak detector soap.*

If a leak is found on the Parker CPI UltraSeal or Cajon VCR couplings

- With a finger cover the lower access hole 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.
- If the coupling still leaks, it must be reassembled. Open the manifold's suction valve to release the gas in the refrigerant line and cryosurface. Then disassemble the coupling following the instructions in [Step 4 in section 8.2 How to Disconnect the Refrigerant Line](#). Make certain the coupling's sealing surfaces are not scratched or damaged. Re-assemble the coupling following the instructions in [section 3.3.1 Connect the Refrigerant Line](#).

If a leak is found on a brazed joint

- Apply leak detector soap to the joint. Use an inspection mirror to view all sides of the joint. Observe the joint for at least 2 minutes. If the joint has a leak, it must be repaired. Open the manifold's suction valve to release the gas in the refrigerant line and cryosurface. Repair the leak following the instructions in [section 3.7 Brazing Specification](#).

If a leak is found on the EVACUATION VALVE

- Apply leak detector soap to the packing. Observe the packing for at least 2 minutes. Tighten the valve packing if it is the source of the leak. If the packing is not the source of the leak, the valve must be replaced.

### 3.3.3.4 Confirm that the Refrigerant Line and Cryosurface are Leak-free

Use the halogen leak detector to check any repair that was made. (See [section 3.3.3.1 Pressurize the Refrigerant Line and Cryosurface](#) and [section 3.3.3.2 Check for Refrigerant Leaks](#).) Repeat this procedure until all leaks have been repaired.

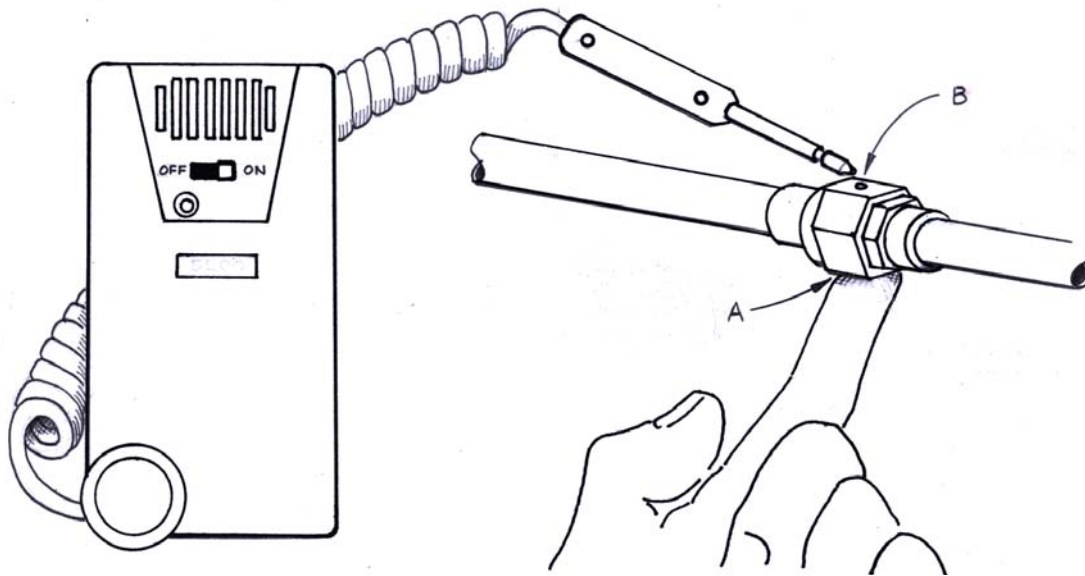



Figure 3-19: Couplings—Leak-checking Method

- A. Cover one hole with finger
- B. Put sensor at other hole

### 3.3.4 Evacuate the Refrigerant Line and Cryosurface

#### Tools and materials needed:

- 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
- Cylinder of dry nitrogen gas with a regulator
- Service manifold gauge set with hoses (manifold)
- 1/4 inch ratchet valve wrench
- 5/8 inch end wrench
- 15/16 inch end wrench

	<b>⚠ WARNING</b>
	<b>GENERAL HAZARD</b> Failure to have a qualified refrigeration technician do all refrigeration work could result in death or serious injury. Do not attempt evacuation. Contact a qualified refrigeration technician.

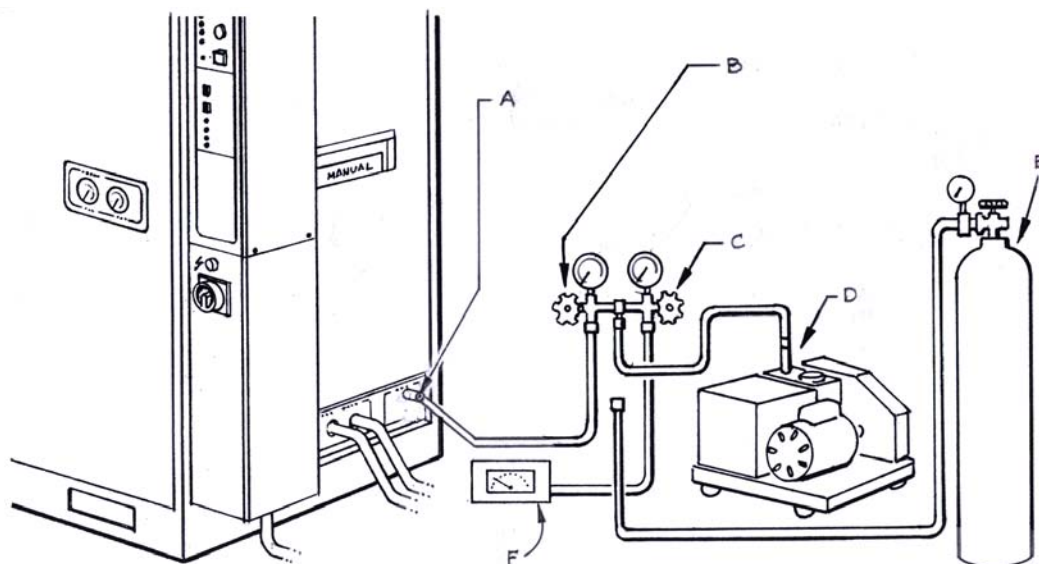
### 3.3.4.1 Evacuate the Refrigerant Line and Cryosurface

1. Evacuate the refrigerant line and cryosurface to 0.1 torr (13 Pa). (See [Figure 3-20](#).)
2. Allow the vacuum pump to continue pumping for 30 minutes.
3. Close the manifold's suction valve and turn off the vacuum pump.

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

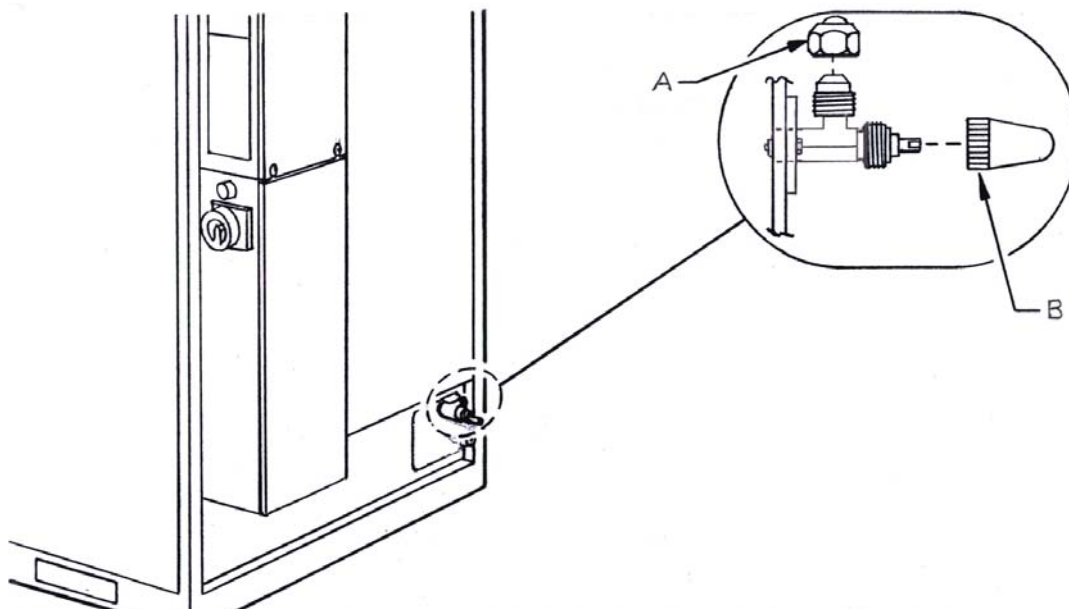
### 3.3.4.2 Evacuate the Refrigerant Line and Cryosurface a Second Time

1. Connect the nitrogen cylinder to the manifold's center hose. (See [Figure 3-20](#).) Pressurize the refrigerant line and cryosurface to 10-20 psig (70-140 kPa).
2. Evacuate the refrigerant line and cryosurface to 0.1 torr (13 Pa). Allow the vacuum pump to continue pumping for 30 minutes. Close the unit's EVACUATION VALVE while the vacuum pump is still pumping. Turn off the vacuum pump. Slowly remove the hose from the EVACUATION VALVE.
3. Reinstall the protective cap and the flare nut with bonnet onto the EVACUATION VALVE. (See [Figure 3-21](#)).



*Figure 3-20: Refrigerant Line & Cryosurface—Evacuation Set-up*

- A. Evacuation valve
- B. Manifold suction valve
- C. Manifold discharge valve
- D. Vacuum pump
- E. Cylinder of dry nitrogen gas
- F. Vacuum gauge



*Figure 3-21: Evacuation Valve Closure*

- A. Bonnet with flare nut
- B. Cap

### 3.3.5 Connect the COIL IN & COIL OUT Thermocouples


#### Tools and materials needed:

- Phillips screwdriver
- small straight blade screwdriver
- wire stripper, a thermal wire stripper is preferred

#### For PFC/PFC or PFC/P:

- four small labels or tape
- Armaflex tape, about 1x2 inches (25x50 mm)

If someone other than Polycold made the refrigerant line on this system, make sure that the thermocouples were properly installed. Please refer to [section 3.6 Refrigerant Line Specification](#).

	<b>⚠ WARNING</b>
	<b>ELECTRICAL HAZARD</b> Contact could cause electric shock and result in death or serious injury. Make certain the ON/OFF switch and the power disconnect switch are in the OFF position.

### 3.3.5.1 Remove the Low Voltage Box Panel

Loosen the two lower screws on the side of the low voltage box. Slide the panel straight up to remove it. (See [Figure 3-22](#).)

### 3.3.5.2 Put the COIL IN and COIL OUT Thermocouples in the Low Voltage Box

1. Locate the thermocouple wires labeled COIL IN and COIL OUT on the refrigerant line. Locate the EXTERNAL TC fitting on the back of the low voltage box.
2. Unscrew the cap and remove the rubber seal from the EXTERNAL TC fitting.
3. Slide the cap over the thermocouple wires.
4. Slip the thermocouple wires into the slit in the rubber seal. Insert the rubber seal into the fitting and screw on the cap.

**NOTE:** For PFC/PFC or PFC/P

- Fold a small piece of tape around each thermocouple wire next to its label.
  - Label the tape “#1” on the COIL IN and COIL OUT thermocouple wires coming from the first refrigerant circuit.
5. Label the tape “#2” on the COIL IN and COIL OUT thermocouple wires coming from the second refrigerant circuit.
  6. Instead of using the rubber seal, wrap the Armaflex tape around the thermocouple wires so that the wires fit tightly in the EXTERNAL TC fitting.

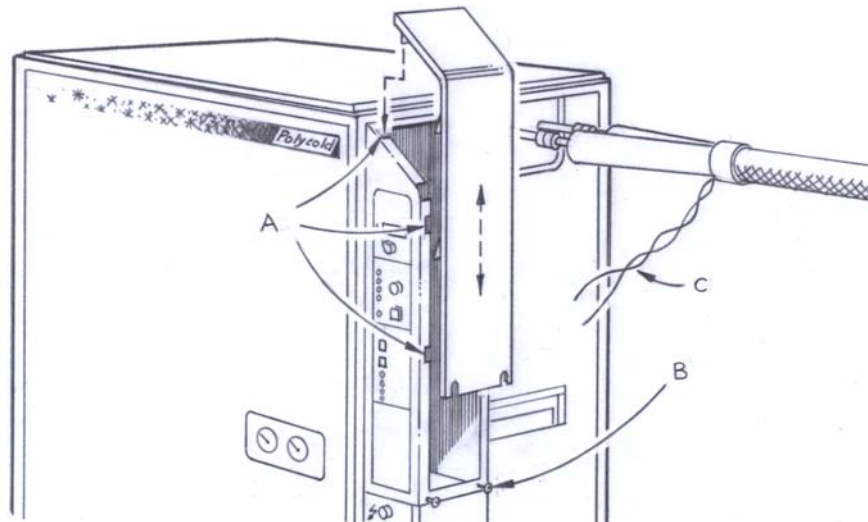



Figure 3-22: Low Voltage Box Panel Removal

- A. Notches
- B. Loosen screws
- C. Thermocouple wires

### 3.3.5.3 Connect the Thermocouple Wires to the Terminal Boards

**NOTE:** The terminal blocks are located on a printed circuit board directly below the temperature meter.

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

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b>                  Make sure not to nick the conductor. The wire may break with future vibration and can result in damage to the equipment.                  Do not nick the conductor.</p>

2. Attach the thermocouple wires to their designated locations. The blue-insulated copper wire must be attached to the positive (+) terminal. The red-insulated constantan wire must be attached to the negative (-) terminal. (See [Figure 3-23](#).)
  - Position #3: COIL IN
  - Position #4: COIL OUT

**For PFC/PFC or PFC/P:**

- Position #3: #1 COIL IN
- Position #4: #1 COIL OUT
- Position #5: #2 COIL IN
- Position #6: #2 COIL OUT

#### **3.3.5.4 Reinstall the Low Voltage Box Panel**

1. Slide the panel straight down onto the low voltage box so that the two side tabs go into their notches.
2. Push the top of the panel towards the unit and at the same time push down so that the top tab goes into its notch.
3. Tighten the two screws.

**NOTE:** *The temperature from a single thermocouple in [Figure 3-20](#) can be displayed at a remote location through the remote connector. To accomplish this see [section 3.8.2 Additional Instructions for Remote Temperature Indication](#).*



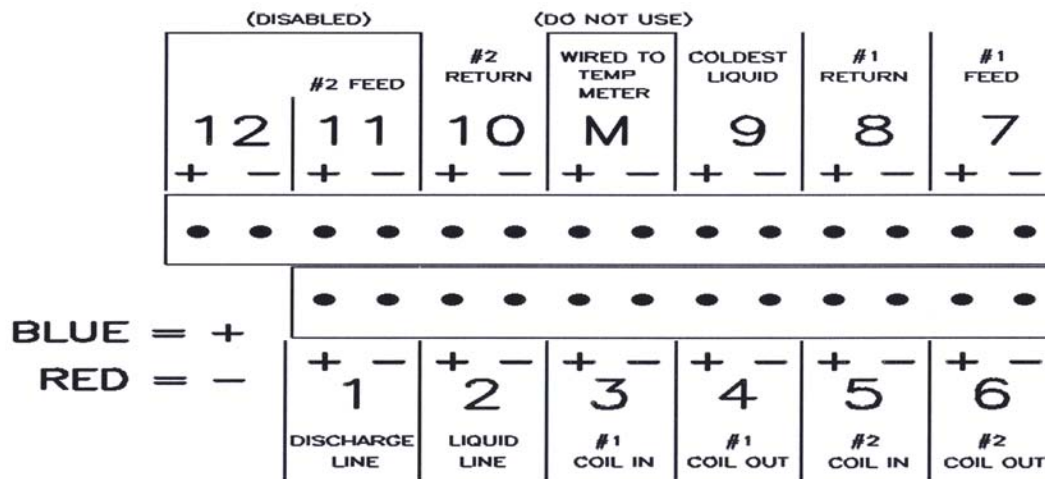



Figure 3-23: Thermocouple (TC) positions identification

1. TC #1 = DISCHARGE LINE
2. TC #2 = LIQUID LINE
3. TC #3 = #1 COIL IN
4. TC #4 = #1 COIL OUT
5. TC #5 = #2 COIL IN
6. TC #6 = #2 COIL OUT
7. TC #7 = #1 FEED
8. TC #8 = #1 RETURN
9. TC #9 = COLDEST LIQUID
- M. Wired to temperature meter—do not use.
10. TC #10 = #2 RETURN
11. #2 FEED—disabled
12. Disabled

## 3.4 How to Prepare the Cryopump for Operation

### 3.4.1 Open the Isolation Valves

	<b>⚠ CAUTION</b>
	<p>GENERAL HAZARD Do not open the isolation valves doing so can result in damage to the equipment. Make sure to follow the instructions in <a href="#">section 3.3.3 Check the Refrigerant Line &amp; Cryosurface for Leaks</a> and <a href="#">section 3.3.4 Evacuate the Refrigerant Line and Cryosurface</a> before opening the isolation valves.</p>

#### 3.4.1.1 Open the Isolation Valves

1. Locate the red hand valves underneath the top panel of the unit. They are labeled COLD GAS FEED, COMMON RETURN, and HOT GAS FEED. (See [Figure 3-24](#).)
2. Turn each hand valve counter-clockwise until it is all the way open.
3. Turn each hand valve back (clockwise) 1/4 turn.

#### 3.4.1.2 Record the Balance Pressure of the Cryopump

1. Wait 10 minutes for the pressure to equalize in the system. The pressure may drop 5-10 psig (35-70 kPa) as the refrigerant mixture enters the refrigerant line and cryosurface.
2. Record the pressure of the discharge gauge below. Also transfer this pressure to the "Inspection Log" in [section 5 Periodic Inspection and Maintenance](#). This measurement will be used as a baseline reference for future inspections.

Cryopump's balance pressure: \_\_\_\_\_ psig

#### 3.4.1.3 Reinstall the Valve Box Lid and the Top Panel

Make certain the valve box gasket is in its groove. Screw the valve box lid completely shut. The gasket should form a seal to keep out water vapor.

### 3.4.1.4 Reinstall the Top Panel

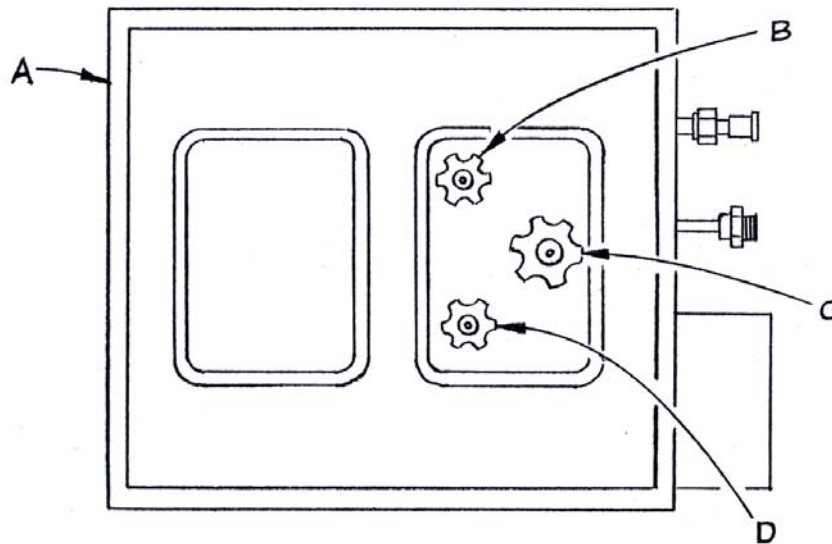


Figure 3-24: Location of Isolation Valves

**NOTE:** Two valve boxes are shown. Some units have a single valve box.

- A. Refrigeration unit (top view with panel removed)
- B. Cold gas feed isolation valve
- C. Common return isolation valve
- D. Hot gas feed isolation valve

### 3.4.2 Cycle the Cryopump & Check for Refrigerant Leaks

**Tools and materials needed:**

- electronic halogen leak detector
- clean rag

### **3.4.2.1 Cycle the Cryopump**

1. Start the cooling water. Verify the power disconnect switch is in the ON position. Select LOCAL and STANDBY. Turn on the unit.
2. Wait at least 30 minutes for the “Polycold stack” (heat exchangers and other components that are encased in insulating foam) to reach operating temperature.
3. Evacuate the location of your cryosurface to at least 0.01 torr (1.33 Pa).
4. Select COOL and wait 5-10 minutes (10 minutes if the refrigerant line is longer than 20 feet (6 m)).
5. Select DEFROST. The unit will automatically go into STANDBY when DEFROST is complete. Remain in STANDBY for 15 minutes.
6. Repeat this COOL, DEFROST, and STANDBY cycle two or three times.

**NOTE:** *For PFC/PFC: Select LOCAL and STANDBY for both refrigerant circuits. Cycle both refrigerant circuits at the same time.*


**NOTE:** *For PFC/P: Select LOCAL and STANDBY for both refrigerant circuits. Cycle the first refrigerant circuit only.*

7. For the second refrigerant circuit, select COOL and wait 10 minutes.
8. Then select STANDBY and wait 10 minutes.
9. Turn off the unit, and dry the exposed tubes of the refrigerant line with a clean rag.

### **3.4.2.2 Check for Refrigerant Leaks**

With the halogen leak detector carefully check each connection that was made. This includes the Parker CPI UltraSeal or Cajon VCR couplings, the EVACUATION VALVE, and any brazed joint that was made.

Optionally, check the refrigeration unit’s compressor compartment. Check the compressor’s suction and discharge valves, and the valves on the tanks.

	<b>⚠ CAUTION</b>
	<b>EXTREME TEMPERATURES EXIST</b> The compressor's heads and discharge line may be hot; contact with the hot surface may result in minor or moderate injury. Do not touch the compressor's heads or discharge line.

### 3.4.2.3 Pinpoint and Repair Any Leaks

To pinpoint the location of a leak, follow the instructions in [section 3.3.3 Check the Refrigerant Line & Cryosurface for Leaks](#). If reassembly of a coupling is needed (or to fix a brazed joint), the refrigerant mixture must first be drawn back into the unit. To do this, follow the [Step 1](#) and [Step 2](#) in [section 8.2 How to Disconnect the Refrigerant Line](#).

With the leak detector, check the repairs following the instructions in [section 3.3.3 Check the Refrigerant Line & Cryosurface for Leaks](#).



### 3.4.3 Insulate the Exposed Tubes and Couplings

#### Tools and materials needed:

- tubes of closed-cell pipe insulation †
- sheet of closed-cell pipe insulation †
- Armaflex tape †
- Armstrong 520 adhesive †
- large pair of scissors or knife

† Shipped with the unit if purchased with a refrigerant line.

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

 	<b>WARNING</b>
	<b>FLAMMABLE MATERIAL (1101, 1100, 670, 661, 660, 551, and 550 ONLY) AND CHEMICAL HAZARD</b> Fumes are a source of ignition and suffocation. Make sure there is adequate ventilation and no ignition source when using the Armstrong 520 adhesive. Failure to do so could result in death or serious injury. Read the label on the container.

### 3.4.3.1 Insulate the Exposed Tubes between the Unit and the Refrigerant Line Insulation.

(See Cross-section A-A in [Figure 3-25](#).)

1. Cut the tubes of insulation so that they will fit snugly between the 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. Cut the sheet of insulation the same length as the tubes of insulation. Wrap the sheet once around the tubes of insulation, 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 sheet with tape. Secure the sheet to the refrigerant line's insulation and to the unit's panel. Flare the tape so that it connects the sheet to the panel.

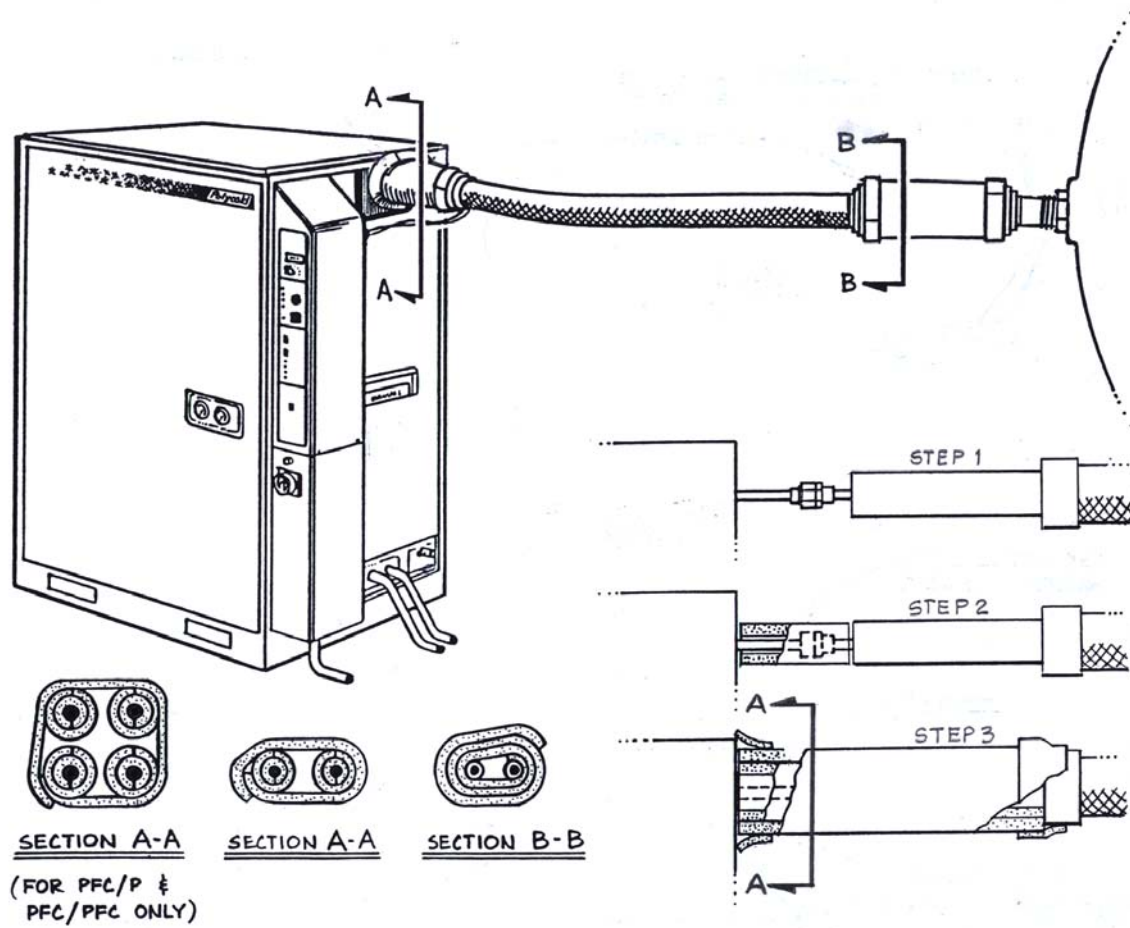



Figure 3-25: Insulating Exposed Tubes and Couplings Method

### 3.4.3.2 Insulate the Exposed Tubes between the Refrigerant Line Insulation and the Feed-through.

(See Cross-section B-B in [Figure 3-25](#).)

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> Armaflex tape or Armstrong 520 adhesive in the threads of the feed-through is extremely difficult to remove. It makes the feed-through nut bind when unscrewed and may result in damage to the equipment. Do not put Armaflex tape or Armstrong 520 adhesive into the threads on the feed-through.</p>

1. Fit the sheet of insulation between the pre-insulated refrigerant line and the feed-through. 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.
2. Seal both ends of the sheet with tape. Secure the sheet to the refrigerant line's insulation 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.


### 3.4.4 Evaluate the Cryopump


#### 3.4.4.1 Evaluate the Cryopump in STANDBY

1. Start the cooling water. Make sure the minimum flow rate for the water's temperature is adequate; see [section 3.2.5 Connect the Cooling Water](#).
2. Select LOCAL and STANDBY.
3. Turn on the unit and wait 30 minutes for the stack to cool down.

**NOTE:** *For PFC/PFC or PFC/P: Select LOCAL and STANDBY for both refrigerant circuits.*



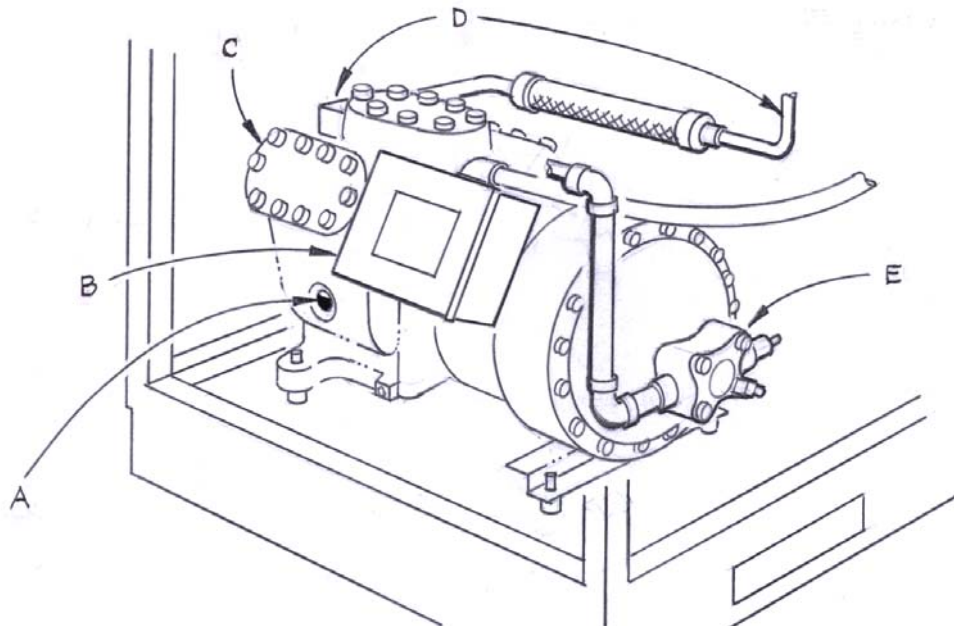
	<b>⚠ CAUTION</b>
	<p><b>EXTREME TEMPERATURES EXIST</b> Do not reach inside the compressor compartment when the unit is operating. The compressor's heads and discharge line may be hot; contact with the hot surface may result in minor or moderate injury. Do not touch the compressor's heads or discharge line. See <a href="#">Figure 3-26</a>.</p>

	<b>⚠ DANGER</b>
	<p><b>ELECTRICAL</b> Do not reach inside the compressor compartment when the unit is operating. The compressor electrical box contains hazardous voltages. Failure to have a qualified electrician do all electrical work could result in death or serious injury. Do not reach inside the unit. A qualified electrician must do all electrical work.</p>

4. Listen to the compressor. It should run continuously without cycling or turning off.
5. Remove the unit's left panel. Locate the oil sightglass on the compressor. ([Figure 3-26](#).) It should be 1/8 to 1/2 full (1/8 full is preferred) while the compressor is running for at least 60 minutes.
6. Record the compressor oil level while the compressor is running for at least 60 minutes:
7. Check the direction of the cooling water's flow. The drain line (OUT) should be warmer than the supply line (IN). (See [Figure 3-27](#)). If not, turn off the unit and connect the supply and drain lines to the proper ports.
8. Record the following pressures and temperatures:

*Table 3-6: Pressures and Temperatures in Standby*

	Acceptable Range For			Your Measurements For		
	550 660 670 1100	551 661 1101	552 662 672 1102	550 660 670 1100	551 661 1101	552 662 672 1102
<b>SUCTION Pressure</b>	3-12 psig (.2-.8 bar)	3-25 psig (.2-1.7 bar)	10-25 psig (.7-1.7 bar)	___ psig 1 ___ bar 1	___ psig 1 ___ bar 1	___ psig 1 ___ bar 1
<b>DISCHARGE Pressure</b>	90-160 psig (6.2-11 bar)	90-235 psig (6.2-16.2 bar)	150-230 psig (10.3-15.8 bar)	___ psig 1 ___ bar 1	___ psig 1 ___ bar 1	___ psig 1 ___ bar 1
<b>DISCHARGE LINE (TC #1)</b>	80-120°C	80-120°C	80-120°C	___°C 1	___°C 1	___°C 1
<b>LIQUIDLINE (TC #2)</b>	13-32°C	13-32°C	13-32°C	___°C 1	___°C 1	___°C 1



*Figure 3-26: Compressor parts location*

- A. Oil sightglass
- B. Electrical box—high voltage
- C. Heads—hot
- D. Discharge valve and line—hot
- E. Suction valve—may be cold

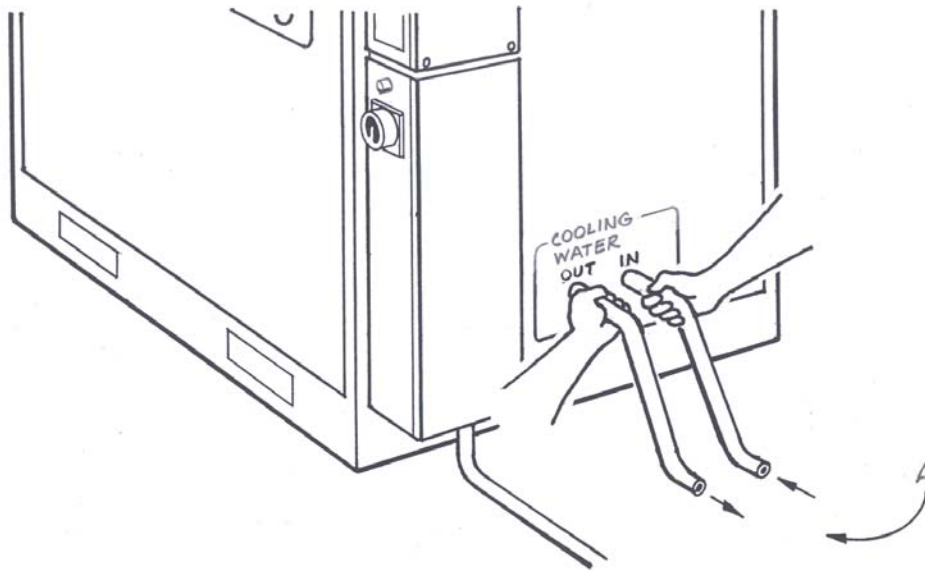


Figure 3-27: Cooling water flow direction check

A. The water coming out should be warmer than the water going in

#### 3.4.4.2 Evaluate the Cryopump in COOL

1. Evacuate the location of the cryosurface to at least 0.01 torr (1.33 Pa).
2. Select COOL and wait 30 minutes.

**NOTE:** For PFC/PFC or PFC/P: Select COOL for both refrigerant circuits.

3. Check the outlet temperature of the cooling water. The drain line (OUT) should be 72-95°F (22-35°C). If not, adjust the water flow to attain a water outlet temperature in this range.
4. If there is any ice or water on the refrigerant line, turn off the unit and remove the ice or water. Apply another layer of insulation following the instructions in [section 3.4.3 Insulate the Exposed Tubes and Couplings](#). Re-evaluate the cryopump starting at the beginning of [Step 1](#).
5. Record the following pressures and temperatures:

*Table 3-7: Pressures and Temperatures in Cool*

	Acceptable Range For			Your Measurements For		
	550 660 670 1100	551 661 1101	552 662 672 1102	550 660 670 1100	551 661 1101	552 662 672 1102
<b>SUCTION Pressure</b>	4-30 psig (2.8-20.6 bar)	4-45 psig (2.8-31 bar)	10-50 psig (6.8-34 bar)	_____ psig _____ bar	_____ psig _____ bar	_____ psig _____ bar
<b>DISCHARGE Pressure</b>	100-380 psig (6.9-26.2 bar)	100-380 psig (6.9-26.2 bar)	150-390 psig (10.34-26.9 bar)	_____ psig _____ bar	_____ psig _____ bar	_____ psig _____ bar
<b>DISCHARGE LINE (TC #1)</b>	80-125°C	80-125°C	90-125°C	_____°C	_____°C	_____°C
<b>LIQUIDLINE (TC #2)</b>	13-32°C	13-32°C	13-32°C	_____°C	_____°C	_____°C
<b>COIL IN (TC #3)</b>	See <a href="#">Table 3-8</a>	See <a href="#">Table 3-8</a>	See <a href="#">Table 3-8</a>	_____°C <sub>1</sub>	_____°C <sub>1</sub>	_____°C <sub>1</sub>
<b>COIL IN (TC #4)</b>	See <a href="#">Table 3-8</a>	See <a href="#">Table 3-8</a>	See <a href="#">Table 3-8</a>	_____°C <sub>1</sub>	_____°C <sub>1</sub>	_____°C <sub>1</sub>

**NOTE:** For PFC/PFC or PFC/P: Also record the following temperatures.

#2 COIL IN (TC #5):	See <a href="#">Table 3-8</a>	_____°C <sub>1</sub>
#2 COIL OUT (TC#6):	See <a href="#">Table 3-8</a>	_____°C <sub>1</sub>

*Table 3-8: Cryosurface Temperature Needed for Desired Water Vapor Partial Pressure*

Desired Water Vapor Partial Pressure			Average Cryosurface Temperature Needed †
torr	Pascal	mbar	°C
$5 \times 10^0$	$7 \times 10^2$	$7 \times 10^0$	-25.4
$2 \times 10^0$	$3 \times 10^2$	$3 \times 10^0$	-34.4
$1 \times 10^0$	$1 \times 10^2$	$1 \times 10^0$	-40.8
$5 \times 10^{-1}$	$7 \times 10^1$	$7 \times 10^{-1}$	-46.8
$2 \times 10^{-1}$	$3 \times 10^1$	$3 \times 10^{-1}$	-54.3
$1 \times 10^{-1}$	$1 \times 10^1$	$1 \times 10^{-1}$	-59.7
$5 \times 10^{-2}$	$7 \times 10^0$	$7 \times 10^{-2}$	-64.8
$2 \times 10^{-2}$	$3 \times 10^0$	$3 \times 10^{-2}$	-71.2
$1 \times 10^{-2}$	$1 \times 10^0$	$1 \times 10^{-2}$	-75.8
$5 \times 10^{-3}$	$7 \times 10^{-1}$	$7 \times 10^{-3}$	-80.1
$2 \times 10^{-3}$	$3 \times 10^{-1}$	$3 \times 10^{-3}$	-85.6
$1 \times 10^{-3}$	$1 \times 10^{-1}$	$1 \times 10^{-3}$	-89.6
$5 \times 10^{-4}$	$7 \times 10^{-2}$	$7 \times 10^{-4}$	-93.4
$2 \times 10^{-4}$	$3 \times 10^{-2}$	$3 \times 10^{-4}$	-98.2
$1 \times 10^{-4}$	$1 \times 10^{-2}$	$1 \times 10^{-4}$	-101.6
$5 \times 10^{-5}$	$7 \times 10^{-3}$	$7 \times 10^{-5}$	-104.9
$2 \times 10^{-5}$	$3 \times 10^{-3}$	$3 \times 10^{-5}$	-109.1
$1 \times 10^{-5}$	$1 \times 10^{-3}$	$1 \times 10^{-5}$	-112.2
$5 \times 10^{-6}$	$7 \times 10^{-4}$	$7 \times 10^{-6}$	-115.1
$2 \times 10^{-6}$	$3 \times 10^{-4}$	$3 \times 10^{-6}$	-118.1
$1 \times 10^{-6}$	$1 \times 10^{-4}$	$1 \times 10^{-6}$	-121.5

Table 3-8: Cryosurface Temperature Needed for Desired Water Vapor Partial Pressure

Desired Water Vapor Partial Pressure			Average Cryosurface Temperature Needed †
torr	Pascal	mbar	°C
$5 \times 10^{-7}$	$7 \times 10^{-5}$	$7 \times 10^{-7}$	-124.1
$2 \times 10^{-7}$	$3 \times 10^{-5}$	$3 \times 10^{-7}$	-127.5
$1 \times 10^{-7}$	$1 \times 10^{-5}$	$1 \times 10^{-7}$	-129.9
$5 \times 10^{-8}$	$7 \times 10^{-6}$	$7 \times 10^{-8}$	-132.2
$2 \times 10^{-8}$	$3 \times 10^{-6}$	$3 \times 10^{-8}$	-135.2
$1 \times 10^{-8}$	$1 \times 10^{-6}$	$1 \times 10^{-8}$	-137.3
$5 \times 10^{-9}$	$7 \times 10^{-7}$	$7 \times 10^{-9}$	-139.5
$2 \times 10^{-9}$	$3 \times 10^{-7}$	$3 \times 10^{-9}$	-142.1
$1 \times 10^{-9}$	$1 \times 10^{-7}$	$1 \times 10^{-9}$	-144.1
<p><b>NOTE:</b>                      † This is the <u>average</u> of your COIL IN (TC #3) and COIL OUT (TC #4) measurements.                      The COIL OUT temperature must be within 10°C of the <u>average</u> temperature.                      For PFC/PFC or PFC/P: Also average your #2 COIL IN (TC #5) and #2 COIL OUT (TC #6) measurements.</p>			

### 3.4.4.3 Evaluate the Cryopump in DEFROST

1. Select DEFROST.


**NOTE:** For a PFC/PFC: Select DEFROST for both refrigerant circuits.

**NOTE:** For a PFC/P: Select DEFROST for the first refrigerant circuit. Select STANDBY for the second refrigerant circuit.

2. Record the time it takes for the cryosurface to defrost. When DEFROST is complete, the DEFROST COMPLETE lamp will light and the unit will automatically switch to STANDBY.

Actual Defrost Time: \_\_\_\_\_ minutes (should be less than 4 minutes)

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

	<b>⚠ CAUTION</b>
	EXTREME TEMPERATURES EXIST Parts of the cryosurface may be hot; contact with the hot surface may result in minor or moderate injury. Do not touch the cryosurface.


#### **3.4.4.4 Ensure that the Cryopump is Operating Properly**

Recheck all measurements to verify the cryopump is operating within specification. Transfer all measurements marked with a “1” to “Inspection Log” in [section 5 Periodic Inspection and Maintenance](#). These measurements will be used as a baseline reference for future inspections.

#### **3.4.4.5 Reinstall the Unit Panels**



### 3.5 Cryosurface & Cryogenic Feed-through Specification

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> The tubing, cryosurfaces, and feed-through must be free of oil and moisture before connecting it to the refrigeration unit. Failure to comply with the former specification can result in damage to the equipment. Make sure the tubing, cryosurfaces, and feed-through are free of oil and moisture before connecting it to the refrigeration unit.</p>

#### 3.5.1 If the Cryosurface is a Coil

**NOTE:** *This section assumes that a refrigerant circuit will be used to capture water vapor in a vacuum chamber.*

##### 3.5.1.1 Choose a Good Location

The cryocoil must be located so that:


- Evaporant (deposition source material) is not deposited on its surface.
- It has the best possible (unimpeded) view of the surfaces most likely to emit water vapor.
- It is facing away (or can be shielded) from sources of heat greater than 50°C.
- It is not subject to damage from moving objects.
- It can be supported without significant thermal conductance from the vacuum chamber.

If vacuum isolated feed-through is used, it must be located so that water will not collect in it when the cryocoil is defrosted. Subsequent freezing of this water may damage the cryocoil and/or cause vacuum or refrigerant leaks.

Table 3-9: Cryocoil Size Specification

Refrigeration Unit	Total Surface Area ft <sup>2</sup> (m <sup>2</sup> )	Tube Diameter in (mm)	Tube Length ft (m)
PFC-550-LT	2.7 (0.25)	3/8 (10)	27 (8.0)
PFC-550-HC	5.4 (0.50)	1/2 (12)	41 (13)
PFC-551-HC (CE)	5.4 (0.50)	1/2 (12)	41 (13)
PFC-552-HC (CE)	5.4 (0.50)	1/2 (12)	41.1 (13.3)
PFC-660-HC	7.5 (0.70)	5/8 (16)	46 (14)
PFC-661-HC (CE)	7.5 (0.70)	5/8 (16)	46 (14)
PFC-662-HC (CE)	7.5 (0.70)	5/8 (16)	46 (14)
PFC-670-HC	7.5 (0.70)	5/8 (16)	46 (14)
PFC-672-HC (CE)	7.5 (0.70)	5/8 (16)	46 (14)
PFC-1100-LT	5.4 (0.50)	1/2 (12)	41 (13)
PFC-1100-HC	21.6 (2.0)	5/8 (16)	132 (40)
PFC-1101-LT (CE)	5.4 (0.50)	1/2 (12)	41 (13)
PFC-1101-HC (CE)	21.6 (2.0)	5/8 (16)	132 (40)
PFC-1102-HC (CE)	21.6 (2.0)	5/8 (16)	132 (40)
<p><b>NOTE:</b>  <i>For PFC/PFC: The total surface area must be divided between the two cryocoils.  Larger cryocoils may give faster pumping speeds, and can be used in some applications. However, if the heat load is too great, the cryopump will become less efficient and may be shut off by a protective device.</i></p>			

### 3.5.1.2 Design the Cryocoil and Feed-through to the Following Requirements:

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> The cryocoil and feed-through must be designed to sustain a working pressure of 450 psig (3100 kPa). The cryocoil and feed-through are part of the refrigerant circuit of the cryopump. Failure to comply with the former specifications can result in damage to the equipment. Do <u>not</u> use reservoir-type or large volume cryocoils. Do <u>not</u> use large diameter tubing.</p>

1. The cryocoil must be a single continuous circuit (tube).
  - Do not put branches in the circuit. It causes uneven distribution of the refrigerant mixture that degrades the performance of the cryopump.
  - Do not add fins or panels to the circuit. The increased mass takes longer to cool and defrost the cryocoil and raises the cryocoil temperature.
2. The cryocoil must be either stainless steel or refrigeration grade copper tubing.
  - Stainless steel tubing is more durable and less chemically reactive. Minimum wall thickness is 0.020 inches (0.5 mm).
  - Refrigeration grade copper tubing is easier to work with. Minimum wall thickness is 0.030 inches (0.76 mm).
3. The cryocoil must have the proper surface area based on the diameter and length of the tubing. See [Table 3-9](#).
4. The cryogenic feed-through must be thermally isolated; a vacuum isolated feed-through is preferred.
5. If customer is providing feed-through, mating couplings are shipped with the unit. The couplings must be offset 3 inches (76 mm) to be connected to the refrigerant line. (See [Figure 3-1](#).)
6. It is preferable to weld or braze all connections inside the vacuum chamber. If this is not practical, use one of the couplings listed below. These couplings have been tested and found to be satisfactory. Other types of couplings may leak.
  - Parker CPI Ultra Seal couplings with silver-plated stainless steel O-rings.

- Cajon VCR couplings with silver-plated stainless steel gaskets or unplated nickel gaskets.
7. The supports for the cryocoil must allow for thermal contraction and expansion as the coil is cooled and defrosted. Also the supports must not add a significant heat load to the cryopump. Suitable supports can be made of thin stainless steel rods or tubing. Some plastics may be suitable for certain applications.

### 3.5.1.3 Carefully Build the CryoCoil (and Feed-through)

Use a tubing bender or mandrel so that the tubing is smooth and wrinkle-free. Follow the instructions in [section 3.7 Brazing Specification](#). Make certain the tubing is clean and free of corrosion, flux, and particle residue (inside and out).


### 3.5.1.4 Pressure-test the CryoCoil to 615 psig 4240 kPa (gage) (i.e., 6.895 X psig)

This test must be done before you connect the cryocoil to the refrigeration unit. The pressure relief valve for the refrigerant line and cryosurface may leak if it is pressurized above 335 psig (2310 kPa).

NOTE:  $615 \text{ psig} = 1.43 \times 430 \text{ psig}$ .

### 3.5.1.5 Check the Cryocoil for Leaks

Use a helium mass spectrometer if one is available.

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> The tubing must be free of oil and moisture before connecting it to the refrigeration unit. Failure to comply with the former specification can result in damage to the equipment. Make sure the tubing is free of oil and moisture before connecting it to the refrigeration unit.

### 3.5.2 If the Cryosurface is a Baffle


NOTE: *This section assumes the use of a refrigerant circuit to control back streaming. Back streaming will contaminate the system because it is the process of hot vapor migrating and condensing on cold surfaces. When the vacuum pump is used, the pump*

*oil heats up and travels opposite of the pumping direction and condenses the system resulting in system contamination.*

### 3.5.2.1 Choose a Good Location

- The cryobaffle must be shielded from sources of heat greater than 50°C.
- The cryobaffle must not come in direct contact with the vacuum chamber.

### 3.5.2.2 Design the Cryobaffle (and Feed-through) to the Following Requirements

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> The cryocoil, cryobaffle and feed-through must be designed to sustain a working pressure of 450 psig (3100 kPa). The cryocoil, cryobaffle and feed-through are part of the refrigerant circuit of the cryopump. Failure to comply with the former specifications can result in damage to the equipment. Do <u>not</u> use reservoir-type or large volume cryobaffles. Do <u>not</u> use large diameter tubing.

1. The cryobaffle should have a single continuous circuit (tube). Braze the fins of a baffle to this tube.
  - Contact a local Polycold sales representative or Brooks Polycold Systems Inc. for instructions on sizing the cryobaffle and other information.
  - Do not put branches in the circuit. It causes uneven distribution of the refrigerant mixture that degrades the performance of the cryopump.
2. The cryobaffle should be made with refrigeration grade copper tubing and with OFHC (oxygen free, high capacity) copper fins.
  - The refrigeration grade copper tubing must have a minimum wall thickness of 0.030 inches (0.76 mm).
  - The cryobaffle may be nickel-plated.
3. The cryogenic feed-through must be thermally isolated; a vacuum isolated feed-through is preferred.

**NOTE:** *Some multi-coolant baffles do not have appropriate feed-throughs and should not be used. If the feed-through is not sufficiently insulated:*

- The additional heat load at the feed-through can significantly degrade the performance of the cryopump.
- The elastomeric seal (O-ring) may become too cold and cause a vacuum leak.
- Ice may form on the outside surfaces of the vacuum chamber.

**NOTE:** *If customer is providing feed-through, mating couplings are shipped with the unit. The couplings must be offset 3 inches (76 mm) to be connected to the refrigerant line. (See [Figure 3-1](#).)*

### 3.5.2.3 Carefully Build the Cryobaffle (and Feed-through)

- Use a tubing bender or mandrel so that the tubing is smooth and wrinkle-free.
- Follow the instructions in [section 3.7 Brazing Specification](#).
- Make certain the tubing is clean and free of corrosion, flux, and particle residue inside and out.


### 3.5.2.4 Pressure-test the Cryobaffle to 615 psig 4240 kPa (gage) (i.e., 6.895 X psig)

This test must be done before connecting the cryobaffle to the refrigeration unit. The pressure relief valve for the refrigerant line and cryosurface may leak if it is pressurized above 335 psig (2310 kPa).

**NOTE:** *615 psig = 1.43 x 430 psig*

### 3.5.2.5 Check the Cryobaffle for Leaks

Use a helium mass spectrometer if one is available

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> The tubing must be free of oil and moisture before connecting it to the refrigeration unit. Failure to comply with the former specification can result in damage to the equipment. Make sure the tubing is free of oil and moisture before connecting it to the refrigeration unit.

### 3.6 Refrigerant Line Specification

#### Tools and materials needed:

- closed-cell pipe insulation rated for cryogenic temperatures
- type T (copper-constantan) thermocouple wire
- wire stripper, a thermal wire stripper is preferred
- soft drawn refrigeration grade copper tubing with a minimum wall thickness of 0.030 inches (0.76 mm)

For 550, 551, 552, 660, 661, 662, 670, 672, and PFC/PFC-1100, 1101, and 1102

feed line: 5/16 inch (8 mm) OD tube brazed to a short 1/2 inch (12 mm) OD tube

return line: 1/2 inch (12 mm) OD tube

For PFC-1100, 1101, and 1102

feed line: 3/8 inch (10 mm) OD tube brazed to a short 5/8 inch (16 mm) OD tube

return line: 5/8 inch (16 mm) OD tube

Parker CPI UltraSeal or Cajon VCR couplings (Mating couplings are provided to connect the refrigerant line to the unit).

For 550, 551, 552, 660, 661, 662, 670, 672, and PFC/PFC-1100, 1101, and 1102

1/2-inch Parker CPI UltraSeal couplings with silver-plated stainless steel O-rings

For PFC-1100, 1101, and 1102

5/8-inch Cajon VCR couplings with silver-plated stainless steel gaskets or unplated nickel gaskets


For brazing:

See [section 3.7 Brazing Specification](#).

For soldering:

- sand paper
- propane torch
- 60/40 tin-lead rosin core solder
- rosin flux

### 3.6.1 How to Build the Feed and Return Lines

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> The refrigerant line must be designed to sustain a working pressure of 450 psig (3100 kPa). The refrigerant line is part of the refrigerant circuit of the cryopump. Improper design and / or handling can result in damage to the line or equipment. Design and handle the refrigerant line carefully.

**NOTE:** *Position the unit as close as possible to the cryosurface. The longer the refrigerant line, the warmer the refrigerant gets before it reaches the cryosurface.*

**NOTE:** *Braze the refrigerant line to the cryosurface unless the cryosurface will be removable. If so, use Parker CPI UltraSeal or Cajon VCR couplings. These couplings have been tested and found to be satisfactory. Other types of couplings may leak.*


#### 3.6.1.1 Carefully Build the Feed and Return Lines

- Follow the instructions in [section 3.7 Brazing Specification](#).
- Make certain the tubes are clean and free of corrosion, flux, and particle residue inside and out.

#### 3.6.1.2 Attach Thermocouples to the Feed and Return Lines near the Feed-through Port


Remove 1/2 inch (13 mm) of insulation from one end of the thermocouple wire.



	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> Make sure not to nick the conductor. The wire may break with future vibration and can result in damage to the equipment. Do not nick the conductor.

- Twist the two wires together. Apply flux and pre-tin the twisted wires. Remove the flux residue with a wet rag while it is still hot.
- Use sand paper to remove oxidation from the copper tube. Apply flux to the tube. Position the thermocouple wire so that the first twist of wire (nearest the insulation) is against the tube. Solder the wire twist to the copper tube. Remove the flux residue with a wet rag while the joint is still hot.

**NOTE:** *Make certain the wire twist closest to the insulation is in contact with the copper tube. It is the first twist of wire closest to the insulation that senses and determines the temperature reading.*

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> Do <u>not</u> overheat the flux. Do <u>not</u> melt or cut the plastic insulation on the thermocouple wire. It may create false readings and can result in damage to the equipment. Be careful when attaching thermocouples to the feed and return lines.

- Wrap the thermocouple wire tightly around the tube 3-4 times. Allow enough thermocouple wire to run along the refrigerant line to the unit, plus an additional 4 feet (1.2 m) to reach the terminal blocks inside the low voltage box.

### 3.6.1.3 Pressure Test the Refrigerant Line to 615 psig (4237 kPa)

This test must be done before connecting the cryosurface to the refrigeration unit. The pressure relief valve for the refrigerant line and cryosurface may leak if it is pressurized above 335 psig (2310 kPa).


**NOTE:** *615 psig = 1.43 x 450 psig*

### 3.6.1.4 Check the Feed and Return Lines for Leaks

Use a helium mass spectrometer if one is available.

### 3.6.1.5 Insulate the Feed and Return Lines

Provide at least 1-1/4 inches (32 mm) wall thickness of insulation around the feed and return lines. The insulation must be airtight or the refrigerant line will cryopump water. If the system is not completely sealed and airtight, water vapor from the air will accumulate on some of the surfaces.

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> The tubing must be free of oil and moisture before connecting it to the refrigeration unit. Failure to comply with the former specification can result in damage to the equipment. Make sure the tubing is free of oil and moisture before connecting it to the refrigeration unit.</p>

### **3.7 Brazing Specification**

**Tools and materials needed:**

- Sand paper or wire brush or steel wool
- Pressure or flow regulated dry nitrogen gas
- Oxy-acetylene torch or air-acetylene torch (propane is not hot enough)

For copper-to-copper joints:

- Harris Dynaflow or Handy & Harman Sil-Fos 6M or equivalent alloy

For copper-to-stainless steel or copper-to-brass joints:

- Harris Safety-Silv 56 or Handy & Harman Braze 560 or equivalent alloy
- Harris Stay-Silv black flux or Handy Flux Type B-1 or equivalent flux

1. Thoroughly clean all mating surfaces to bare metal.
2. Purge the tubes with dry nitrogen gas while brazing and until the tubes and joints have cooled to at least 374-392°F (190-200°C).
  - This prevents internal scale formation or oxidation.
3. Remove all excess flux from the brazed joints with a wet or damp rag while the brazed joint is still hot.
4. Carefully inspect each joint for the proper flow of the brazing alloy. Both surfaces should be “wetted” by the alloy.
5. Carefully check all joints for leaks.

## 3.8 How to Install the Remote Control (Optional)

This is the Polycold standard remote control.

Electrical signals are transferred to and from the refrigeration unit via remote connector.

### 3.8.1 Connect the Remote Control to a Remote Connector

Tools and materials needed:

- Connector plug (shipped with the unit)
- Remote connector pins (shipped with the unit)
- Heat shrinkable insulating tubes (shipped with the unit)
- Multi-strand cable with 18 AWG (0.75 mm<sup>2</sup> cross-sectional area) wires
- Wire stripper
- 60/40 tin-lead rosin core solder
- soldering iron
- switches with a minimum capacity of 1A
- 24 V indicator lamps (optional<sup>1</sup>)


<sup>1</sup> If function indicator lamps are wanted at a remote location

#### 3.8.1.1 Review the Remote Control Schematic

Determine if a unit ON/OFF switch or function indicator lamps are wanted at a remote location. All circuits connected to the remote connector are 24 V(ac). (See [Figure 10-6](#), [Figure 10-7](#), or [Figure 10-8](#).)

**NOTE:** *A temperature from the TC SELECT switch can also be displayed at a remote location through the remote connector. To do this, see [section 3.8.2 Additional Instructions for Remote Temperature Indication](#).*

### 3.8.1.2 Assemble the Connector Plug


	<b>⚠ WARNING</b>
	<b>ELECTRICAL HAZARD</b> Contact could cause electric shock and result in death or serious injury. Make certain the ON/OFF switch and the power disconnect switch are in the OFF position.


(See [Figure 3-28](#).)

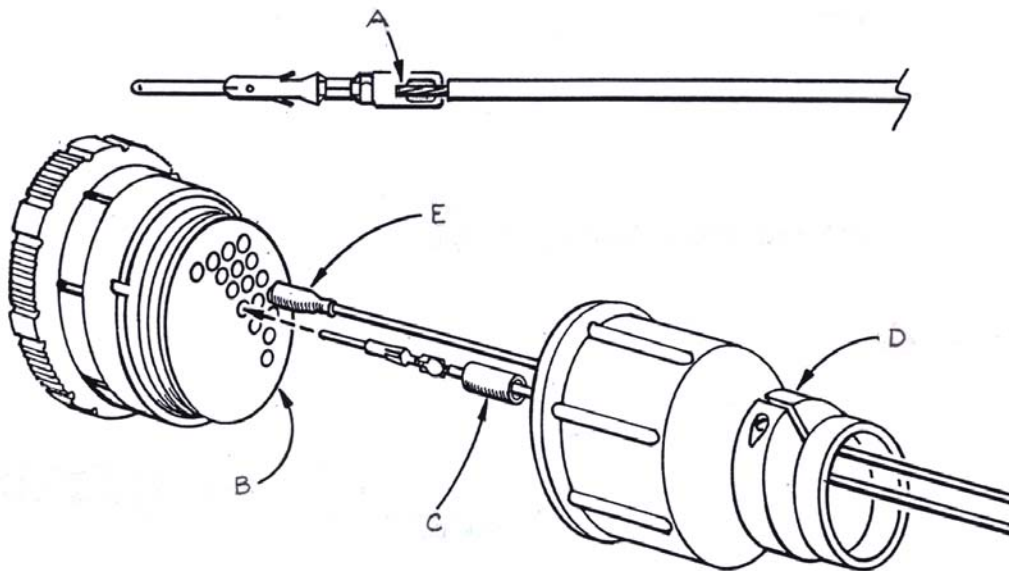
1. Remove no more than 1/2 inch (13 mm) of the cable jacket. The cable jacket is the outer most covering of the insulated cable. Once the cable jacket has been removed, strip 5/32 inch (4 mm) of inner insulation from the 18 AWG wires. Pre-tin each wire. Solder a pre-tinned wire to the back of each pin—do not insert the wire into the hole on the back of each pin.
2. Cut the heat shrinkable insulating tubes into 1/2-inch (13 mm) lengths. Slide a 1/2-inch long insulating tube onto each wire. Slide the cable clamp over the jacket. (Item D in [Figure 3-28](#).)
3. Insert each pin into the back of the connector until it clicks into place.
4. Slide the 1/2-inch long insulating tubes over the uninsulated wire and solder joint. Use a heat gun to shrink them in place. Firmly attach (thread, turn or screw) the cable clamp onto the connector. Tighten the cable clamp over the cable jacket.

### 3.8.1.3 Connect the Wires to the Remote Control

See [Figure 3-28](#); [Figure 3-29](#); and [Table 3-10](#) in this section.

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> Make sure the wiring configuration does not operate the unit in COOL & DEFROST at the same time; damage to the equipment can result. Polycold recommends the use of a three-position switch.

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> Make sure the wiring configuration does not start the unit in COOL or DEFROST; damage to the equipment can result. The three-position switch should be in the neutral position so that the unit will start in STANDBY. (When REMOTE is selected local functions will be disabled.)</p>



*Figure 3-28: Remote Connector Assembly*

- A. Wire soldered to pin
- B. Wire side of connector
- C. Heat shrinkable insulating tube
- D. Cable clamp
- E. Pin inserted with insulating tube shrunk in place

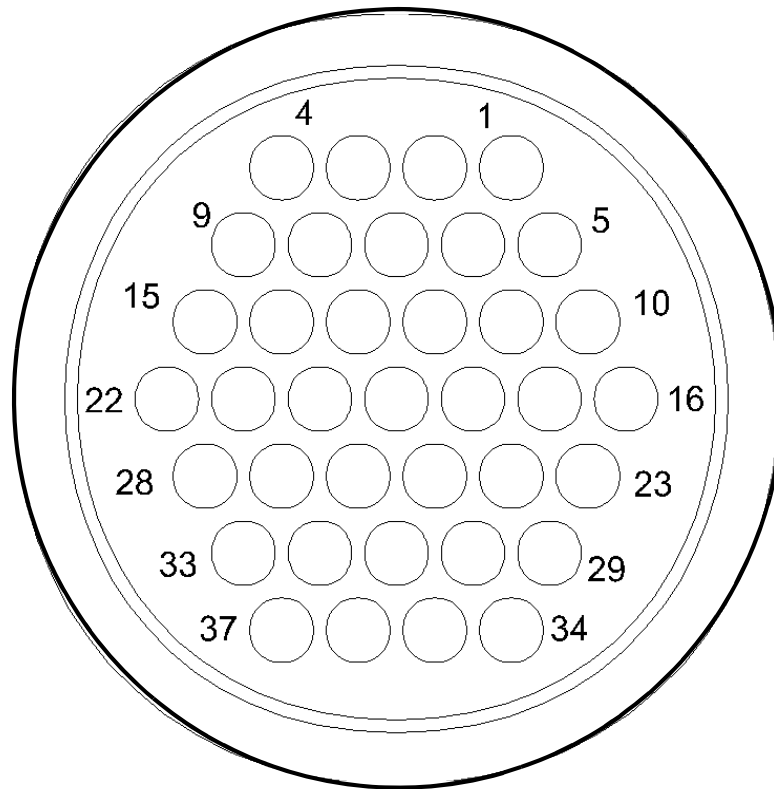


Figure 3-29: Wire Side of Remote Connector Plug

Table 3-10: Remote Connector Wiring Worksheet

Group	Wire Function	Pin Number	Customer's Wire Color
System Control	Operate Unit	1	
		2	
	Indicate Unit OK	3	
	Indicate Power	4	
	Common	5	
	Ground	6	

*Table 3-10: Remote Connector Wiring Worksheet*

<b>Group</b>	<b>Wire Function</b>	<b>Pin Number</b>	<b>Customer's Wire Color</b>
Refrigerant Circuit 1 (PFC)	Indicate REMOTE	10	
	Operate COOL	11	
	Operate DEFROST	12	
	Indicate DEFROST COMPLETE	13	
	Indicate DEFROST ACTIVE	14	
Refrigerant Circuit 2 (PFC or P)	Indicate REMOTE	18	
	Operate COOL	19	
	Operate DEFROST (PFC only)	20	
	Indicate DEFROST COMPLETE (PFC only)	21	
	Indicate DEFROST ACTIVE (PFC only)	22	
Option	Indicate Setpoint Relay A	26	
		27	
Temperature Meter 1	Analog # 1 - Out	28	
	Analog # 1 - Return	29	
	Analog # 1 - Shield	30	
Option	Indicate Setpoint Relay B	31	
		32	
Option— Temperature Meter 2	Analog # 2 - Out	33	
	Analog # 2 - Return	34	
	Analog # 2 - Shield	35	

**3.8.1.4 Program the Remote Control if a Controller is Present**

(See [section 4 Operation](#).)



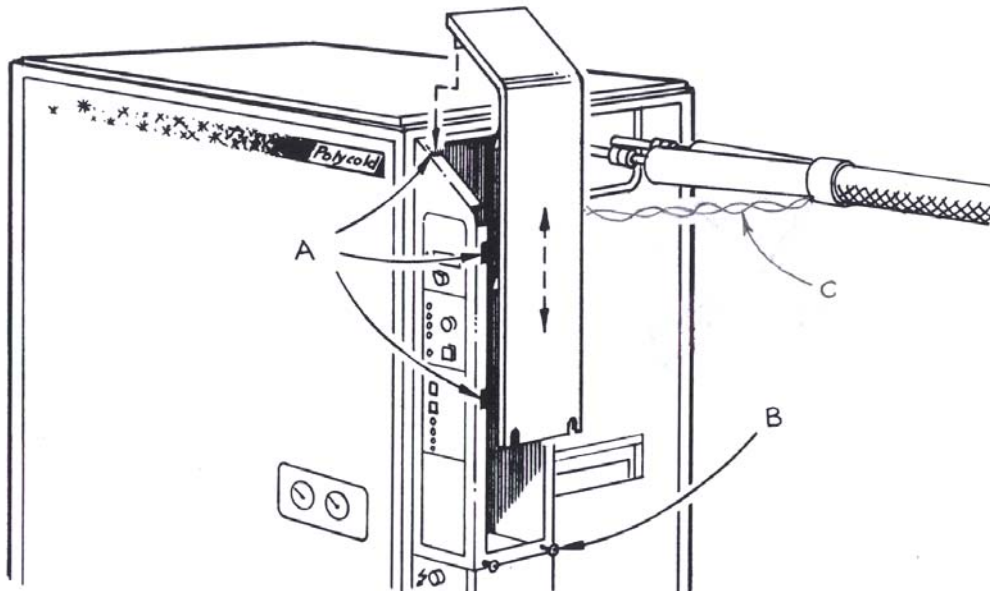
**3.8.1.5 If a remote ON / OFF Switch has been Installed, Unplug Jumper J11 from the SYSTEM CONTROL Printed Circuit Board**

1. Loosen the two lower screws on the side of the low voltage box. Slide the panel straight up to remove it. (See [Figure 3-30](#) Low voltage box panel removal and [Figure 3-31](#) Jumper J11 Location.)
2. Locate JMPR J11 on the SYSTEM CONTROL printed circuit board in the low voltage box. Squeeze the jumper's latch to unplug it.
3. Reinstall the low voltage box panel. Slide it straight down onto the low voltage box so that the two tabs go into their notches. Push the top of the panel towards the unit and at the same time push down so that the top tab goes into its notch. Tighten the two screws.

**3.8.1.6 Connect the Remote Plug to the Unit's Remote Receptacle and Select REMOTE**

**NOTE:** *Loosen the two lower screws on the side of the low voltage box. Slide the panel straight up to remove it.*

**NOTE:** *When a refrigerant circuit is in LOCAL, its remote functions are disabled (including the unit's ON/OFF switch).*



*Figure 3-30: Low Voltage Box Panel Removal*

- A. Notches
- B. Loosen screws
- C. Thermocouple wires

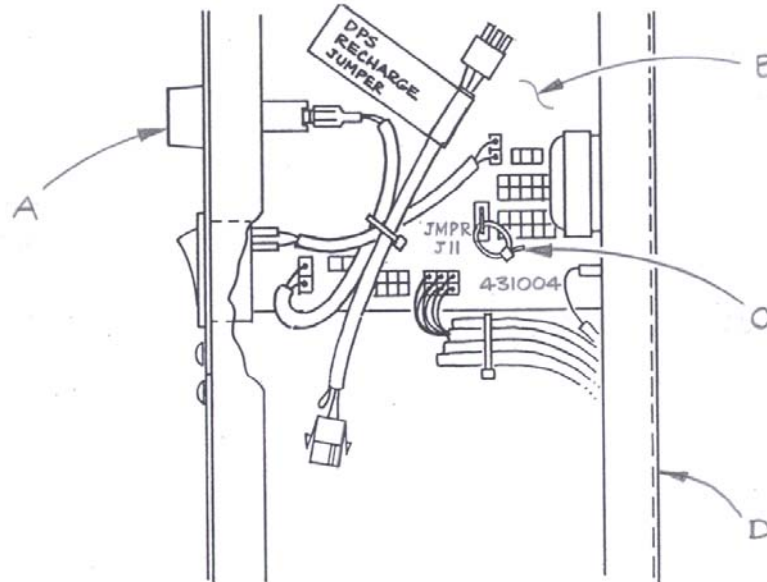


Figure 3-31: Jumper J11 location

**NOTE:** *DPS = Dual Pressure Switch*


- A. Reset button
- B. System control printed circuit board
- C. Jumper J11
- D. Low voltage box with panel removed

### 3.8.1.7 Ensure that the Remote Control Operates the Unit Properly

Use the remote control to do the following test:

1. Select STANDBY and turn on the refrigeration unit. The unit's compressor should be running. The unit's STANDBY indicator lamp should be lighted. The COLDEST LIQUID (TC #9) temperature should start getting colder. Wait 30 minutes.
2. Evacuate location of the cryosurface to at least 0.01 torr (1.33 Pa).

3. Switch to COOL.
  - The unit's COOL indicator lamp should be lighted.
  - The COIL OUT (TC #4) temperature should start getting colder.
4. Switch to DEFROST.
  - The unit's DEFROST ACTIVE indicator lamp should be lighted.
  - When DEFROST is complete, the unit's DEFROST COMPLETE and STANDBY indicator lamps should be lighted.
5. Open your vacuum chamber. The cryosurface should be dry and at room temperature or warmer.

	<b>⚠ CAUTION</b>
	<b>EXTREME TEMPERATURES EXIST</b> Parts of the cryosurface may be hot; contact with the hot surface may result in minor or moderate injury. Do not touch the cryosurface.

**NOTE:** *For PFC/PFC: Also test the second refrigerant circuit (#2 COIL OUT temperature = TC #6).*

**NOTE:** *For PFC/P: For the second refrigerant circuit, select COOL with your remote control. The #2 COIL OUT (TC #6) temperature should start getting colder.*

### 3.8.2 Additional Instructions for Remote Temperature Indication

#### 3.8.2.1 About the Thermocouples

##### **DISCHARGE LINE (TC #1):**

The thermocouple is located in the refrigeration unit's compressor compartment. It is on the compressor discharge line near the compressor. It can be used to monitor compressor performance.

##### **LIQUID LINE (TC #2):**

The thermocouple is located in the refrigeration unit's compressor compartment. It is on the refrigerant circuit near the exit of the condenser. It can be used to monitor the effectiveness of the system's cooling water.

**#1 COIL IN (TC #3):**

The thermocouple is located on the feed line near the cryosurface. It can be used for troubleshooting if cryopumping is inadequate.

**#1 COIL OUT (TC #4):**

The thermocouple is located on the return line near the cryosurface. It can be used to monitor the warmest cryosurface temperature.

**#1 FEED (TC #7):**

The thermocouple is in the refrigeration unit's foamed compartment. It is on the refrigerant circuit near the feed line. It can be used for troubleshooting if cryopumping is inadequate.

**#1 RETURN (TC #8):**

The thermocouple is in the refrigeration unit's foamed compartment. It is on the refrigerant circuit near the return line. It can be used for troubleshooting if cryopumping is inadequate.

**3.8.3 COLDEST LIQUID (TC #9):**

The thermocouple is in the refrigeration unit's foamed compartment. It is on the final strainer in the "Polycold stack". It can be used to determine when to switch from STANDBY to COOL.

**NOTE:** *For PFC/PFC or PFC/P—additional thermocouples for the second refrigerant circuit:*

#2 COIL IN (TC #5): See #1 COIL IN

#2 COIL OUT (TC #6): See #1 COIL OUT

#2 FEED (tied back): See #1 FEED

#2 RETURN (TC #10): See #1 RETURN

**NOTE:** *The COIL IN, COIL OUT, FEED and RETURN thermocouples only provide meaningful information when refrigerant is flowing through the cryosurface (i.e., when the unit is in COOL or DEFROST).*

### 3.8.3.1 About the Temperature Meter

The display range is  $-199.9$  to  $+199.9^{\circ}\text{C}$  and has an accuracy of  $\pm 3^{\circ}\text{C}$ . The temperature meter accepts a type T (copper-constantan) thermocouple input and is powered by the unit's 24 V(ac) control transformer.

The temperature meter provides an analog output from  $-1.999$  to  $+1.999$  V(dc). The output is 0 V(dc) for  $0^{\circ}\text{C}$ . It provides positive voltage for positive temperatures and negative voltage for negative temperatures at a rate of  $10\text{ mV}/^{\circ}\text{C}$ .

### 3.8.3.2 Using the Analog Output

The output is taken directly from the analog stages immediately preceding the analog-to-digital conversion for the meter's display. This circuit is sensitive to currents introduced into the output from external noise sources and ground loop situations. Therefore, the following precautions must be observed.

- The connecting cable must be less than 100 feet (30.5 m).
- The connecting cable must be shielded with only one end of the shield connected to ground. This grounding is done at the refrigeration unit. Use the designated pins in the remote connector for cable shield connections.
- The shielded connecting cable must be separate from the remote cable bundle. However, it may be routed next to the remote cable bundle.
- Do not ground either side of the analog output of the meter. The external device must have a differential input to isolate the connections.

# 4

# Operation

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## Overview

This chapter provides complete operation directions for the Brooks Automation Product.

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## 4.1 What the Cryopump Does in STANDBY, COOL, and DEFROST

The cryopump operates in three different modes: STANDBY, COOL, and DEFROST.

### What the cryopump does in STANDBY

When the unit is in STANDBY, the COOL and DEFROST solenoid valves are closed. The unit circulates (and cools) the mixture of refrigerants in the “Polycold stack.” The refrigerant is coldest when the unit is operating in this mode because it has the least heat load.

### What the cryopump does in COOL

When the unit is in COOL, the COOL solenoid valve is open and the DEFROST solenoid valve is closed. Cold refrigerant is pumped into the feed line. The cold refrigerant cools the cryosurface and comes back through the return line. The refrigerant then goes through the “Polycold stack” to the suction side of the compressor.

### What the cryopump does in DEFROST

When the unit is in DEFROST, the COOL solenoid valve is closed and the DEFROST solenoid valve is open. Hot refrigerant is pumped from the “Polycold stack” into the feed line. The hot refrigerant warms the cryosurface and comes back through the return line. The unit will automatically switch to STANDBY when the cryosurface is defrosted.

#### 4.1.1 Special notes for PFC/PFC or PFC/P

The PFC/PFC and PFC/P function in the same way as the PFC. However, the refrigerant is split into two separate feed and return lines so that it services two cryosurfaces. Also, the second circuit of a PFC/P cannot be defrosted rapidly. (It does not have a DEFROST mode.)

When one circuit is defrosted while the other circuit is in cool, the circuit in cool will warm up by up to 20°C. Therefore, the timing of defrost must be coordinated so as to maintain your process requirements. If the second circuit is a baffle for a diffusion pump, this is normally not a problem. However, when both circuits cool cryocoils, you must evaluate the impact on your process when you defrost one circuit while the other circuit is in cool during your deposition process.

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



### STANDBY versus 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.

### DEFROST versus COOL

The cryosurface being cooled will warm up by up to 20° C while the other cryosurface is defrosted. This is because refrigerant from both cryosurfaces is combined in the common return line. Contact the Polycold service department for an evaluation if this warm up will cause a problem.

### DEFROST versus STANDBY (PFC/PFC only).

The cryosurface being defrosted will defrost slightly faster than when both cryosurfaces are defrosted simultaneously.

## 4.2 How to Use the Cryopump

### 4.2.1 If the Cryosurface is a Coil

**Select STANDBY to precool the unit.**

When the refrigeration unit is in STANDBY, it cools the refrigerant mixture and “Polycold stack.” Complete precooling may take 60 minutes if the unit was off for more than 12 hours.

The COLDEST LIQUID (TC #9) temperature may be used to monitor the internal temperature of the unit. For quick cooling when switching to COOL, this temperature should be 5-10°C colder than your desired cryocoil temperature. See [Table 3-8](#).

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

**Select COOL to capture water on the cryocoil.**

Once the unit is precooled, the unit may be switched to COOL any time after the vacuum chamber is under vacuum. Most users switch to COOL at crossover (when opening the high vacuum valve). The cryocoil will start capturing water within 60 seconds.


Experimentation can be done with the cryopump to determine the shortest pump-down time for a particular application. The sooner the unit is switched to COOL, the faster the vacuum chamber’s pumpdown time. However, if the cryocoil captures too much water, the cryocoil’s apparent surface temperature will rise and limit the ultimate attainable base pressure.


**Select DEFROST to remove the captured water from the cryocoil.**

DEFROST allows the “regeneration” of a cryocoil in preparation for the next vacuum cycle. Start DEFROST so that the cryocoil is warm before the vacuum chamber reaches atmospheric pressure. A typical DEFROST takes 4 minutes or less. The unit will terminate DEFROST when the return temperature of the refrigerant reaches 20°C. This assures that no additional moisture will condense on the cryocoil from the atmosphere.

The unit will automatically go into STANDBY when DEFROST is complete. Allow the unit to remain in STANDBY for at least 5 minutes before selecting COOL.

**NOTE:** *To shorten the DEFROST cycle, terminate DEFROST early by putting the unit in STANDBY.*

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b></p> <p>If large amounts of water are collected during the vacuum cycle, liquid or ice may drop from the cryocoil during DEFROST. This could cause minor or moderate injury.</p> <p>You may need to provide a drip pan or similar device to prevent liquid water from accumulating in an undesirable location.</p>

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b></p> <p>For PFC/PFC and PFC/P users:</p> <p>Be aware that when defrosting one circuit while the other circuit is in cool, the temperature of the coil being cooled will increase by up to 20° C. Review the required temperatures for the affected process to make sure this warming will not affect your process. If such a temperature is not acceptable, wait until the completion of this process before performing defrost. Both circuits may be defrosted at once.</p>

#### 4.2.2 If the Cryosurface is a Baffle



##### To cool the cryobaffle

1. Evacuate the location of the cryobaffle to at least 0.01 torr (1.33 Pa).
2. Turn on the refrigeration unit and select COOL. A typical cryobaffle may take more than 60 minutes to cool down.
3. Turn on the high vacuum pump. It is not necessary to wait until the cryobaffle has cooled down.

##### To defrost the cryobaffle

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 suggested 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. Turn off your high vacuum pump.
2. Turn off the refrigeration unit or select STANDBY.

	 <b>CAUTION</b>
	<b>GENERAL HAZARD</b> Selecting DEFROST when the cryobaffle is being used to prevent back-streaming can damage the equipment. Do not select DEFROST if the cryobaffle is being used to prevent back-streaming.

**NOTE:** *Backstreaming will contaminate the system because it is the process of hot vapor migrating and condensing on cold surfaces. When the vacuum pump is used, the pump oil heats up and travels opposite of the pumping direction and condenses the system resulting in system contamination.*

## 5 Periodic Inspection and Maintenance

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### Overview

This chapter provides maintenance schedules and procedures for the Brooks Automation Product.

### Chapter Contents

5.1 Record Temperatures and Pressures Every Month .....	5-2
5.2 Check the Cryopump Every Six Months .....	5-4

## 5.1 Record Temperatures and Pressures Every Month

Record all measurements in [Table 5-1](#). If all measurements are not within specification, see [section 7 Troubleshooting and Repair](#).

### In STANDBY

Select LOCAL and STANDBY. Turn on the unit and wait 30 minutes. Record the SUCTION & DISCHARGE pressures, the DISCHARGE LINE (TC #1) temperature, and the LIQUID LINE (TC #2) temperature.

**NOTE:** *For PFC/PFC or PFC/P: Select LOCAL and STANDBY for both refrigerant circuits.*

### In COOL

Evacuate the location of your cryosurface to at least 0.01 torr (1.33 Pa). Select COOL and wait 30 minutes. Record the COIL IN (TC #3) and COIL OUT (TC #4) temperatures.

**NOTE:** *For PFC/PFC or PFC/P: Select COOL for both refrigerant circuits. Also record the #2 COIL IN (TC #5) and #2 COIL OUT (TC #6) temperatures.*

Check the outlet temperature of the cooling water. The drain line (OUT) should be 72–95°F (22–35°C). If not, adjust the water flow to attain a water outlet temperature in this range.

Table 5-1: Inspection Log

Refrigeration Unit's Serial Number: _____		Baseline Reference	Acceptable Variance From the Baseline Reference	Inspections		
Date						
After 30 Minutes STANDBY	SUCTION	psig <sup>1</sup> , bar <sup>1</sup>	Can vary ±5 psig (±0.34 bar) if it remains between 3 - 30 psig (0.2 - 2.1 bar).			
	DISCHARGE	psig <sup>1</sup> , bar <sup>1</sup>	Can vary ±10%.			
	DISCHARGE LINE (TC #1)	°C <sup>1</sup>	Can vary ±10%, if it remains ≥125°C.			
	LIQUID LINE (TC #2)	°C <sup>1</sup>	Can vary ±10%, if it is within 15°C - 33°C.			
After 30 Minutes COOL	# 1 COIL IN (TC #3)	°C	Remains stable (depending on load). See <a href="#">Table 3-8</a> .			
	# 2 COIL IN (TC #5)	°C				
End of COOL cycle	# 1 COIL OUT (TC #4)					
	# 2 COIL OUT (TC #6)					
Off 12 hours	Additional noise?	No	None			
	Ice or water on refrigerant line?	No	None			
Off 48 hours	Water in valve boxes?	No	None			
Off 48 hours	Balance pressure	psig <sup>2</sup> , bar <sup>2</sup>	Can drop 15 psig (1 bar).			

**NOTE:** <sup>1</sup>See [section 3.4.4 Evaluate the Cryopump](#).

<sup>2</sup>See [section 3.4.1 Open the Isolation Valves](#).

Record your baseline reference measurements and make copies of this sheet. If, in the future, you recharge (or “top off”) your cryopump, you will need to establish a new baseline reference.

## 5.2 Check the Cryopump Every Six Months

Record all measurements in [Table 5-1](#). If all measurements are not within specification, see [section 7 Troubleshooting and Repair](#).

### Noise Level or New Type of Sound

Listen to the unit. Locate the source of any new noise. If the noise is caused by a tube vibrating against something, move the tube slightly to avoid unnecessary wear.

If the noise is in the compressor, check the compressor oil level—see [section 3.4.4 Evaluate the Cryopump](#). Contact a local sales representative or the Polycold service department for advice.

### Refrigerant Line

Near the end of a typical **COOL** cycle, check the refrigerant line for ice or water. If there is ice or water, remove it. Apply another layer of insulation following the instructions in [section 3.4.3 Insulate the Exposed Tubes and Couplings](#).

### Valve Boxes

Turn off the unit and wait 12 hours. Remove the top panel of the unit. Unscrew the lids to the valve boxes. If there is water in the valve boxes, remove the water.

Make certain each gasket is in its groove. Screw the valve box lids completely shut. The gaskets should form a seal to keep out water vapor.

Reinstall the top panel of the unit.

### Balance Pressure

Wait until the unit is off for 48 hours. Locate the compressor's pressure gauges on the front of the unit. Record the pressure of the discharge gauge. If the pressure has dropped more than 15 psig, the cryopump may have a leak.

### Discoloration of Moisture Indicator on PFC Models 552, 662, 672, & 1102

Remove outer panel to view the units' moisture indicator. If the indicator appears red, the excessive moisture must be removed. Contact Polycold service and order the Polycold 04 x 04 Drier Service Kit, PN 840189-00.





**⚠ WARNING**

**GENERAL HAZARD**

Failure to have a qualified refrigeration technician do all refrigeration work could result in death or serious injury.

Contact a qualified refrigeration technician if the cryopump needs to be repaired.

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# 6

# Model History

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## Overview

This chapter provides the configurations and the manufacturing history of specific Brooks Automation Product models.

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## 6.1 Review of Configurations

Various configurations have been developed to comply with evolving legislation concerning refrigerants. The hardware, electrical, and refrigerant changes for each new configuration are reviewed briefly in this section.

### 6.1.1 PFC 1101

The PFC 1101 differs from the PFC 1100 as follows: The PFC 1101 utilizes new oil separators, a new pressure switch arrangement, and a new pressure fault Printed Circuit Board (PCB). Refer to troubleshooting section for pressure switch arrangement details. The pressure switch PCB is shown in [Figure 6-2](#). The PFC 1101 uses a different HCFC blend than used in the PFC 1100. The P&ID and Electrical Schematics for the PFC 1101 are available in document 825118-00.

### 6.1.2 PFC 1102

The PFC 1102 differs from the PFC 1101 as follows: In addition to the oil separators, pressure switch arrangement, and pressure fault PCB introduced on the PFC 1101, the PFC 1102 has a moisture indicator. (See [Figure 6-1](#).) Additionally, units manufactured after September of 2002, have a buffer unloader feature. (See [Figure 6-2](#).) The PFC 1102 uses an HCFC-Free refrigerant blend. The Process and Instrumentation Diagram (P&ID) and Electrical Schematics for the PFC 1102 are available in document 825119-00.

**NOTE:** *The Buffer Unloader is a circuit that controls the buffer pressure switch which activates the buffer valve when excess discharge pressure develops. The discharged pressure (gas) is removed from circulation and stored in the expansion tank.*

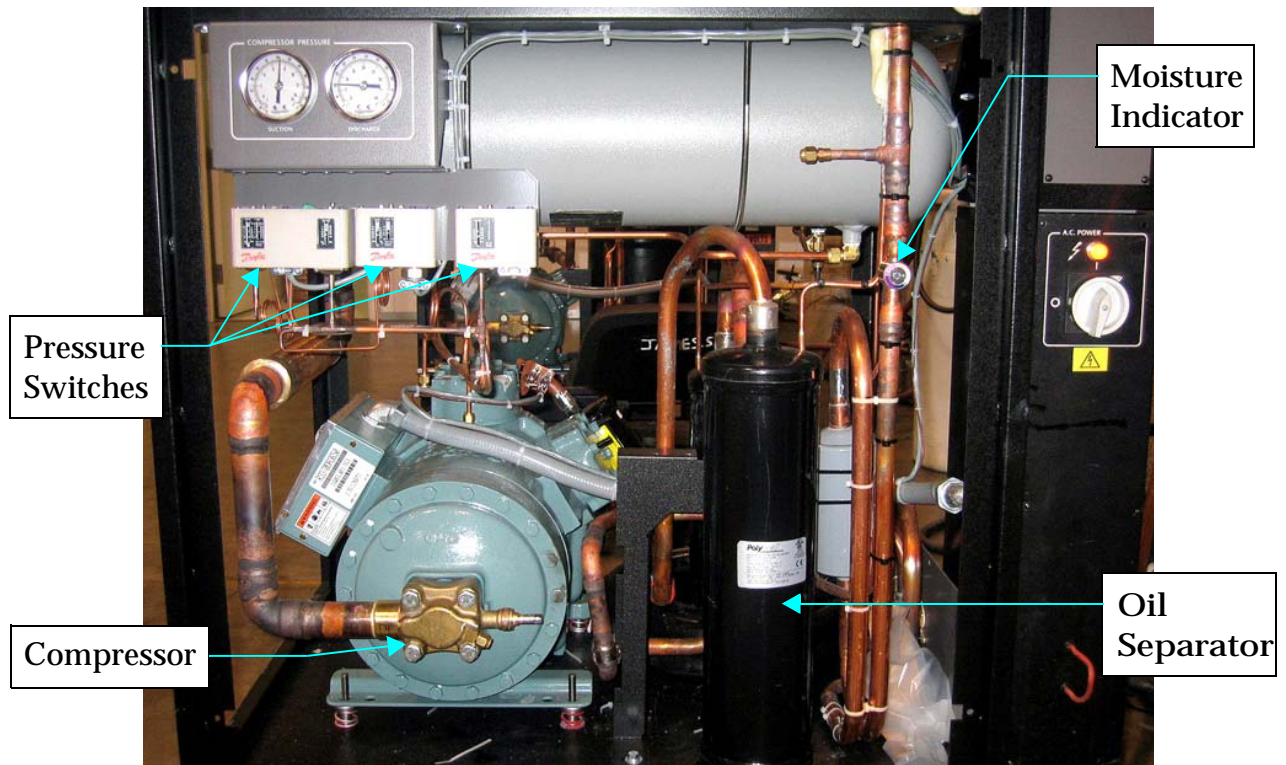


Figure 6-1: PFC Model 1102 Hardware

**NOTE:** Read individual model sections to determine if electrical features shown below apply to a particular model.

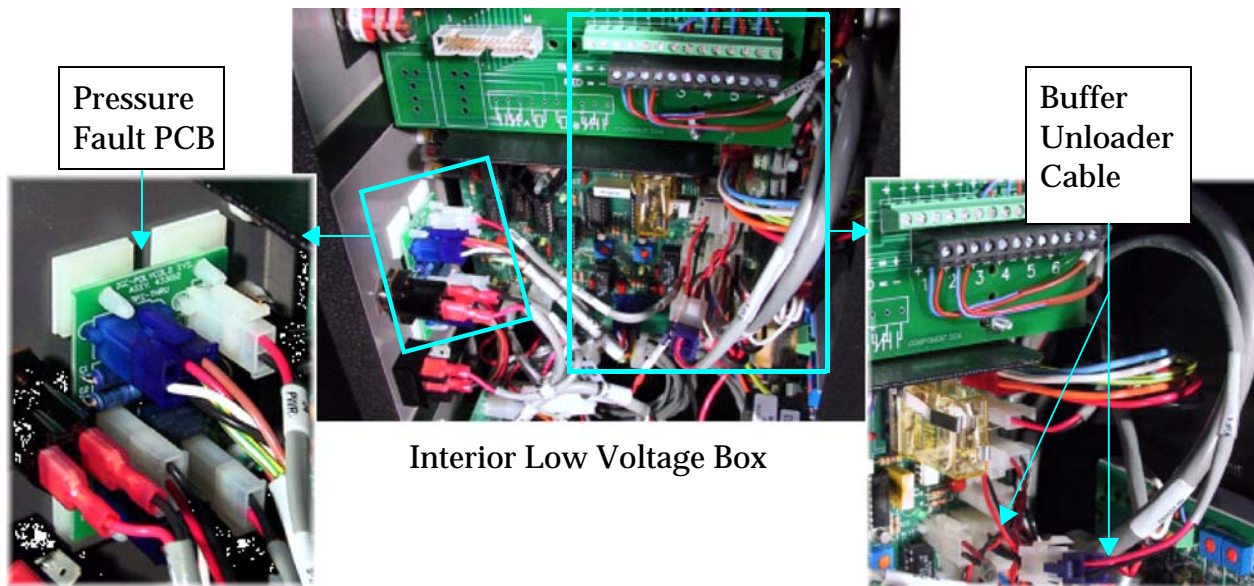


Figure 6-2: Electrical Changes to PFC Models with CE Mark

### 6.1.3 PFC 661

The PFC 661 differs from the PFC 660 as follows: The PFC 661 utilizes new oil separators, a new pressure switch arrangement, and a new pressure fault PCB. Refer to the troubleshooting section for pressure switch arrangement details. (The pressure switch PCB is shown in Figure 6-2.) The PFC 661 uses a different HCFC blend than used in the PFC 660. The P&ID and Electrical Schematics for the PFC 661 are available in document 825115-00.

### 6.1.4 PFC 662 and 672

The PFC 662 and 672 differ from the PFC 661 as follows. In addition to the oil separators, pressure switch arrangement, and pressure fault PCB introduced on the PFC 661, the PFC 662 and 672 are equipped with moisture indicators, Evaporator Pressure Regulating Valves (EPR Valves), and use HCFC-Free refrigerant blends. (See Figure 6-3.) Units manufactured after September of 2002, have a buffer unloader feature. (See Figure 6-2.) Additionally, the PFC 672 has a different compressor than the PFC 662. The P&ID and Electrical Schematics for the PFC 662 & 672 are available in documents 825116-00 & 825117-00 respectively.

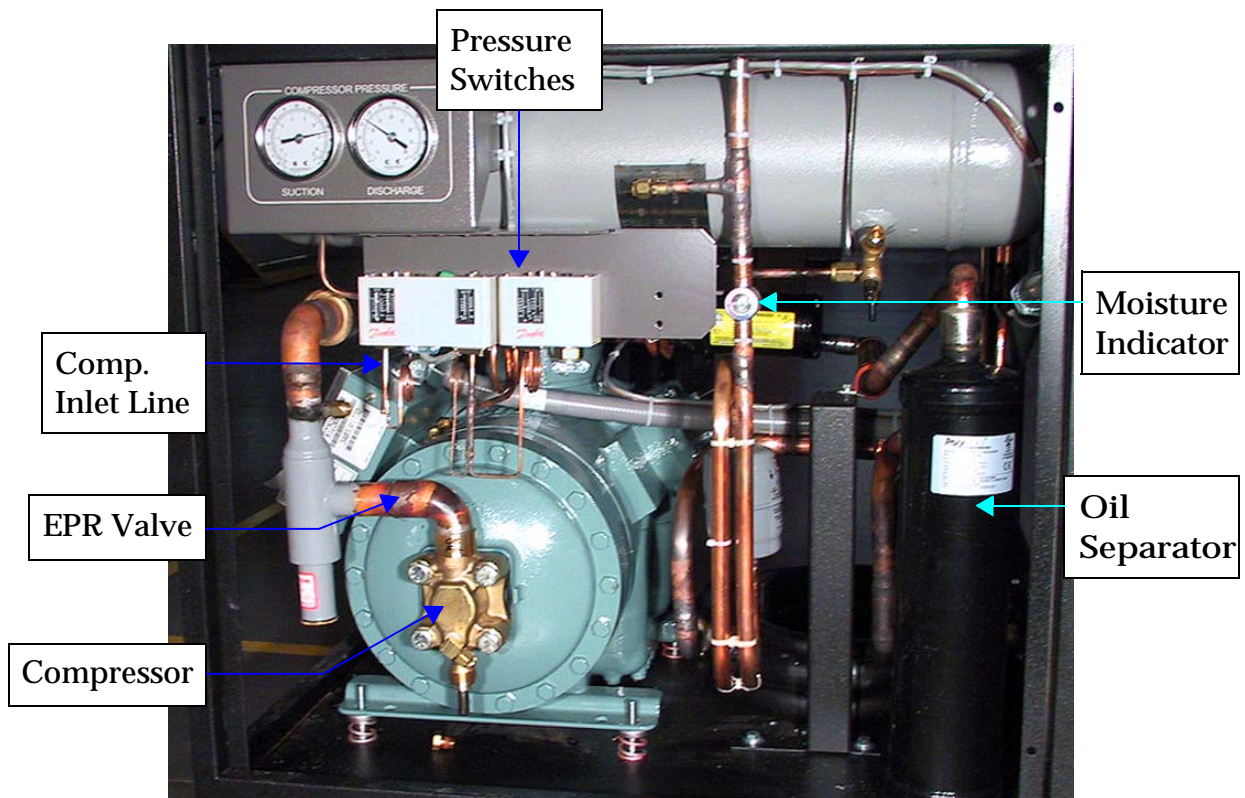


Figure 6-3: PFC Model 672 Hardware

### 6.1.5 PFC 670

The PFC 670 differs from the PFC 660 as follows: It utilizes a different compressor model.

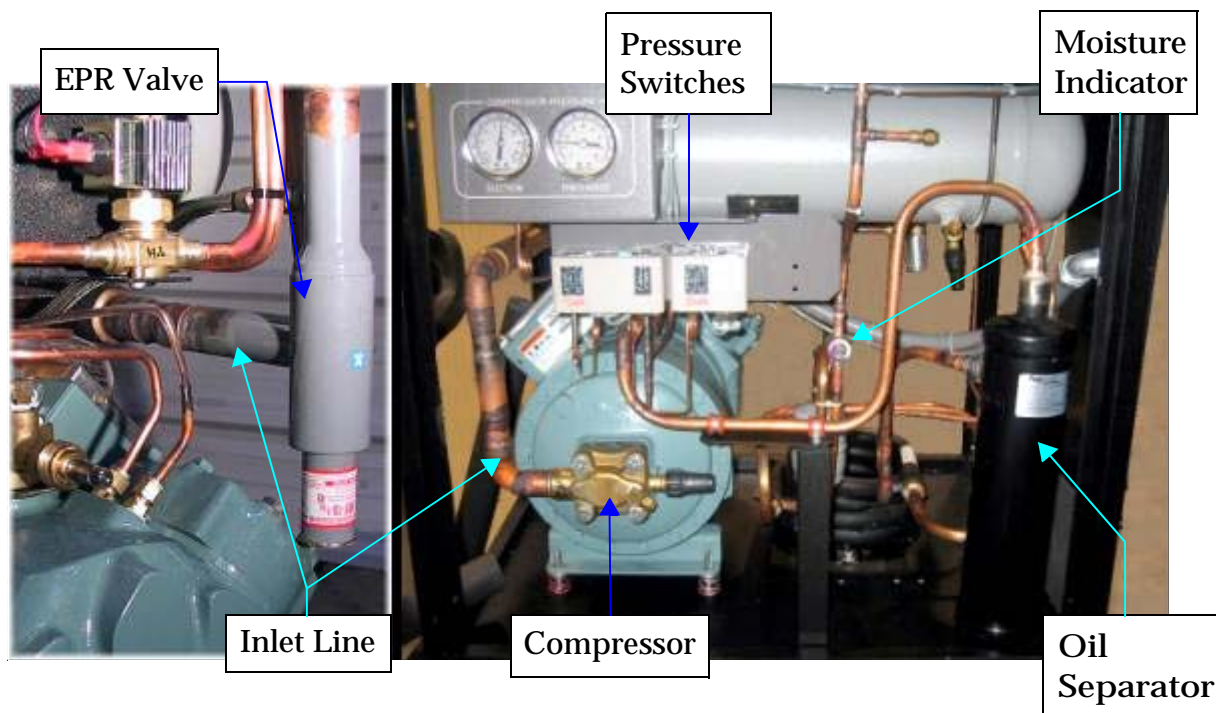
### 6.1.6 PFC 551

The PFC 551 differs from the PFC 550 as follows: The PFC 551 utilizes new oil separators, a new pressure switch arrangement, and a new pressure fault PCB. (See [Figure 6-2](#).) Refer to the troubleshooting section for pressure switch arrangement details. The PFC 551 uses a different HCFC blend than used in the PFC 550. The P&ID and Electrical Schematics for the PFC 551 are available in document 825113-00.

### 6.1.7 PFC 552

The PFC 552 differs from the PFC 551 as follows: In addition to the oil separators, pressure switch arrangement, and pressure fault PCB introduced on the PFC 551, the PFC 552 has a moisture indicator, an Evaporator Pressure Regulating Valve (EPR

Valve), and uses an HCFC-Free refrigerant blend. (See [Figure 6-4](#).) Also, units manufactured after September of 2002, have a buffer unloader feature. (See [Figure 6-2](#).) The P&ID and Electrical Schematics for the PFC 552 are available in document 825114-00.



*Figure 6-4: PFC Model 552 Hardware*

**NOTE:** *The PFC 552s EPR Valve is located on the compressor inlet line near the rear of the compressor.*



## **6.2 Revision Histories**

### **6.2.1 PFC-550 HC**

2004: In the Fall of 2004, the pressure switch setting was changed to 400 psi (2760 kPa) from 375 psi (2590 kPa).

### **6.2.2 PFC-550 LT**

2004: In the Fall of 2004, the pressure switch setting was changed to 400 psi (2760 kPa) from 375 psi (2590 kPa).

### **6.2.3 PFC-660 HC**

2003: The model was discontinued as a result of a compressor change by the manufacturer.

### **6.2.4 PFC-670 HC**

2003: PFC-670 HC replaces PFC-660 HC

2004: In the Fall of 2004, the pressure switch setting was changed to 400 psi (2760 kPa) from 375 psi (2590 kPa).

### **6.2.5 PFC-1100 HC**

2005: August: The two valve box design was replaced with a one valve box design.

### **6.2.6 PFC-1100 LT**

2004: In the Fall of 2004, the pressure switch setting was changed to 400 psi (2760 kPa) from 375 psi (2590 kPa).

2005: August: The two valve box design was replaced with a one valve box design.

### **6.2.7 PFC-552 HC**

2001: PED compliant materials and processes were implemented.

2002: The buffer unloader was made standard on all 552s.

2003: The exhaust plumbing for the PRV and rupture discs was eliminated.

### **6.2.8 PFC-662 HC**

2001: PED compliant materials and processes were implemented.

2002: The buffer unloader was made standard on all 662s. The model was discontinued as a result of a compressor change by the manufacturer.

### **6.2.9 PFC-672 HC**

2003: PFC-672 HC replaces the PFC-662 HC The exhaust plumbing for the PRV and rupture discs was eliminated.

### **6.2.10 PFC-1102 HC**

2001: PED compliant materials and processes were implemented.

2002: The buffer unloader was made standard on all 1102s.

2003: The exhaust plumbing for the PRV and rupture discs was eliminated.

2005: August: The two valve box design was replaced with a one valve box design.

# 7 Troubleshooting and Repair

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## Overview

Only trained, qualified persons should attempt to troubleshoot the product. Brooks Automation provides training in the troubleshooting and repair of the product.

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## 7.1 What to Do If the Cryopump Stops Running

Use the unit's indicator lamps to help find the problem. Note which lamps on the refrigeration unit are lit. See [Figure 7-1](#). Then find the appropriate troubleshooting section below. See [section 7.1.8 SYSTEM CONTROL Printed Circuit Board Indicator Lamps](#).

- [section 7.1.1 Low \(Suction\) Pressure Lamp is Lighted](#)
- [section 7.1.2 High \(Discharge\) Pressure Lamp is Lighted](#)
- [section 7.1.3 High Discharge Temperature Lamp Is Lighted](#)
- [section 7.1.4 High Liquid \(Line\) Temperature Lamp is Lighted](#)
- [section 7.1.5 "Unit OK" Lamp & Compressor Cycle Off & On](#)
- [section 7.1.6 System Control Lamps are Off; Temperature Display & High Voltage Box Lamp are Lighted](#)
- [section 7.1.7 System Control Lamps, Temperature Display & High Voltage Box Lamps are Off](#)
- [section 7.1.8 SYSTEM CONTROL Printed Circuit Board Indicator Lamps](#)



### Attention

After Investigating the cause of the fault and correcting the problem, the system must be reset in order to be restarted.

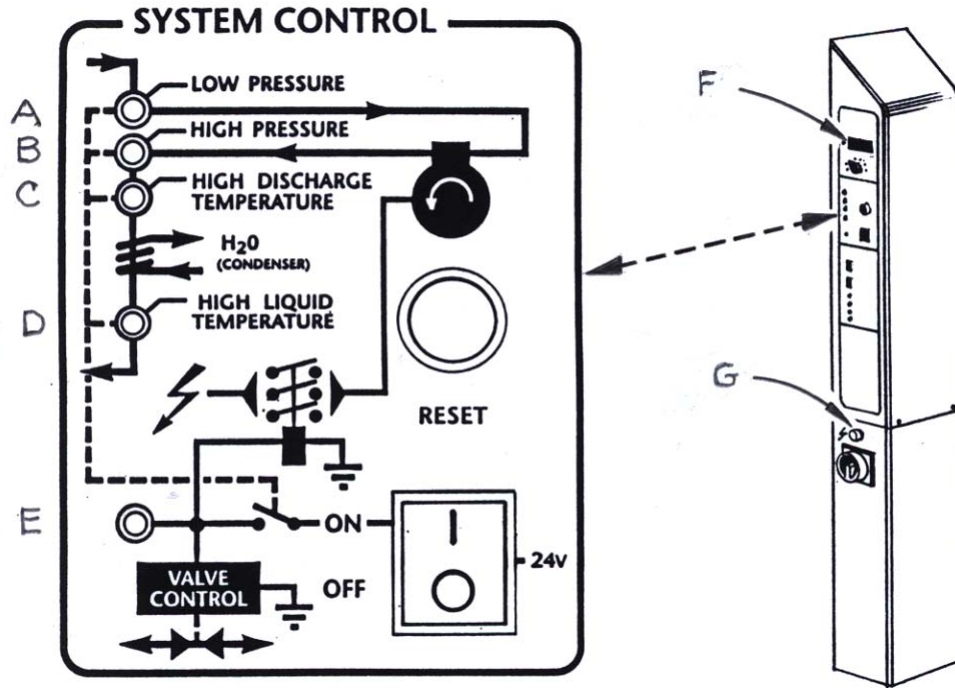




Figure 7-1: Unit indicator lamps

- A. LOW PRESSURE lamp
- B. HIGH PRESSURE lamp
- C. HIGH DISCHARGE TEMPERATURE lamp
- D. HIGH LIQUID TEMPERATURE lamp
- E. "Unit OK" lamp
- F. Temperature display
- G. High voltage box lamp
- H. Reset button (See note)



	 <b>Attention</b>
	Attention For 551, 552, 661, 662, 672, 1101, 1102 a discharge pressure fault requires resetting pressure switch inside unit. See section 7.1.2.1

### 7.1.1 Low (Suction) Pressure Lamp is Lighted

#### Before starting

A dual pressure switch controls the LOW PRESSURE and HIGH PRESSURE lamps. The LOW PRESSURE side is set at 2 psig (14 kPa). This setting ensures that a positive pressure is maintained on the suction side of the compressor. If the cryopump has a leak, the unit will be shutoff before it draws in moist air and contaminates the refrigerant circuit.

**NOTE:** *If the cryopump has previously been inspected, see [Step 5-1](#) for more accurate specifications.*

	 <b>WARNING</b>
	<b>GENERAL HAZARD</b> Failure to have a qualified refrigeration technician do all refrigeration work could result in death or serious injury. Contact a qualified refrigeration technician if the cryopump needs to be repaired.

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running.	Cooling water overcooling the unit.	Note the LIQUID LINE (TC #2) temperature. Turn off the unit and press the RESET button. Select STANDBY and LOCAL. Turn on the unit. Monitor the LIQUID LINE temperature in STANDBY for 30 minutes. It should be 15-33°C. If not, make sure the cooling water meets the requirements in <a href="#">section 3.2.5 Connect the Cooling Water</a> .
	Refrigeration unit shuts off: <ul style="list-style-type: none"> <li>• Within a few minutes of switching from COOL to STANDBY.</li> <li>• When the unit is experiencing a light load.**</li> <li>• When the LIQUID LINE temperature is below 20°C.</li> </ul>	Raise the LIQUID LINE temperature a few degrees by decreasing the flow or increasing the temperature of the cooling water.
<b>NOTE:</b> <i>**No Load means that no external heat load or rather no thermal energy (Watts) are being removed. Maximum Rated Load can be defined as the unit being rated for light heat load (light compared to the maximum which is less than 1/2 or 1/3)</i>		

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running	Cryopump has a leak.	Turn off the cryopump and wait 48 hours. Compare the DISCHARGE pressure to the measurement in <a href="#">section 3.4.1.1 Open the Isolation Valves</a> . If variance is greater than 20 psi, call your certified service agent or Polycold for instructions.
	The compressor's suction valve may not be fully open.	This valve may have been closed while recharging the unit. Check the valve and close if necessary.
	The suction side of the dual pressure switch is set at 2 psig.	This setting may have been temporarily changed while recharging the unit—Cut In = 31 psig & Differential = 29 psig. However, the accuracy of the switch setting must be checked with the SUCTION gauge. Call your certified service agent or Polycold for instructions.
	Cables not securely connected or connections show signs of overheating.	Visually check all system cables. Tighten as necessary; replace bad cables with qualified Polycold parts.
	The cryopump is leaking liquid refrigerant.	Call your certified service agent or Polycold for instructions.
<p><b>NOTE:</b> <i>**No Load means that no external heat load or rather no thermal energy (Watts) are being removed. Maximum Rated Load can be defined as the unit being rated for light heat load (light compared to the maximum which is less than ½ or 1/3)</i></p>		

### 7.1.2 High (Discharge) Pressure Lamp is Lighted

#### Before starting

A dual pressure switch controls the LOW PRESSURE and HIGH PRESSURE lamps.

These settings ensure that the discharge side of the compressor (and other components) operate within their rated working pressures.

#### 7.1.2.1 HIGH PRESSURE Setting: 400 Psig (2760 kPa)

For the 550 HC, 550 LT, 670 HC, 1100 LT models manufactured in Fall 2004 and beyond and all 1100 HC models, the HIGH PRESSURE side is set at 400 psig (2760 kPa).




### 7.1.2.2 HIGH PRESSURE Setting: 375 Psig (2590 kPa)

For the 550 HC, 550 LT, 670 HC, and 1100 LT models manufactured prior to Fall 2004, the HIGH PRESSURE side is set at 375 psig.

### 7.1.2.3 HIGH PRESSURE Setting: 415 Psig (2690 kPa)

For the 1102 HC, 672 HC, and 552 HC models, the HIGH PRESSURE side is set at 415 psig (2690 kPa).

**NOTE:** *If the cryopump has previously been inspected, see [Step 5-1](#) for more accurate specifications.*

	<b>⚠ WARNING</b>
	<b>GENERAL HAZARD</b> Failure to have a qualified refrigeration technician do all refrigeration work could result in death or serious injury. Contact a qualified refrigeration technician if the cryopump needs to be repaired.

**NOTE:** *Models 551, 552, 661, 662, 672, 1101, and 1102 use a discharge pressure switch with a manual reset. In some cases, the pressure switch has an external reset. In other cases the pressure switch has an internal reset. See [section 7.1.2.4 Resetting the Discharge Pressure Switch after a Fault](#) for reset details.*

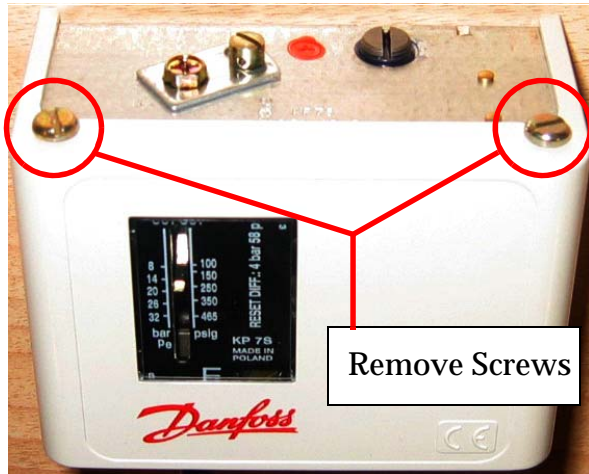
PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running.	The cryosurface is exposed to an excessive heat load.	Switch to COOL. Monitor the DISCHARGE pressure for 30 minutes. If the unit shuts off due to high discharge pressure, check the following: <ul style="list-style-type: none"> <li>• The cryocoil is at least 5/8 inch (16 mm) from the vacuum chamber wall.</li> <li>• The cryosurface is not in direct view of a heat source greater than 50°C.</li> <li>• The cryosurface is the correct size for this application (if this is a new application).</li> <li>• Water or air is not leaking into the vacuum chamber.</li> </ul> If the potential heat sources (above) are within specification, make sure the unit is allowed to remain in STANDBY at least 5 minutes after DEFROST (before switching to COOL).
	Switching from STANDBY to COOL after defrosting the cryosurface.	Allow the unit to remain in STANDBY at least 5 minutes after DEFROST is complete.
	Internal error occurring only during DEFROST or when switching from DEFROST to STANDBY.	Switch to STANDBY after the cooling cycle is finished. Allow the DISCHARGE pressure to drop below 300 psi before switching to DEFROST.
	Defrost termination system NOT working correctly.	Switch to DEFROST and monitor the #1 RETURN (TC #8) temperature until the DEFROST COMPLETE lamp lights. The #1 RETURN temperature should not exceed 25°C and the unit should automatically go into STANDBY. If the #1 RETURN exceeds 30°C, switch to STANDBY.  <b>NOTE:</b> For PFC/PFC: Also monitor the second refrigerant circuit (#2 RETURN = TC #10).

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running.	The cryopump has too much refrigerant charge in it. The cryopump was recharged incorrectly.	Turn off the cryopump and wait 48 hours. Compare the DISCHARGE pressure to the measurement in <a href="#">section 3.4.1.1 Open the Isolation Valves</a> .
	The compressor discharge valve is <b>NOT</b> fully open. This valve may have been closed while recharging the unit.	Check the valve and open if necessary.
	The discharge setting of the dual pressure switch is incorrect.	<p>HIGH PRESSURE Switch Settings:</p> <p><u>375 psig (2590 kPa)</u>: For the 550 HC, 550 LT, 670 HC, and 1100 LT models manufactured prior to Fall 2004, the switch is set at 375 psig.</p> <p><u>400 psig (2760 kPa)</u>: For all 1100 HC models, the switch is set at 400 psig. As of Fall 2004, the HIGH PRESSURE SWITCH setting for the 550 HC, 550 LT, 670 HC, and 1100 LT models was changed to 400 psig.</p> <p><u>415 psig (2690 kPa)</u>: For all 1102 HC, 672 HC, and 552 HC models, the switch is set at 415 psig.</p>
	Cables not securely connected or connections show signs of overheating.	Visually check all system cables. Tighten as necessary; replace bad cables with qualified Polycold parts.

#### 7.1.2.4 Resetting the Discharge Pressure Switch after a Fault

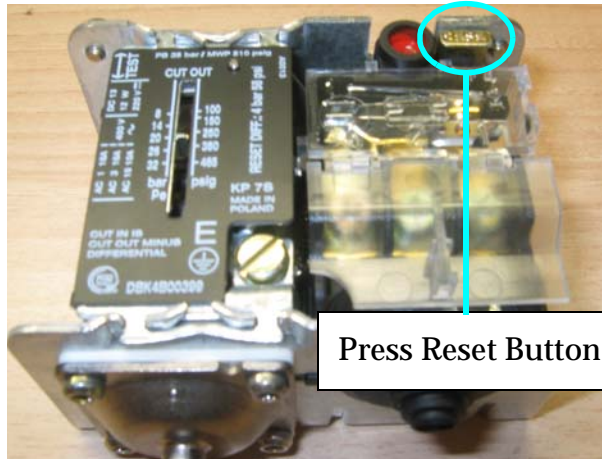
**NOTE:** *With the following figures (Figure 7-2 through Figure 7-7), identify the correct pressure switch for your unit and press the green reset button to reset the switch. If your unit has a reset switch internal to the switch unit make sure to reset it.*

A discharge pressure fault requires a resetting of the manual pressure switch. In some cases (models 551, 661, 1101, and 1102) the reset switch is internal to the switch unit as shown in *Figure 7-2*.



Remove Screws

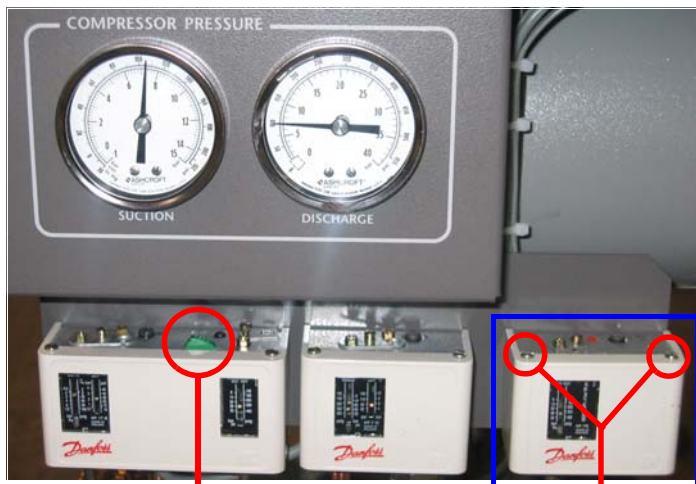
Top View



Press Reset Button

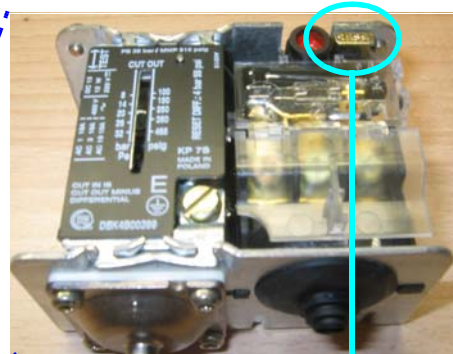
Bottom View

Figure 7-2: Pressure Switch



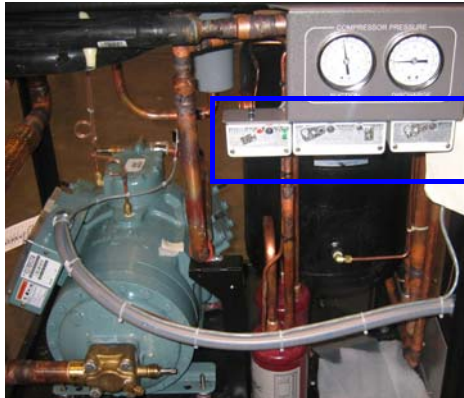
Press Reset Button

Remove Screws  
 (Pressure Switch, Top View)



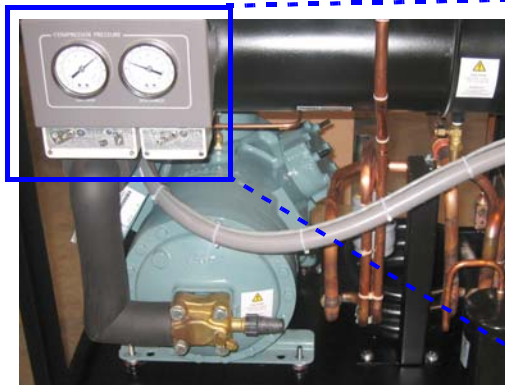
Press Reset Button

Figure 7-3: 1102



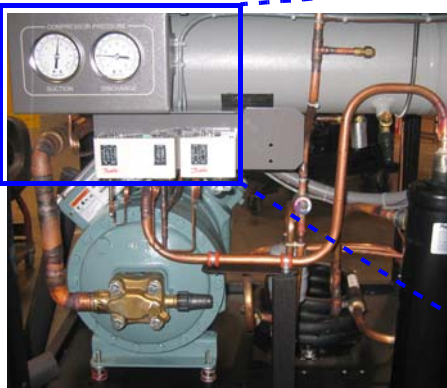
Press Reset Button

*Figure 7-4: 1100*



Press Reset Button

*Figure 7-5: 660 and 670*



Press Reset Button

*Figure 7-6: 552, 662, and 672*

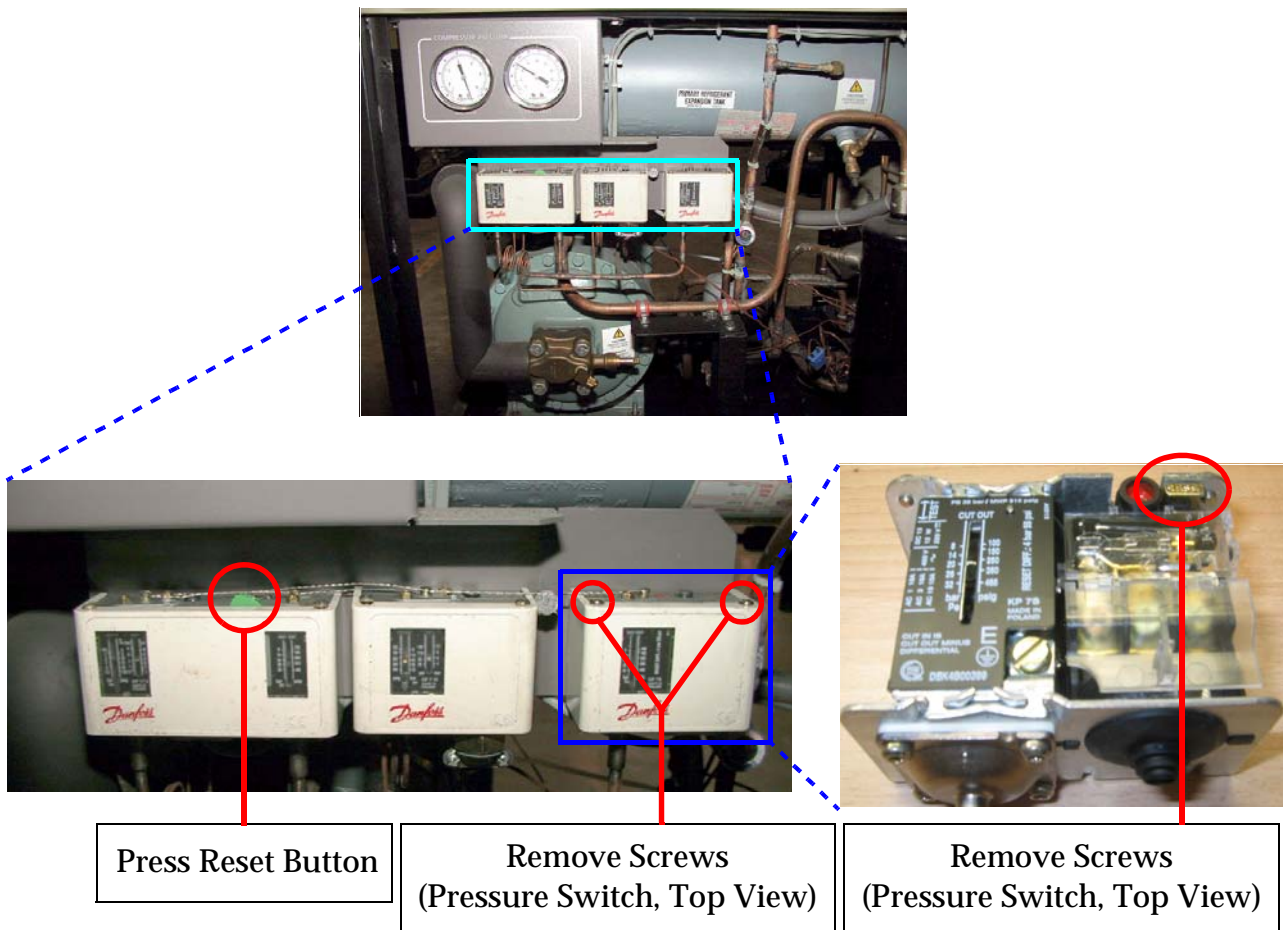


Figure 7-7: 551 and 661



### 7.1.3 High Discharge Temperature Lamp Is Lighted

#### Before starting

This lamp is controlled by two thermostat switches located on the compressor's DISCHARGE LINE. One is set at 275°F (135°C) and the other is set at 300°F (149°C).

- If the DISCHARGE LINE exceeds 149°C, the second thermostat will immediately shut off the unit. This protects the compressor from overheating.
- If the DISCHARGE LINE exceeds 135°C, the first thermostat is activated which starts a timer. (The cryopump may need to operate above normal discharge temperatures for a short time—such as starting the unit after it has been off for 48 hours.) The thermostat switch will shut off the unit if it remains between 135°C and 149°C after 40 minutes. This protects the life of the compressor.

**NOTE:** *If the cryopump has previously been inspected, see [Table 5-1](#) for more accurate specifications.*

	 <b>WARNING</b>
	<p><b>GENERAL HAZARD</b> Failure to have a qualified refrigeration technician do all refrigeration work could result in death or serious injury. Contact a qualified refrigeration technician if the cryopump needs to be repaired.</p>

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running.	Cooling water is inadequate.	<p>Turn off the unit and press the RESET button. Select LOCAL and STANDBY. Turn on the unit. Monitor the DISCHARGE LINE (TC #1) temperature and the LIQUID LINE (TC #2) temperature for 90 minutes.</p> <ul style="list-style-type: none"> <li>• The DISCHARGE LINE should not exceed 125°C and should remain stable after 30 minutes.</li> <li>• The LIQUID LINE should be 15-33°C. If the LIQUID LINE temperature exceeds 33°C, see <a href="#">section 3.2.5 Connect the Cooling Water</a>. If the LIQUID LINE temperature exceeds 38°C, turn off the unit. Either the temperature sensing system or the protective device's logic is faulty.</li> </ul>
	The cryosurface is exposed to an excessive heat load.	<p>Switch to COOL. Monitor the DISCHARGE LINE temperature for 30 minutes. If the unit shuts off due to high discharge temperature, check the following.</p> <ul style="list-style-type: none"> <li>• The cryocoil is at least 5/8 inch (16 mm) from the vacuum chamber wall.</li> <li>• The cryosurface is not in direct view of a heat source greater than 50°C.</li> <li>• The cryosurface is the correct size for this application (if this is a new application).</li> <li>• Water or air is not leaking into the vacuum chamber.</li> </ul>

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running	The cables in the compressor's electrical box are not securely connected. The connections show signs of overheating.	Inspect each cable termination and assure that the connections are tight. Tighten only loose connections. Replace any parts with signs of heat stress.
	Both "high discharge temperature" thermostats and cables are not securely attached and functioning.	Call your certified service agent or Polycold for instructions.
	The compressor's internal valves are not sealing.	Call your certified service agent or Polycold for instructions.

#### 7.1.4 High Liquid (Line) Temperature Lamp is Lighted


##### Before starting

This lamp is controlled by a thermocouple limit switch. This switch is set at 92°F (33°C) to allow reliable operation of the cryopump. Some systems may have an optional thermocouple limit switch set to 100°F (38°C)

- If the LIQUID LINE exceeds 33°C (38°C for optional TC Limit Switch) while the unit is operating, this switch will immediately shut off the unit.
- If the LIQUID LINE exceeds 33°C (38°C for optional TC Limit Switch) when the unit is first started, this switch will shut off the unit after 14 seconds. (The 14 seconds should allow enough time for the water to cool the refrigerant circuit.)

**NOTE:** *If the cryopump has previously been inspected, see [Table 5-1](#) for more accurate specifications.*



	<b>⚠ WARNING</b>
	<p><b>GENERAL HAZARD</b> Failure to have a qualified refrigeration technician do all refrigeration work could result in death or serious injury. Contact a qualified refrigeration technician if the cryopump needs to be repaired.</p>


PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running.	Cooling water is not flowing in the correct direction.	Turn off the unit and press the RESET button. Select LOCAL and STANDBY. Turn on the unit.  Grasp the cooling water supply line (IN) with one hand and the drain line (OUT) with the other hand. The drain line should be warmer than the supply line. If not, turn off the unit. Connect the supply and drain lines to the proper ports.
	Cooling water is not adequately cooling the unit.	Monitor the LIQUID LINE (TC #2) temperature for 30 minutes. It should be 15-33°C (15-38°C for optional TC Limit Switch). If not, see <a href="#">section 3.2.5 Connect the Cooling Water</a> . Determine if the unit only shuts off: <ul style="list-style-type: none"> <li>• when the cryopump is experiencing a heavy thermal load, <u>and</u></li> <li>• the LIQUID LINE temperature is at the high end of the acceptable range.</li> <li>• If so, an increase in the unit's cooling capacity may be possible by increasing the flow or lowering the temperature of the cooling water.</li> </ul>
	The liquid line thermocouple wires are not securely attached or they are broken	Tighten or repair thermocouple wiring connections.

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running	The cables between the thermocouple limit switch and the SYSTEM CONTROL printed circuit board are not securely connected. The connections show signs of overheating	Tighten thermocouple cable connections or replace cables as required.

### 7.1.5 “Unit OK” Lamp & Compressor Cycle Off & On


Before starting

The green “Unit OK” lamp is lighted whenever the compressor is running. The compressor should run continuously when the unit is ON. However, if the compressor draws too much current, its motor overloads will cycle the compressor (and green “Unit OK” lamp) off and on.

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b>                  Do not operate the cryopump if the compressor is cycling off and on. Doing this will lower the performance of the cryopump and shorten the life of the compressor and can damage the equipment. Call for assistance at this time if you are not a qualified technician.</p>


PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running.	The electrical supply is inadequate	Requires a qualified electrician.
	Control voltage is inadequate	(Requires a qualified electrician.) See <a href="#">section 3.2.4.2 How to Check the Control Voltage and Change the Transformer Taps.</a>
	Cables in the high voltage box are not securely connected. The connections show signs of overheating	Inspect each cable termination and assure that the connections are tight. Tighten only loose connections. Replace any parts with signs of heat stress.
	The cables in the compressor's electrical box are not securely connected. They show signs of overheating	Inspect each cable termination and assure that the connections are tight. Tighten only loose connections. Replace any parts with signs of heat stress.
Cryopump stops running	The compressor's overloads are not functioning properly	Replace overloads.

### 7.1.6 System Control Lamps are Off; Temperature Display & High Voltage Box Lamp are Lighted

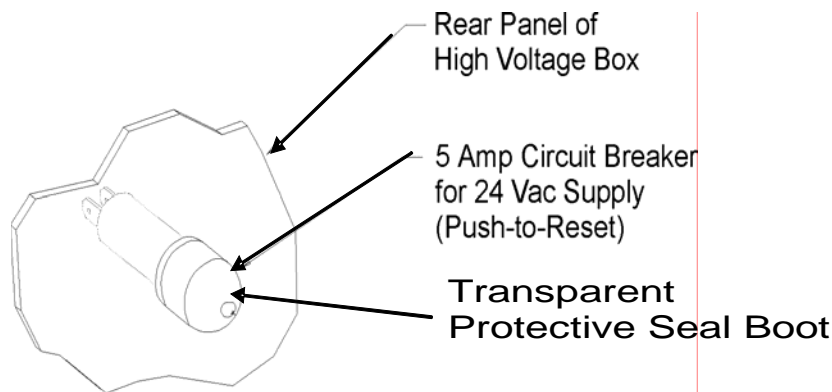
	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> Do not operate the unit. Doing so can damage the equipment. Call for assistance at this time if you are not a qualified technician.</p>

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryopump stops running.	The unit's ON/OFF switch in the OFF position	Move switch to "ON" position.
	Will the unit start in the LOCAL mode	Select STANDBY and LOCAL. Turn on the unit.
	Is jumper J11 plugged into the SYSTEM CONTROL printed circuit board	(This step does not apply if a remote ON/OFF switch is installed. See section 3.8 "How to Install the GVE Remote Control Option.")
	The fuse on the SYSTEM CONTROL printed circuit board is blown	(Requires a qualified electrician.)
Cryopump stops running	The expansion tank pressure switch has been triggered (units with the CE Mark option and 1100s only)	Call your certified service agent or Polycold for instructions.

**7.1.7 System Control Lamps, Temperature Display & High Voltage Box Lamps are Off**

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> Do not operate the unit. Doing so can damage the equipment. Call for assistance at this time if you are not a qualified technician.

<b>PROBLEM</b>	<b>POSSIBLE CAUSE</b>	<b>CORRECTIVE ACTION</b>
Cryopump stops running.	The power disconnect switch is in the OFF position	Move switch to “ON” position.
	Control voltage is inadequate	(Requires a qualified electrician.) See “How to Check the Control Voltage & Change the Transformer Taps” in section 3.2.3
	Is the electrical supply adequate	(Requires a qualified electrician.)
	The control voltage circuit breaker for the transformer has been triggered	A small plunger being fully extended within the transparent protective seal boot of the circuit breaker indicates a tripped condition. If so, check electrical components and connections for signs of overheating. If the problem began following installation of remote control wiring, check for proper connections or shorted wires. Pushing the plunger will reset the circuit breaker. See figure 7-2.



*Figure 7-8: Control voltage circuit breaker*

7.1.8 SYSTEM CONTROL Printed Circuit Board Indicator Lamps

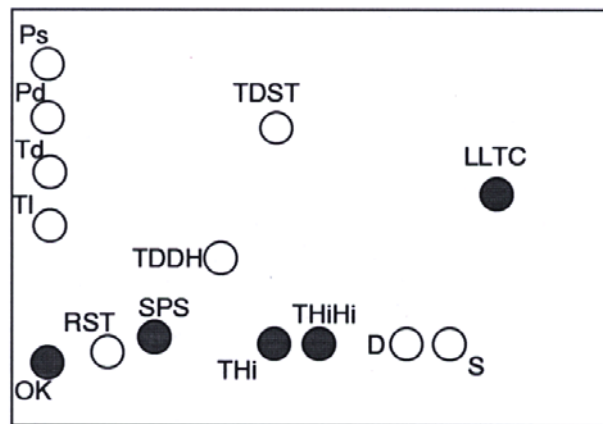


Figure 7-9: SYSTEM CONTROL printed circuit board indicator lamps

●	<b>GREEN LEDs</b>
OK	This lamp is lighted when the contactor is closed.
SPS	<ul style="list-style-type: none"> <li>For models without a buffer unloader cable (550, 660, 670, 1100, 551, 661, and 1101): Upon initial start-up*, the SPS LED is off, the buffer valve is open, and the TDST LED is on. After 14 seconds, the TDST times-out. The SPS LED illuminates once the single pressure switch (SPS) on the discharge line reaches 350 psig (2410 kPa).</li> </ul> <p><b>NOTE:</b> *The SPS LED will stay on if the system is turned off and on again before allowing pressure to drop below 350 psig.</p> <ul style="list-style-type: none"> <li>For models with a buffer unloader cable (552, 662, 672, and 1102): The SPS LED is on and the buffer valve is open whenever discharge pressure exceeds 400 psig (2760 kPa).</li> </ul>
THi	This lamp is lighted when the first discharge thermostat is below 275°F (135°C). When THi turns off, TDDH comes on.
THiHi	This lamp is lighted when the second discharge thermostat is below 300°F (149°C). When THi turns off, Td comes on.

○	<b>YELLOW LEDs</b>
Ps	This is the LOW PRESSURE indicator lamp on the SYSTEM CONTROL panel. It is on when the unit has been shut off due to low suction pressure. When Ps comes on, OK turns off.
Pd	This is the HIGH PRESSURE indicator lamp on the SYSTEM CONTROL panel. It is on when the unit has been shut off due to high discharge pressure. When Pd comes on, OK turns off.
Td	This is the HIGH DISCHARGE TEMPERATURE indicator lamp on the SYSTEM CONTROL panel. It is on when the unit has been shut off due to high discharge temperature. When Td comes on, OK turns off.
Tl	This is the HIGH LIQUID TEMPERATURE indicator lamp on the SYSTEM CONTROL panel. It is on when the unit has been shut off due to high LIQUID LINE temperature. When Tl comes on, OK turns off.
RST	This lamp lights while the reset switch on the SYSTEM CONTROL panel is being pressed.
TDDH	This lamp lights and times 40 minutes when the THi lamp turns off. If after 40 minutes THi is still off, TDDH will turn off and Td will turn on.
TDST	This lamp lights when the unit is started and times 14 seconds.
D	This lamp lights when the discharge side of the dual switch is set above the model's specifications (see the following specifications for each model). When D comes on, it triggers Pd to come on. <ul style="list-style-type: none"> <li>• For the 550 HC, 550 LT, 670 HC, and 1100 LT models manufactured prior to Fall 2004: 375 psig (2590 kPa)</li> <li>• For the models (listed above) manufactured from Fall 2005 on and all 1100 HC models: 400 psig (2760 kPa)</li> <li>• For all 1102 HC, 672 HC, and 552 HC models: 415 psig (2790 kPa)</li> </ul>
S	This lamp lights when the suction side of the dual pressure switch is below 2 psig (14 kPa). When S comes on, it triggers Ps to come on.

## 7.2 What to Do If the Cryosurface is Not Cryopumping Adequately

### 7.2.1 Check Coil Temperatures

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
<p>Cryosurface is not cryopumping adequately</p>	<p>COIL IN and COIL OUT temperatures are out of specification</p>	<p>Select LOCAL and STANDBY. Turn on the unit and wait 30 minutes. Select COOL and wait 30 minutes.</p> <p>Record the COIL IN (TC #3) temperature and the COIL OUT (TC #4) temperature.</p> <p>On Models 552, 662, 672, &amp; 1102 check the units' Moisture Indicator. (See Periodic Inspection &amp; Maintenance Section.)</p> <p><b>NOTE:</b> <i>For PFC/PFC or PFC/P: Also record the #2 COIL IN (TC #5) and #2 COIL OUT (TC #6) temperatures.</i></p>
	<p>Cryosurface is not being adequately cooled</p>	<p>Use the above measurements to determine if the cryosurface is adequately being cooled</p> <p>The <u>average</u> of COIL IN and COIL OUT temperatures must be colder than the temperature required for the desired water vapor partial pressure in the vacuum chamber. See Table 3.8 in Section 3.4.4 "Evaluate the Cryopump."</p> <p>The COIL OUT temperature must be within 10°C of the <u>average</u> temperature.</p> <p><b>NOTE:</b> <i>If the cryopump has previously been inspected, see <a href="#">Table 5-1</a> for more accurate specifications.</i></p>





**Troubleshooting Sections to Consider**

Is the COIL IN temperature OK?	Is the COIL OUT temperature OK?	Then...
Yes	Yes	Check your vacuum pump.
Yes	No	See <a href="#">section 7.2.2 COIL IN Temperature Is OK, but COIL OUT Temperature Is Not OK.</a>
No	No	See <a href="#">section 7.2.2 COIL IN Temperature Is OK, but COIL OUT Temperature Is Not OK.</a>

(These sections assume that the thermocouple readings and the pressure gauges are accurate.)

**7.2.2 COIL IN Temperature Is OK, but COIL OUT Temperature Is Not OK**

	 <b>CAUTION</b>
	<p><b>GENERAL HAZARD</b>                  Do not operate the unit. Doing so can damage the equipment.                  Call for assistance at this time if you are not a qualified technician.</p>

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryosurface is not cryopumping adequately	The temperature indication of the COIL OUT thermocouple is incorrect.	<p>Select LOCAL and STANDBY. Turn on the unit and wait 30 minutes. Select COOL and wait 30 minutes.</p> <p>Compare the COIL OUT (TC #4) temperature to the #1 RETURN (TC #8) temperature. They should be within 10°C of each other.</p> <p>On Models 552, 662, 672, &amp; 1102 check the units' Moisture Indicator. (See Routine Maintenance Section.)</p> <p><b>NOTE:</b> For PFC/PFC or PFC/P: The #2 COIL OUT (TC #6) temperature should be within 10°C of the #2 RETURN (TC #10) temperature.</p>
	The refrigerant line has ice or water on it.	Check the refrigerant line at the end of a typical COOL cycle. If there is ice or water, remove it. Apply another layer of insulation following the instructions in <a href="#">section 3.4.3 Insulate the Exposed Tubes and Couplings</a> .
	Cryosurface is exposed to an excessive heat load.	<p>Make sure the cryosurface is:</p> <ul style="list-style-type: none"> <li>• at least 5/8 inch (16 mm) from the vacuum chamber wall (cryocoil only);</li> <li>• not in direct view of a heat source greater than 50°C;</li> <li>• the correct size for this application (if this is a new application).</li> </ul> <p>Make certain the vacuum chamber does not have an air or water leak.</p>
	Cryosurface has large dents or kinks in it.	Call your certified service agent or Polycold Systems for instructions.
	Isolation valves are not fully open.	(The isolation valves are closed when the unit is shipped from the factory and when following the instructions for disconnecting the refrigerant line.)
	Refrigerant line has a large dent or kink in it.	Call your certified service agent or Polycold Systems for instructions.

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryosurface is not cryopumping adequately	The DEFROST solenoid valve keeps closing.	Call your certified service agent or Polycold Systems for instructions.
	The buffer bypass valve is sticking open (All units except the 550).	Call your certified service agent or Polycold Systems for instructions.
	The cryopump has improper refrigerant charge in it.	Call your certified service agent or Polycold Systems for instructions.
	Cryopump has a leak.	Call your certified service agent or Polycold Systems for instructions.


**7.2.3 COIL IN and COIL OUT Temperatures are Not OK**

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryosurface is not cryopumping adequately	Is the temperature indication of the COIL IN and COIL OUT thermocouples correct	<p>Select LOCAL and STANDBY. Turn on the unit and wait 30 minutes. Select COOL and wait 30 minutes.</p> <p>Compare the following temperatures:</p> <ul style="list-style-type: none"> <li>• COIL IN (TC #3) should be within 10°C of #1 FEED (TC #7); and</li> <li>• COIL OUT (TC #4) should be within 10°C of #1 RETURN (TC #8).</li> </ul> <p><b>NOTE:</b> For PFC/PFC or PFC/P: Select COOL for both refrigerant circuits.</p> <ul style="list-style-type: none"> <li>• #2 COIL IN (TC #5) should be within 10°C of #1 FEED (TC #7); and</li> <li>• #2 COIL OUT (TC #6) should be within 10°C of #2 RETURN (TC #10).</li> </ul>
	Isolation valves are not fully open	(The isolation valves are closed when the unit is shipped from the factory and when following the instructions for disconnecting the refrigerant line.)

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryosurface is not cryopumping adequately	Is the COOL solenoid valve opening	Call your certified service agent or Polycold Systems for instructions.
	The DEFROST solenoid valve keeps closing	Call your certified service agent or Polycold Systems for instructions.
	Does the refrigerant line have a kink in it	Replace kinked section.
	The cryopump has improper refrigerant charge in it	Call your certified service agent or Polycold Systems for instructions.
	Cryopump has a leak	Call your certified service agent or Polycold Systems for instructions.
	PFC/PFC or PFC/P units with one circuit in cool while the other circuit is in defrost.	<ul style="list-style-type: none"> <li>• If temperature increase is less than 20°C, review your process sequence and do not defrost one circuit while the other circuit is in cool.</li> <li>• If temperature increase is greater than 20°C, call your certified agent of Polucold Systems for instructions.</li> </ul>

### 7.2.4 What to Do If the Cryosurface is Not Defrosting Adequately

**NOTE:** This section is for a PFC refrigerant circuit whose cryosurface is a coil.

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> Do not operate the unit. Doing so can damage the equipment. Call for assistance at this time if you are not a qualified technician.

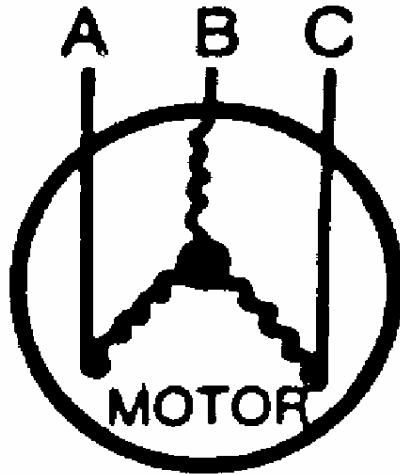
PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cryosurface is not defrosting adequately	Size of the cryosurface is not within specification	(See <a href="#">section 3.5 Cryosurface &amp; Cryogenic Feed-through Specification</a> .)
	Vacuum chamber is being vented before the cryosurface is defrosted	Complete defrost prior to venting the chamber.
	The DEFROST cycle is being terminated early	<p>The unit will automatically terminate the DEFROST cycle when the #1 RETURN (TC #8) temperature reaches 20°C. This should take less than 4 minutes.</p> <p>If terminating the DEFROST cycle earlier with a timer or some other method, check to see if enough time has passed for the cryosurface to be completely defrosted.</p> <p><b>NOTE:</b> <i>For PFC/PFC: If the second refrigerant circuit is not defrosting adequately, do this step with the #2 RETURN (TC #10) temperature.</i></p>
	The defrost termination system is NOT working correctly.	<p>Switch to DEFROST. Monitor the #1 RETURN (TC #8) temperature until the DEFROST COMPLETE lamp lights. The #1 RETURN temperature should not exceed 25°C, and the unit should automatically switch to STANDBY. Select STANDBY if the return line temperature exceeds 30°C.</p> <p><b>NOTE:</b> <i>For PFC/PFC: Also monitor the second refrigerant circuit (#2 RETURN = TC #10).</i></p>
	The cryosurface has a large dent or kink in it	Call your certified service agent or Polycold Systems for instructions
The isolation valves are not fully open	(The isolation valves are closed when the unit is shipped from the factory and when following the instructions for disconnecting the refrigerant line.)	

<b>PROBLEM</b>	<b>POSSIBLE CAUSE</b>	<b>CORRECTIVE ACTION</b>
Cryosurface is not defrosting adequately	The DEFROST solenoid valve is not opening	Call your certified service agent or Polycold Systems for instructions.
	The COOL solenoid valve keeps closing	Call your certified service agent or Polycold Systems for instructions.
	The refrigerant line has a large dent or kink in it	Call your certified service agent or Polycold Systems for instructions.
	PFC/PFC or PFC/P units with one circuit in cool while the other circuit is in defrost.	<ul style="list-style-type: none"> <li>• If temperature increase is less than 20°C, review your process sequence and do not defrost one circuit while the other circuit is in cool.</li> <li>• If temperature increase is greater than 20°C, call your certified agent of Polucold Systems for instructions.</li> </ul>

### 7.3 How to Calculate Voltage Unbalance

Voltage unbalance can cause motors to overheat and fail. The following example is the recommended method for determining voltage unbalance. This example was taken from the Carlyle Corporation Service Guide Manual.

**Example:** Supply voltage is 240-3-60



$$AB = 243V$$

$$BC = 236V$$

$$AC = 238V$$

1. Determine the average voltage:

$$\frac{243+236+238}{3} = \frac{717}{3} = 239V$$

2. Determine maximum deviation from average voltage:

$$(AB) 243 - 239 = 4 V$$

$$(BC) 239 - 236 = 3 V$$

$$(AC) 239 - 238 = 1 V$$

Maximum deviation is 4 V.

3. Determine % voltage unbalance:

$$100 \times \frac{4}{239} = 1.7\%$$

This amount of phase unbalance is satisfactory as it is below the maximum allowable 2%.

**Important:** If the supply voltage phase unbalance is more than 2%, contact the local electric utility company immediately.



# 8 Disconnection, Storage, and Reshipment

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## Overview

Only trained, qualified persons should attempt to troubleshoot the product. Brooks Automation provides training in the troubleshooting and repair of the product.

## Contents

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## 8.1 How to Shut Down or Ship the Cryopump

### How to shut down the cryopump:

1. Defrost the cryosurface following the instructions in [section 4.2 How to Use the Cryopump](#).
2. Turn off the unit.
3. Turn off the POWER DISCONNECT switch (on the high voltage box).
4. Turn off the cooling water.

### How to prepare the cryopump for storage or shipment:

1. Follow the instructions in [section 8.1 How to Shut Down or Ship the Cryopump](#) above.
2. Disconnect the refrigerant line following the instructions in [section 8.2 How to Disconnect the Refrigerant Line](#).
3. Disconnect the cooling water.
4. Blow water from the condenser. (This step protects the unit from freeze damage during storage or a high altitude flight.)
5. Disconnect the electrical supply.
6. Reinstall the compressor hold-down nuts. (These were removed in [section 3.2.2 Position the Unit](#) and should have been stored with the unit.)

## 8.2 How to Disconnect the Refrigerant Line

### Tools and materials needed:

- stepladder
- Phillips screwdriver
- small straight blade screwdriver
- 1/4 inch ratchet valve wrench
- 15/16 inch end wrench
- 5/8 inch end wrench
- blank-off fittings (These were removed in [section 3.3.2.2 Verify that the Isolation Valves are Closed, and Remove the Blank-off Fittings](#) and should have been stored with the unit.)

For Parker CPI UltraSeal couplings (standard fitting):

- 1 inch open end wrench
- 15/16 inch open end wrench
- O-ring removal tool



For Cajon VCR couplings (optional fitting):

- 1-3/16 inch open end wrench
- 1-1/16 inch open end wrench

### 1. Draw the refrigerant mixture back into the unit.

Defrost the cryosurface following the instructions in [section 4.2 How to Use the Cryopump](#). Turn off the unit.

Remove the top panel of the unit. The isolation valves are in the box closest to the couplings. Loosen the screws to open the valve box lid.

 	<b>⚠ CAUTION</b>
	<b>EXTREME TEMPERATURES EXIST</b> Frostbite danger. The isolation valves may be very cold; contact with the cold surface may result in minor or moderate injury. Do not touch the isolation valves. Make certain the cryosurface is fully defrosted before closing the isolation valves, especially if the cryopump is being used to cool a baffle. Otherwise, dangerous pressures could develop in the refrigerant line and cryosurface.

Allow the isolation valves to warm up to room temperature before attempting to use them. This takes 2-3 hours without intervention, or about 10 minutes if gently warmed with a heat gun.

Close the COLD GAS FEED and HOT GAS FEED isolation valves by turning them clockwise. Turn on the unit and wait 30-45 seconds. (The SUCTION pressure should be 15-25 psig.) Close the COMMON RETURN isolation valve while the unit is still running. Turn off the unit.

**2. Allow the remaining refrigerant to escape.**

Locate the EVACUATION VALVE on the right side of the unit. Unscrew the protective cap. Remove the flare nut and bonnet.

Note the SUCTION pressure. Slowly midseat the EVACUATION VALVE to release the remaining refrigerant in the refrigerant line and cryosurface. (Midseat the EVACUATION VALVE by turning the valve stem three complete rotations in the counter-clockwise direction.) Verify the unit's SUCTION pressure is not dropping. If it is, close the valve stem and make certain the isolation valves are fully closed.

Close the valve stem by turning it clockwise. Put on the bonnet and flare nut. Put on the protective cap.

**NOTE:** *For PFC/PFC or PFC/P: This releases the refrigerant from both refrigerant lines and cryosurfaces.*

**3. Disconnect the thermocouples.**

See [Figure 3-22](#) and [Figure 3-23](#).

Loosen the two lower screws on the side of the low voltage box. Slide the panel straight up to remove it. Disconnect the COIL IN (TC #3) and COIL OUT (TC #4) thermocouples from the terminal block.

Unscrew the cap from the EXTERNAL TC fitting on the back of the low voltage box. Remove the rubber seal from the fitting and remove the thermocouples from the low voltage box. Put the rubber seal back in the EXTERNAL TC fitting and screw its cap back on. Secure the thermocouple wires to the refrigerant line to keep them from being damaged.

**NOTE:** *For PFC/PFC or PFC/P: If you are removing the lower refrigerant line, then disconnect the #2 COIL IN (TC #5) and #2 COIL OUT (TC #6) thermocouples.*


#### **4. Disconnect the couplings and install blank-off fittings.**

Remove the insulation from around the couplings on the refrigerant line. Make certain the couplings are at room temperature before disassembling them.

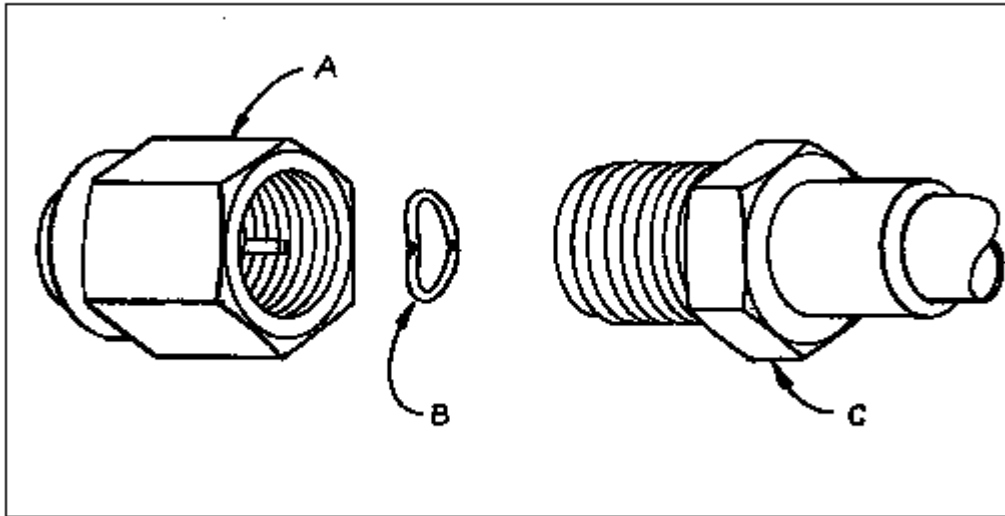
For Parker CPI UltraSeal couplings (standard fitting):

Keep the male coupling stationary with the 15/16-inch wrench and loosen the nut with a 1-inch wrench. Unscrew the nut on each coupling.

Screw the O-ring removal tool onto the male coupling and tighten it to between 10 and 20 foot-pounds (14-27 Nm). Unscrew the O-ring removal tool. The O-ring should be bent enough to remove it easily with two fingers. See Figure 8-1

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> Over tightening the O-ring removal tool will damage the sealing surface of the coupling. Under tightening the O-ring removal tool will not dimple the O-ring enough to remove it easily. Attempting to pry the O-ring from the groove may damage the sealing surface and can damage the equipment. Be careful when screwing the O-ring removal tool onto the male coupling.</p>

Install the rubber O-rings and metal blank-off fittings. (This step ensures that no additional refrigerant will be lost.) Protect the other half of the couplings with plastic caps.



*Figure 8-1: Parker CPI UltraSeal coupling—O-ring removal tool usage (standard fitting)*

- A. O-ring removal tool
- B. Silver plated stainless steel O-ring
- C. Male coupling

For Cajon VCR couplings (optional fitting, not shown):

Hold one nut stationary with a backup wrench, and loosen the other nut with a second wrench. Unscrew the two nuts. Remove the gaskets and install the blank-off fittings. (This step ensures that no additional refrigerant will be lost.) Protect the other half of the couplings with plastic caps.

### **8.3 How to Replace the Refrigerant**

Refer to Polycold Document 825071, Instructions for Replacing the Refrigerant in Large Units.

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# 9

# Options

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## Overview

This section describes the options available for this product.

## Contents

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## 9.1 CE Mark Units

### Introduction

Refrigeration systems with the CE Mark are built to conform to European Community requirements. The refrigeration unit has the following modifications.

- TÜV approved expansion tanks (pressure vessels)
- Additional pressure relief valve hardware

The EC declaration of conformity and the disclosure that is in compliance with EN 60204-1, Annex B should have been received. The following information is compliant with prEN378 when installing and servicing the unit.

### Additional Information for [section 3.2.1 Inspect the Unit](#) and [section 5 Periodic Inspection and Maintenance](#)

The 551, 552, 661, 662, 672, and 1102 have two pressure relief valves that also have a rupture disc with a pressure gauge. One rupture disc with pressure gauge is for the suction side of the compressor. The second rupture disc with pressure gauge is for the refrigerant line and cryosurface. The gauges are located next to each other in the refrigeration unit.

- For 1101 and 1102s: Remove the front panel from the refrigeration unit. Both gauges are on the right side of the unit near the front. The gauge for the refrigerant line and cryosurface is behind the gauge for the suction side of the compressor.
- For 551s, 552s, 661s, 662s, and 672s: Remove the lower back panel from the refrigeration unit. When facing the back of the unit:
- Both pressure gauges are in front of the expansion tanks.
- The gauge for the refrigerant line and cryosurface is to the left of the gauge for the suction side of the compressor.

### Additional Information for [section 3.2.2 Position the Unit](#)

Normally, the manufacturer provides the type and amount of refrigerant used in the refrigeration unit. However, Polycold Systems considers their mixtures of refrigerants to be proprietary. Therefore, the following information is provided.

- The amount of refrigerant mixture, minimum room size, and refrigerant safety group classification are included next to the refrigeration unit's nameplate. The nameplate is located on the back of the low voltage box.


**NOTE:** *Polycold Systems 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 as a guide.*

- The cryopump is a “direct (refrigeration) system.” It is only intended to be installed above ground in an industrial environment (occupancy category C).
- The refrigeration unit has a PRESSURE RELIEF OUTLET with a 3/4-inch female NPT fitting. This port allows direct refrigerant escaping from a pressure relief valve to be moved to another location. See section 7.4.9.1 of prEN378-2 to determine if this is required. See [Table 9-1](#) for piping requirements.

### **Additional Information Regarding Tests**

Polycold Systems leak tested and strength pressure tested the refrigeration unit at its factory. Polycold also checked the refrigeration unit’s protective devices unless the devices were checked by Polycold’s vendor.

Polycold Systems also leak tested and strength pressure tested the refrigerant line and cryosurface at its factory (assuming items were bought from Polycold Systems).

	<b>⚠ CAUTION</b>
	<b>GENERAL HAZARD</b> Strength pressure testing the refrigerant line or cryosurface while it is attached to the refrigeration unit may cause minor or moderate injury. The rupture disk may burst if it is pressurized above 400 psig (2760 kPa). The pressure relief valve may leak if it is pressurized above 335 psig (2310 kPa). Do not strength pressure test the refrigerant line or cryosurface while it is attached to the refrigeration unit.

*Table 9-1: Pressure Relief Piping Requirements to Comply with prEN378*

<b>Refrigeration Unit</b>	<b>Recommended Discharge Capacity <sup>1</sup></b> (kg refrigerant / s)	<b>Maximum Length of 1/2 inch or 15 mm Diameter Pipe <sup>2</sup></b> (m)	<b>Maximum Length of 3/4 inch or 20 mm Diameter Pipe <sup>2</sup></b> (m)
552	0.119	34.4	140
662, 672	0.119	34.4	140
1102	0.119	12.8	53
<p><b>NOTE:</b> <sup>1</sup> These discharge capacities are recommended by Polycold Systems based on the actual relief requirements of the refrigeration system.  <sup>2</sup> Maximum length of piping is based on the recommended discharge capacity using standard wall steel pipe and pressure relief devices set at 300 psig (2070 kPa).</p>			

## 9.2 Isolated Interface Option

### Introduction

The isolated interface is a device that maintains electrical isolation between the refrigeration unit's control voltage and a control system's voltage. This isolation prevents spurious electrical signals in either system from affecting the other system. It also allows the refrigeration unit to interface with an incoming voltage different than the 24 V(ac) used internally. Voltage option was specified when the isolated interface was ordered.

Isolation is provided by relays on a printed circuit board (I/O) board. A signal from the control system to the refrigeration unit activates the appropriate relay coil, closing the contact. This contact closure initiates the desired function within the refrigeration unit.

Status information from the refrigeration unit to the system activates a 24 V(ac) output relay, closing the contact. The control system must provide the appropriate detection circuit to interpret the contact closure.

**NOTE:** *The analog output signal for remote temperature indication is not isolated.*

### Additional Instructions for [section 3 Installation](#)

#### 1. Verify the voltage option

Loosen the two lower screws on the side of the low voltage box. Slide the low voltage box panel straight up to remove it.

Locate the isolated interface I/O board in the lower half of the low voltage box. Check the voltage specification printed on the housings of relays #1, #5, and #7. The voltage specified on the above relays should indicate the control supply voltage.

**NOTE:** *For 12 V(ac) and 24 V(ac) options: Rectifiers are put before each relay, so the relay housings will indicate "DC" instead of "AC."*

**NOTE:** *For PFC/PFC: Also check the housings of relays #11 and #13.*

**NOTE:** *For PFC/P: Also check the housing of relay #11.*

2. Verify that the control system meets the electrical requirements.

See [Table 9-2](#).

*Table 9-2: Isolated Interface Option—Electrical Requirements*

Specified Voltage Option	To Control the Refrigeration Unit		To Obtain Status Information
	Acceptable Voltage Range (V)	Coil Resistance ( $\Omega$ )	Acceptable Current Range <sup>†</sup> (mA)
6 V (ac)	4.8 - 6.6	18.8	100 - 5000
6 V (dc)	4.8 - 6.6	47.0	100 - 5000
12 V (ac or dc)	9.6 - 13.2	188.0	60 - 5000
24 V (ac or dc)	18.2 - 26.4	750.0	30 - 5000
<p><b>NOTE:</b> † The voltage used to obtain status information must not exceed 24 V.            † Minimum current required to keep relay contacts clean. If this is not possible, see <a href="#">section 9.1 CE Mark Units</a>, “Additional Instructions for <a href="#">section 3.2.1 Inspect the Unit</a> and <a href="#">section 5 Periodic Inspection and Maintenance</a>.”            † Maximum switching current for inductive or resistive loads.</p>			

3. Connect the control system to the isolated I/O connector plug.

The isolated interface provides the same status information and control functions as the standard remote connector. Follow the instructions in section 3.8 “How to Install the Remote Control” with the following exceptions:

- Disregard [Figure 10-6](#) through [Figure 10-8](#). See [Figure 9-1](#) through [Figure 9-5](#) and [Table 9-4](#).
- The contacts inserted into the back of the isolated I/O connector plug are sockets instead of pins.

**Additional Instructions for [section 4 Operation](#)**

The refrigeration unit cannot operate in COOL and DEFROST at the same time. If the control system attempts to do this, the refrigeration unit will operate in COOL.

A “remote verification” signal for each refrigerant circuit is provided when the following conditions are met.

- Electrical power is connected to the refrigeration unit and the power disconnect switch is in the ON position.
- The ON/OFF switch on the unit’s SYSTEM CONTROL panel is in the ON position, and the refrigeration unit (compressor) is running.
- The refrigerant circuit is in REMOTE.

If the refrigeration unit is shut off by one of Polycold’s protective devices, both the “remote verification” signal and the “unit OK” signal will turn OFF.

**Additional Instructions for [section 5 Periodic Inspection and Maintenance](#)**

Check the operation of each relay every year if running at less than the minimum current. See [Table 9-2](#). If it is necessary to replace the relay, refer to the following part numbers.

*Table 9-3: Isolated Interface Option Parts List*

<b>Relay Description</b>	<b>IDECs (manufacturer) Part Number</b>	<b>Polycold Part Number</b>
6 V(ac)	RH1B-U AC 6V	Not released
6 V(dc)	RH1B-U DC 6V	Not released
12 V(dc)	RH1B-U DC 12V	Not released
24 V(dc)	RH1B-U DC 24	333026-01
24 V(ac), 1-pole†	RH1B-U AC 24V	333019-01
24 V(ac), 2-pole†	RH2B-U AC 24V	333019-02
<b>NOTE:</b> † For relays operated by the refrigeration unit’s control voltage		

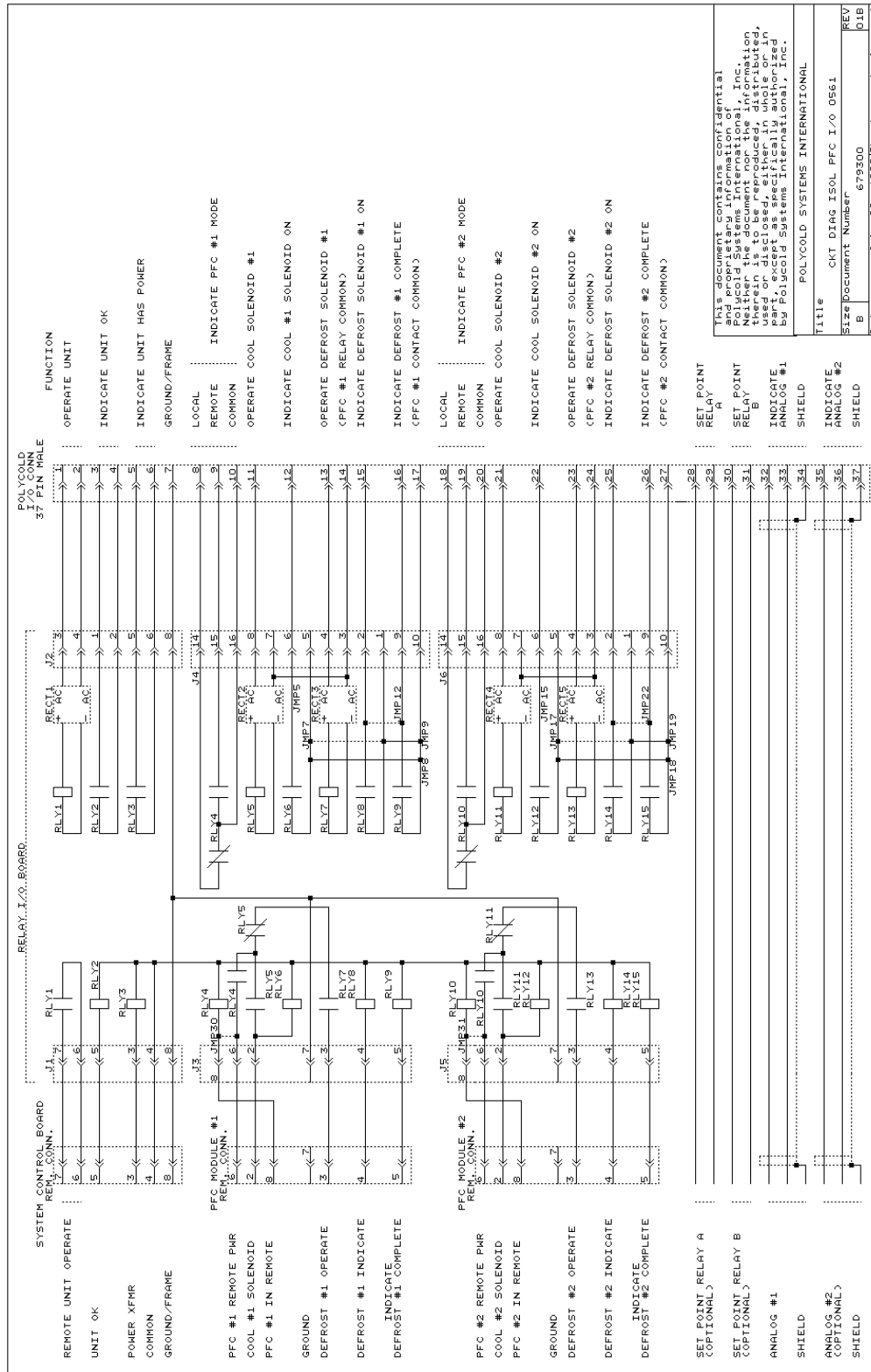
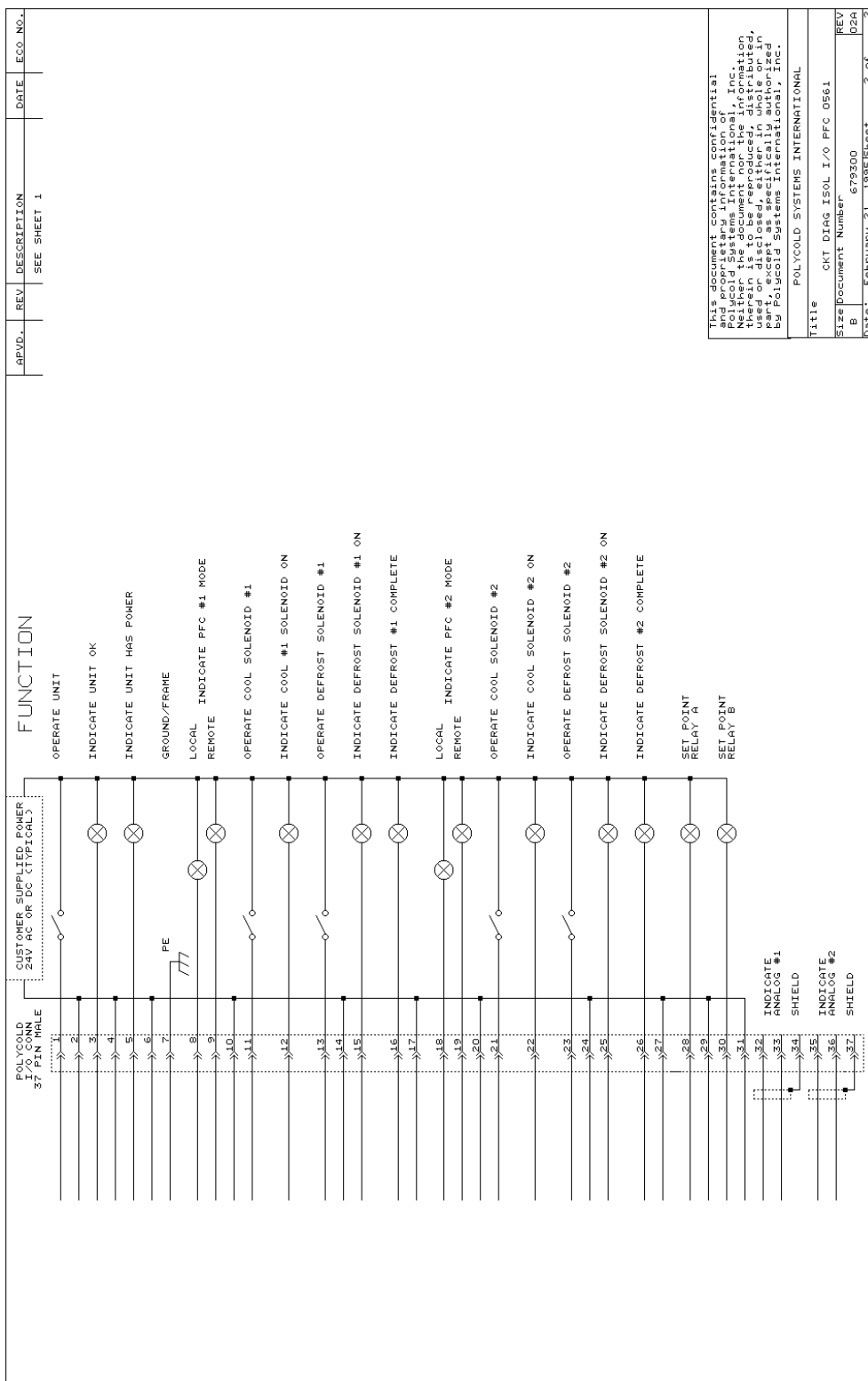


Figure 9-1: PFC and PFC/PFC isolated interface option—internal wiring





*Figure 9-2: PFC and PFC/PFC isolated interface option suggested wiring for customer's control system*

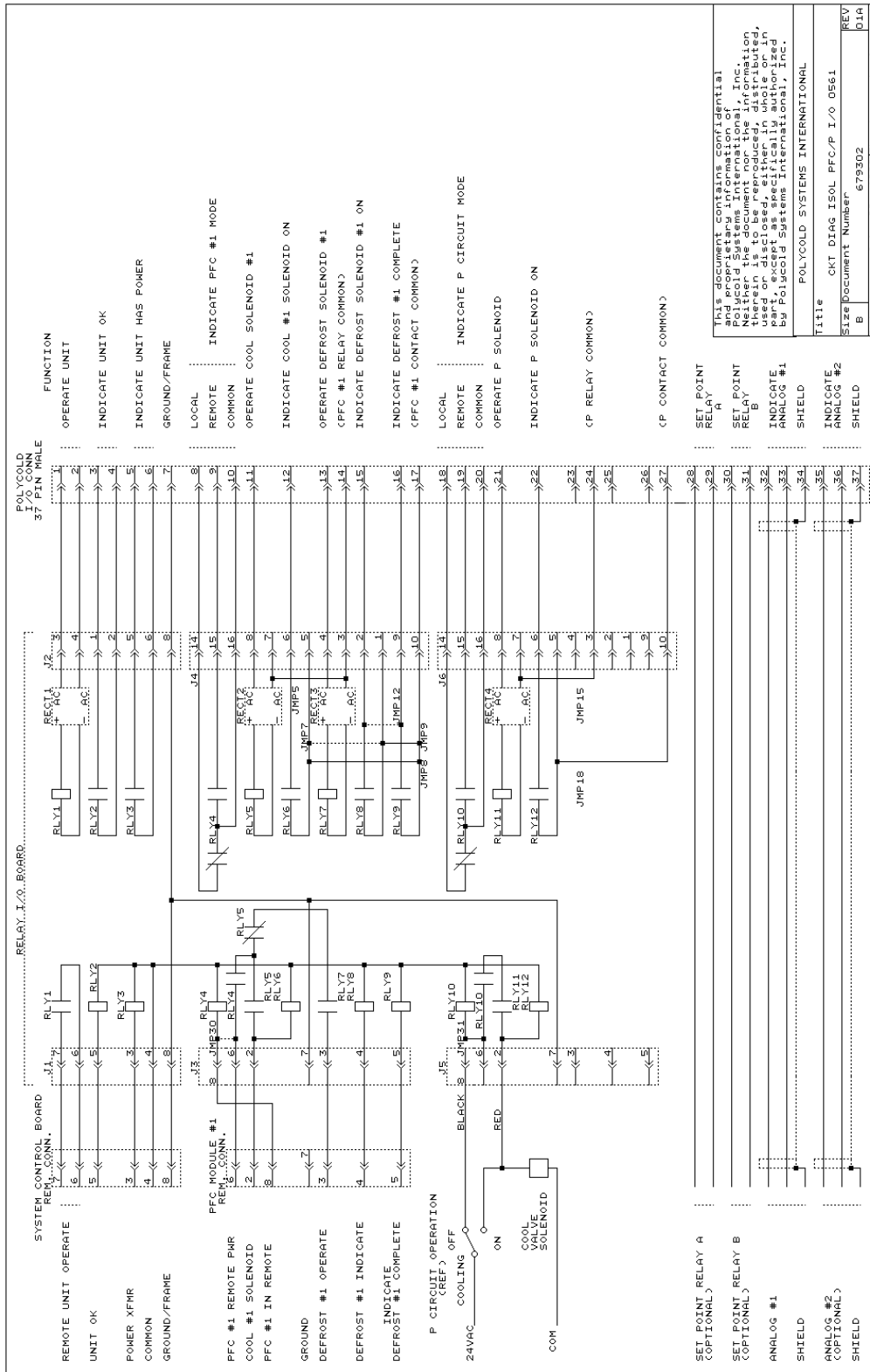
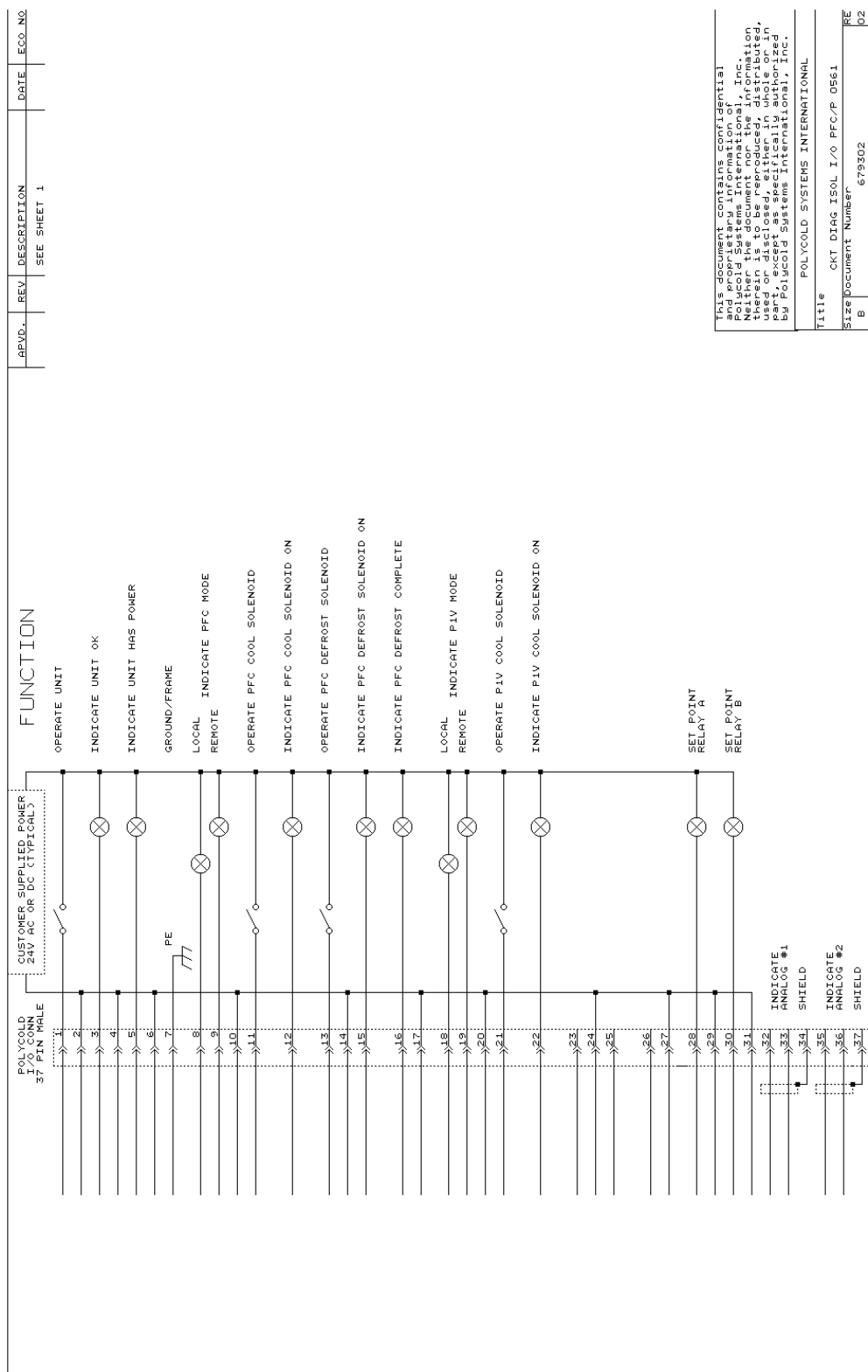


Figure 9-3: PFC/P isolated interface option—internal wiring

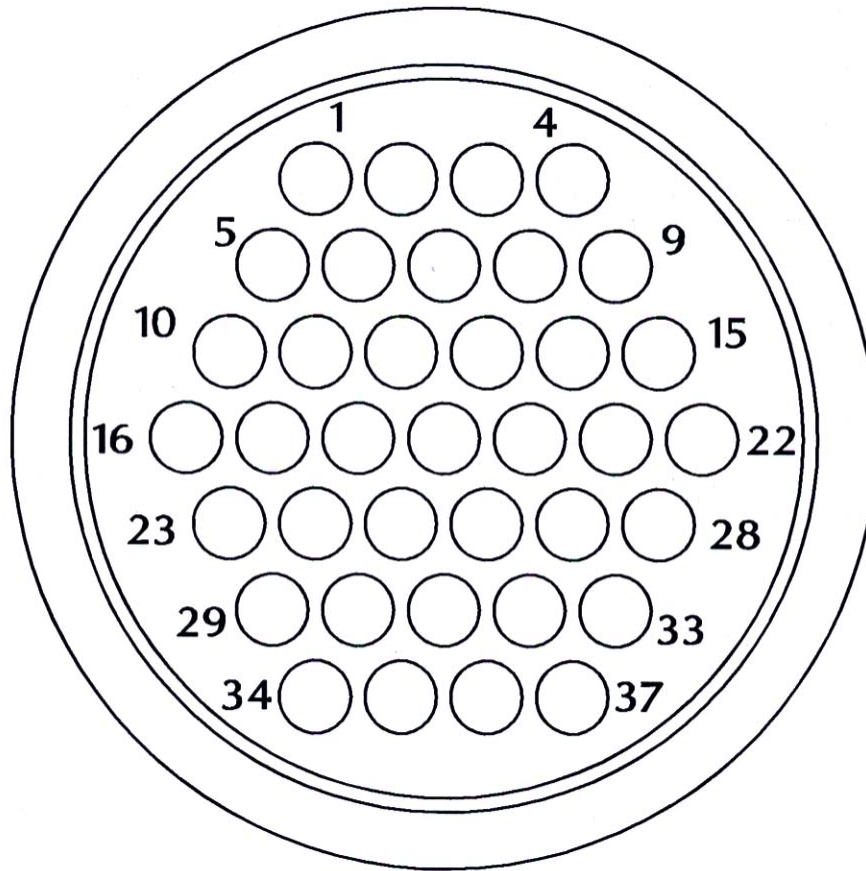


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Figure 9-4: PFC/P isolated interface option—suggested wiring for customer’s control system



*Figure 9-5: Isolated interface option—wire side of isolated I/O connector plug*

*Table 9-4: Isolated Interface Option—Isolated I/O Connector Wiring Worksheet*

<b>Group</b>	<b>Wire Function</b>	<b>Pin Number</b>	<b>Customer's Wire Color</b>
<b>System Control</b>	Operate Unit	1	
		2	
	Indicate Unit OK	3	
		4	
	Indicate Power	5	
		6	
	Ground	7	
<b>Refrigerant Circuit 1 (PFC)</b>	Indicate REMOTE- LOCAL	8	
	Indicate REMOTE – REMOTE	9	
	Indicate REMOTE – Common	10	
	Operate COOL	11	
	Indicate COOL	12	
	Operate DEFROST	13	
	Operate Common	14	
	Indicate DEFROST ACTIVE	15	
	Indicate DEFROST COMPLETE	16	
	Indicate Common	17	

Table 9-4: Isolated Interface Option—Isolated I/O Connector Wiring Worksheet

Group	Wire Function	Pin Number	Customer's Wire Color
<b>Refrigerant Circuit 2 (PFC or P)</b>	Indicate REMOTE- LOCAL	18	
	Indicate REMOTE – REMOTE	19	
	Indicate REMOTE – Common	20	
	Operate COOL	21	
	Indicate COOL	22	
	Operate DEFROST (PFC only)	23	
	Operate Common	24	
	Indicate DEFROST ACTIVE (PFC only)	25	
	Indicate DEFROST COMPLETE (PFC only)	26	
	Indicate Common	27	
<b>Option</b>	Indicate Setpoint Relay A	28	
		29	
<b>Option</b>	Indicate Setpoint Relay B	30	
		31	
<b>Temperature Meter 1</b>	Analog # 1 – Out	32	
	Analog # 1 – Return	33	
	Analog # 1 – Shield	34	
<b>Option—Temperature Meter 2</b>	Analog # 2 – Out	35	
	Analog # 2 – Return	36	
	Analog # 2 – Shield	37	

### 9.3 Leybold Isolated Interface Option

The Leybold isolated interface option is the same as Polycold's standard isolated interface option with the following exceptions.

- The Leybold isolated interface option is only designed for models PFC and PFC/PFC.
- The Leybold isolated interface option is only designed for an incoming voltage of 24V.
- The isolated I/O connector plug has a different pin configuration.
- The Leybold isolated interface does not provide a “remote verification” signal.

Follow the instructions in [section 9.2 Isolated Interface Option](#) with the following exceptions:

- [Figure 9-6](#)
- [Figure 9-7](#)
- Leybold Isolated Interface Option—Isolated I/O Connector Wiring Worksheet
- Disregard all prior figures and [Table 3-10](#)
- Disregard any information with respect to “remote verification” signal

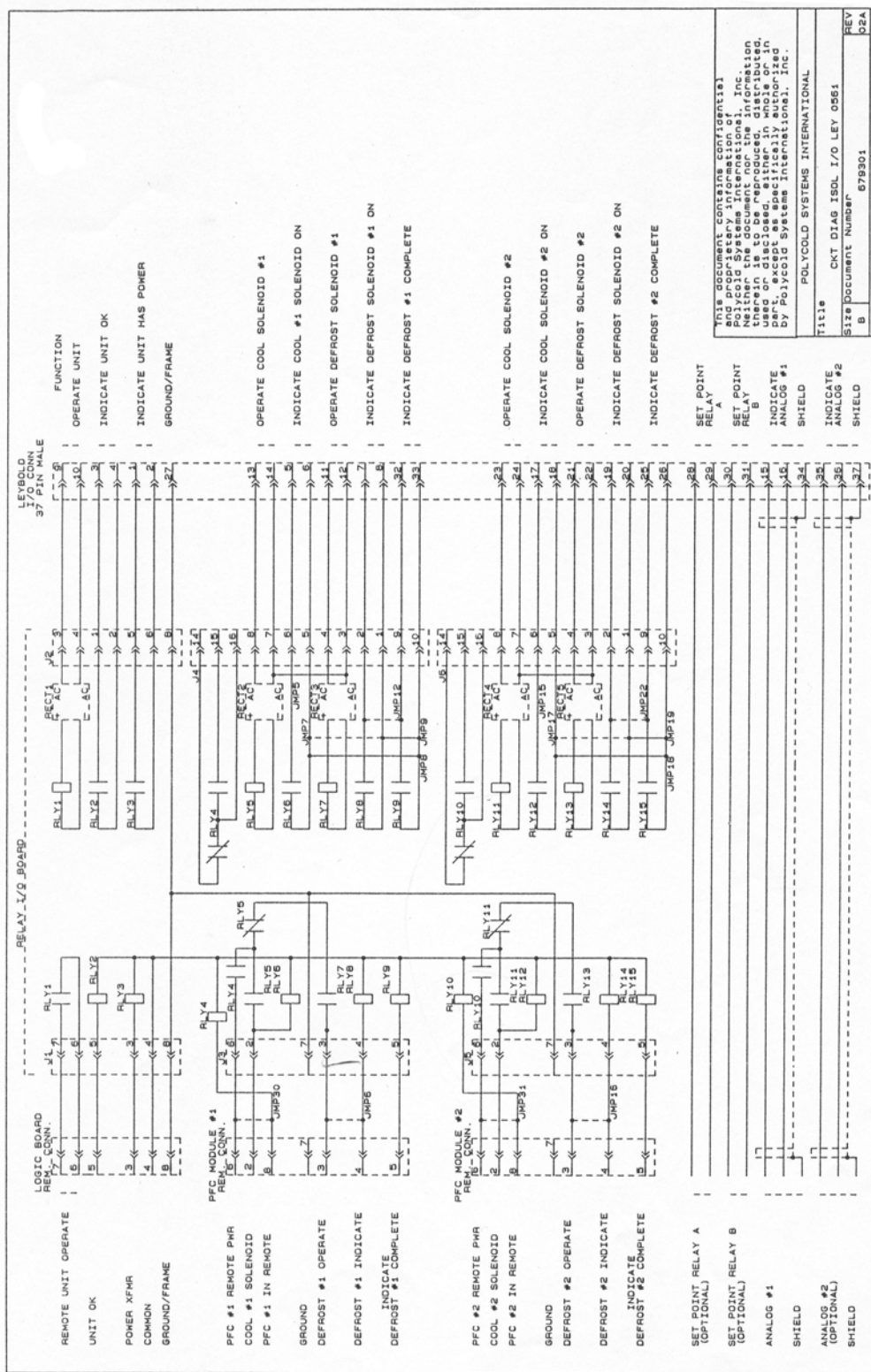


Figure 9-6: Leybold isolated interface option- schematic



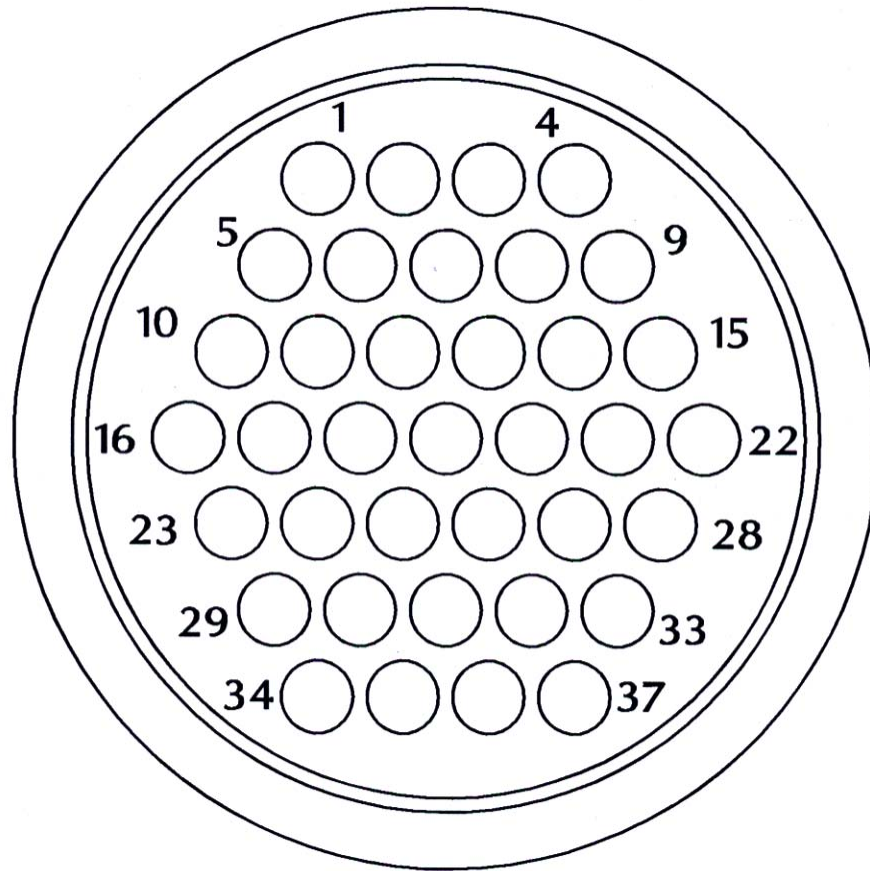


Figure 9-7: Leybold isolated interface option – wiring side of isolated I/O connector plug

Table 9-5: Leybold Isolated Interface Option—Isolated I/O Connector Wiring Worksheet

Group	Wire Function	Pin Number	Customer's Wire Color
System Control	Indicate Power	1	
		2	
	Indicate Unit OK	3	
		4	

Table 9-5: Leybold Isolated Interface Option—Isolated I/O Connector Wiring Worksheet

Group	Wire Function	Pin Number	Customer's Wire Color
<b>Refrigerant Circuit 1 (PFC)</b>	Indicate COOL	5	
		6	
	Indicate DEFROST	7	
		8	
<b>System Control</b>	Operate Unit	9	
		10	
<b>Refrigerant Circuit 1 (PFC)</b>	Operate DEFROST	11	
		12	
	Operate COOL	13	
		14	
<b>Temperature Meter 1</b>	Analog #1 – Out	15	
	Analog #1 – Return	16	
<b>Refrigerant Circuit 2 (PFC)</b>	Indicate COOL	17	
		18	
	Indicate DEFROST	19	
		20	
	Operate DEFROST	21	
		22	
	Operate COOL	23	
		24	
Indicate DEFROST COMPLETE	25		
	26		
<b>System Control</b>	Ground	27	
<b>Option</b>	Indicate Setpoint Relay A	28	
		29	

*Table 9-5: Leybold Isolated Interface Option—Isolated I/O Connector Wiring Worksheet*

<b>Group</b>	<b>Wire Function</b>	<b>Pin Number</b>	<b>Customer's Wire Color</b>
<b>Option</b>	Indicate Setpoint Relay B	30	
		31	
<b>Refrigerant Circuit 1 (PFC)</b>	Indicate DEFROST COMPLETE	32	
		33	
<b>Temperature Meter 1</b>	Analog #1 - Shield	34	
<b>Option— Temperature Meter 2</b>	Analog #2 - Out	35	
	Analog #2 - Return	36	
	Analog #2 - Shield	37	

## 9.4 Temperature Module Options

### Introduction

The temperature module options give the user additional information about one or more temperatures of interest.

- See front of manual for the temperature module option and the thermocouple numbers selected.
- See [Figure 9-9](#) for identification of options.
- See [Figure 3-23](#) for identification of thermocouple numbers.

### Set-point Indication

The setpoint indication provides confirmation that a temperature of interest is below a pre-determined setpoint. This temperature is transmitted to the thermocouple limit switch via a type T thermocouple. The setpoint on the thermocouple limit switch is adjustable from  $-80^{\circ}\text{C}$  to  $-160^{\circ}\text{C}$ . When the temperature from the input thermocouple drops below the defined setpoint, the thermocouple limit switch:

1. lights a lamp on the temperature panel, and
2. closes a relay contact completing a circuit between two pins in the remote connector.

### Second Temperature Meter

The second temperature meter provides continuous indication of a single temperature between  $-199^{\circ}\text{C}$  and  $+199^{\circ}\text{C}$ . For more information about the temperature meter or using the analog output, see [section 3.8.2 Additional Instructions for Remote Temperature Indication](#).

The analog output signal for remote temperature indication is not isolated.

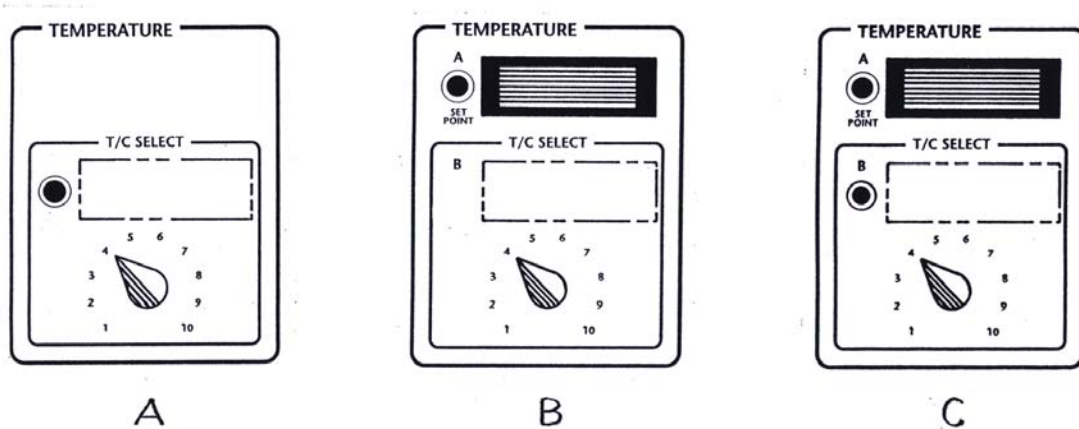


Figure 9-8: Temperature module options identification

- A. Option 600212-02: Setpoint indication, See Figure 9-9.
- B. Option 600212-03: Second temperature meter & setpoint indication, see [Figure 9-10](#).
- C. Option 600212-04: Second temperature meter & two setpoint indications, see [Figure 9-11](#).

Additional Instructions for [section 3 Installation](#)

1. **Connect the thermocouple wires to the appropriate terminal in the terminal block.**

For TCs #1, #2, #7, #8, #9, & #10

These thermocouples were connected at the factory. Skip this step and go to [Step 2](#) in this section.

**NOTE:** *The COLDEST LIQUID (TC #9) temperature may rise above the setpoint when the refrigeration unit is switched from STANDBY to COOL. This is due to increased heat load while cooling the cryosurface.*

For TCs #3, #4, #5, & #6

Connect the thermocouple wire to the appropriate terminal inside the low voltage box. Follow the instructions in [section 3.3.5 Connect the COIL IN & COIL OUT Thermocouples](#).

**2. Set the temperature on the thermocouple limit switch.**

Turn the knob to adjust the thermocouple limit switch to a desired temperature. The accuracy of the setpoint dial is  $\pm 5^{\circ}\text{C}$ .

**3. Connect the refrigeration unit to the remote control system (if a remote connector was installed).**

Verify the remote control system provides an appropriate detection circuit to interpret the setpoint relay contact closure.

- The maximum control voltage is 24V.
- The minimum current is 30 mA. (This is required to keep the relay contacts clean. If this is not possible, see “Additional Instructions for [section 5 Periodic Inspection and Maintenance](#)” in this section.)
- The maximum current is 5A (for inductive or resistive loads).

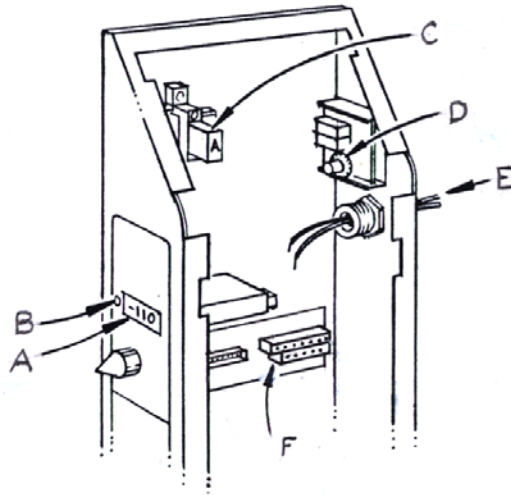
Connect the remote control system to the remote connector.

- For a standard remote connector, follow the instructions in [section 3.8 How to Install the Remote Control \(Optional\)](#)
- For an isolated I/O connector, see [section 9.2 Isolated Interface Option](#)

**Additional Instructions for [section 5 Periodic Inspection and Maintenance](#)**

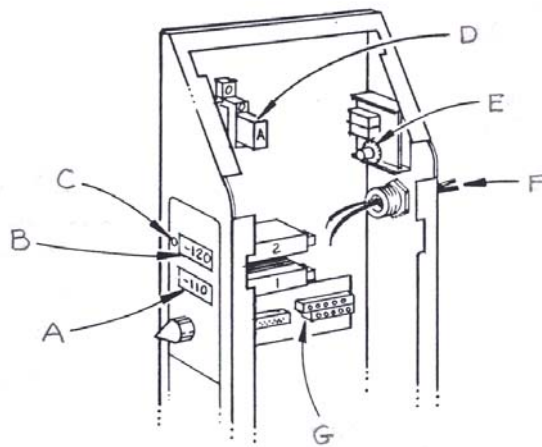
Check the operation of the setpoint relay(s) every year if running at less than the recommended minimum current. See [Figure 9-9](#) through [Figure 9-11](#). If it is necessary to replace a relay, refer to the following part numbers.

<b>Relay Description</b>	<b>IDEC's (manufacturer) Part Number</b>	<b>Polycold's Part Number</b>
24 V(ac), 1-pole	RH1B-U AC 24V	333019-01



*Figure 9-9: Temperature module options—parts identification for option 600212-02*

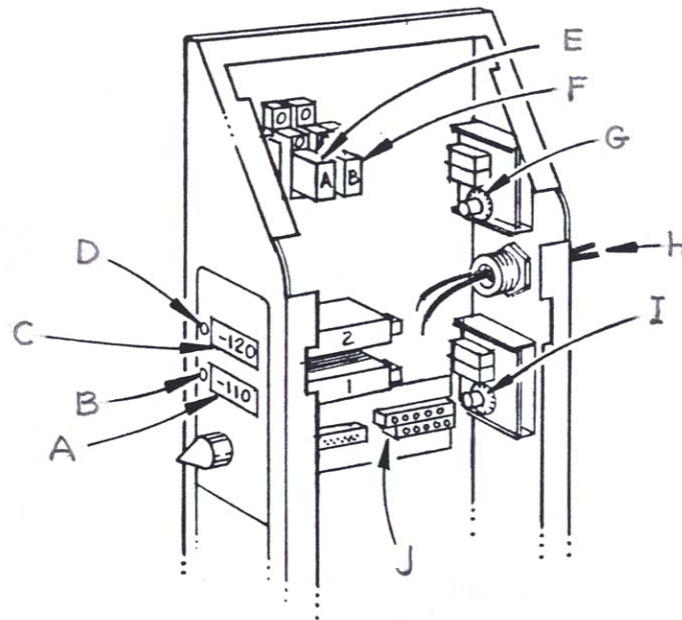
- A. Standard temperature meter
- B. Lamp for setpoint A
- C. Relay for setpoint A
- D. Thermocouple limit switch knob for setpoint A
- E. External thermocouple entrance
- F. Terminal blocks for thermocouple connections



*Figure 9-10: Temperature module options—parts identification for option 600212-03*

- A. Standard temperature meter
- B. Second temperature meter
- C. Lamp for setpoint A
- D. Relay for setpoint A
- E. Thermocouple limit switch knob for setpoint A
- F. External thermocouple entrance
- G. Terminal blocks for thermocouple connections





*Figure 9-11: Temperature module options—parts identification for option 600212-04*

- A. Standard temperature meter
- B. Lamp for setpoint B
- C. Second temperature meter
- D. Lamp for setpoint A
- E. Relay for setpoint A
- F. Relay for setpoint B
- G. Thermocouple limit switch knob for setpoint A
- H. External thermocouple entrance
- I. Thermocouple limit switch knob for setpoint B
- J. Terminal blocks for thermocouple connections

## 9.5 High Liquid Line Temperature Alarm Option

### Introduction

This option is a modification of Polycold's standard liquid line protection and the temperature module options. It is used in locations where the temperature of the cooling water is marginally warm 86-93°F (30-34°C).

Normally the refrigeration unit is shut off if the LIQUID LINE (TC #2) temperature exceeds 33°C. The High Liquid Line Temperature Alarm Option does the following.

If the LIQUID LINE (TC #2) temperature rises above 33°C, a thermocouple limit switch:

- lights the lamp next to the temperature display, and
- closes a relay contact completing a circuit between two pins in the remote connector.

If the LIQUID LINE (TC #2) temperature rises above 38°C, a second thermocouple limit switch:

- shuts off the refrigeration unit,
- lights the HIGH LIQUID TEMPERATURE lamp on the SYSTEM CONTROL panel, and
- opens a contact which terminates the "unit OK" signal to the remote connector.

**NOTE:** *If the LIQUID LINE is too hot when the unit is started, a bypass timer allows 14 seconds for it to cool down before the unit is shut off.*

### Additional Instructions for [section 3 Installation](#) (if a remote connector was installed)

Verify the remote control system provides an appropriate detection circuit to interpret the setpoint relay contact closure.

- The maximum control voltage is 24V.
- The minimum current is 30 mA. (This is required to keep relay contacts clean. If this is not possible, see "Additional Instructions for [section 5 Periodic Inspection and Maintenance](#)" in this section.)
- The maximum current is 5A (for inductive or resistive loads).
- Connect the remote control system to the remote connector.
- If the remote connector is standard, see [section 3.8 How to Install the Remote Control \(Optional\)](#).

- If you have an isolated I/O connector, see [section 9.2 Isolated Interface Option](#).

**NOTE:** *If no other Temperature Module options were purchased, the high liquid line temperature alarm will be designated “Setpoint A.” If the second temperature meter was purchased with setpoint relay, the high liquid line temperature alarm will be designated “Setpoint B.” See [section 9.4 Temperature Module Options](#)*

**Additional Instructions for [section 5 Periodic Inspection and Maintenance](#)**

Check the operation of the relay every year if running at less than the recommended minimum current. The relay is located above the temperature meter(s) on a rail mount inside the low voltage box. If it is necessary to replace the relay, refer to the following part numbers.

<b>Relay Description</b>	<b>IDECs (manufacturer) Part Number</b>	<b>Polycold Part Number</b>
24V(ac), 1-pole	RH1B-U AC 24V	333019-01

## 9.6 How to Install the GVE Remote Control Option

The GVE Remote Control Option is Polycold's standard remote control option:

- The GVE Remote Control Option is designed for models PFC-550s, PFC-660s, PFC-670s, and PFC-1100s.
- Electrical signals are transferred to and from the refrigeration unit via a terminal strip (instead of a remote connector).

### 9.6.1 Connect the GVE Remote Control Option

#### Tools and materials needed:

- Phillips screwdriver
- 5/16 inch nut driver
- Drill or punch (as required)
- Liquid tight fitting (for drilled or punched hole)
- Straight blade screwdriver
- 18 AWG (0.75 mm<sup>2</sup> cross-sectional area) wire / cable
- Wire strippers
- Terminal crimping tool
- Crimp ring terminals for #6 screws
- Switches with a minimum capacity of 1A
- 24V indicator lamps (optional<sup>1</sup>)
- Shielded cable (optional<sup>2</sup>)

<sup>1</sup> If function indicator lamps are wanted at a remote location

<sup>2</sup> If remote temperature indication is wanted



#### 9.6.1.1 Review the remote control schematic

See [Figure 10-6](#). The remote connector pin numbers are the terminal numbers for the GVE Remote Control Option.

Determine if a unit ON/OFF switch or function indicator lamps are wanted at a remote location. All circuits connected to the terminal strip are 24V(ac).

**NOTE:** *A temperature from the TC SELECT switch can also be displayed at a remote location through the remote connector. To do this, see [section 3.8.2 Additional Instructions for Remote Temperature Indication](#).*

### 9.6.1.2 Connect the control system to the terminal strip

	 <b>WARNING</b>
	<p><b>ELECTRICAL HAZARD</b> Contact could cause electric shock and result in death or serious injury. Make certain the ON/OFF switch and the power disconnect switch are in the OFF position.</p>

Loosen the two lower screws on the side of the low voltage box. Slide the panel straight up to remove it. See [Figure 3-22](#).



Remove the plate marked REMOTE from the back of the low voltage box. Drill or punch a hole in the plate and install the liquid tight fitting. Reinstall the plate.


Feed the cable through the liquid tight fitting. Strip the insulation from the end of each wire. Crimp each wire to a terminal. Screw each terminal to the appropriate location on the terminal strip.

Tighten the liquid tight fitting around the cable.

### 9.6.1.3 Connect the wires to the control system

See [Table 9-6](#) in this section. The remote connector pin numbers are the terminal numbers for the GVE Remote Control Option.

	 <b>CAUTION</b>
	<p><b>GENERAL HAZARD</b> Make sure the wiring configuration does not operate the unit in COOL &amp; DEFROST at the same time; damage to the equipment can result. Polycold recommends the use of a three-position switch.</p>

	<b>⚠ CAUTION</b>
	<p><b>GENERAL HAZARD</b> Make sure the wiring configuration does not start the unit in COOL or DEFROST; damage to the equipment can result. The three-position switch should be in the neutral position so that the unit will start in STANDBY. (When REMOTE is selected local functions will be disabled.)</p>

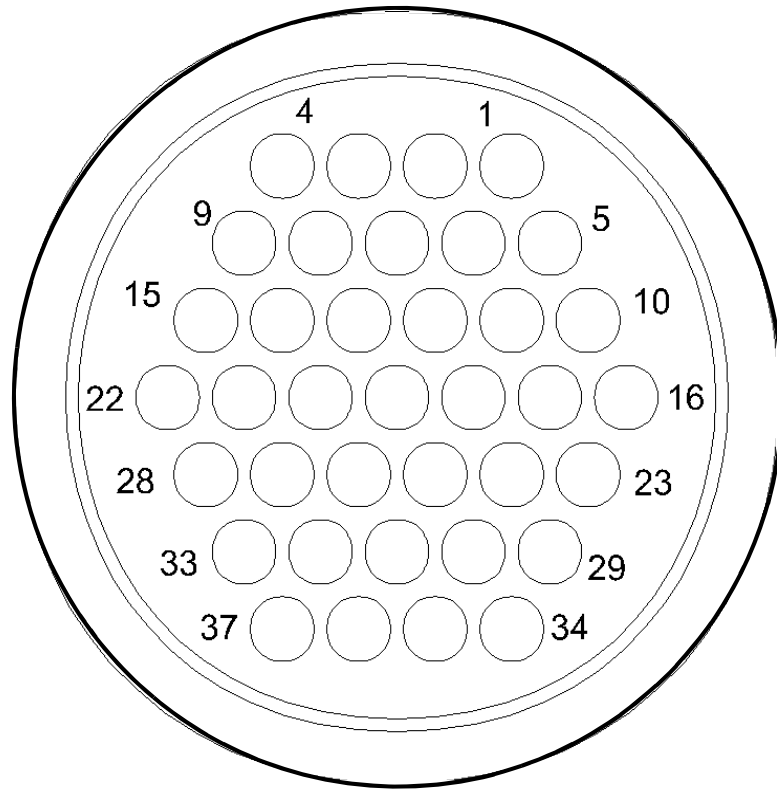


Figure 9-12: Wire side of remote connector plug

*Table 9-6: Remote Connector Wiring Worksheet*

<b>Group</b>	<b>Wire Function</b>	<b>Pin Number</b>	<b>Customer's Wire Color</b>
<b>System Control</b>	Operate Unit	1	
		2	
	Indicate Unit OK	3	
	Indicate Power	4	
	Common	5	
	Ground	6	
<b>Refrigerant Circuit 1 (PFC)</b>	Indicate REMOTE	10	
	Operate COOL	11	
	Operate DEFROST	12	
	Indicate DEFROST COMPLETE	13	
	Indicate DEFROST ACTIVE	14	
<b>Refrigerant Circuit 2 (PFC or P)</b>	Indicate REMOTE	18	
	Operate COOL	19	
	Operate DEFROST (PFC only)	20	
	Indicate DEFROST COMPLETE (PFC only)	21	
	Indicate DEFROST ACTIVE (PFC only)	22	
<b>Option</b>	Indicate Setpoint Relay A	26	
		27	
<b>Temperature Meter 1</b>	Analog # 1 - Out	28	
	Analog # 1 - Return	29	
	Analog # 1 - Shield	30	
<b>Option</b>	Indicate Setpoint Relay B	31	
		32	

Table 9-6: Remote Connector Wiring Worksheet

Group	Wire Function	Pin Number	Customer's Wire Color
Option— Temperature Meter 2	Analog #2 - Out	33	
	Analog #2 - Return	34	
	Analog #2 - Shield	35	

#### 9.6.1.4 Program the remote control if a controller is present

See [section 4 Operation](#) for operation modes.

#### 9.6.1.5 If a remote ON / OFF switch has been installed, unplug jumper J11 from the SYSTEM CONTROL printed circuit board

Locate JMPR J11 on the SYSTEM CONTROL printed circuit board in the low voltage box. See [Figure 3-30](#) and [Figure 3-31](#). Squeeze the jumper's latch to unplug it.

Reinstall the low voltage box panel. Slide it straight down onto the low voltage box so that the two tabs go into their notches. Push the top of the panel towards the unit and at the same time push down so that the top tab goes into its notch. Tighten the two screws.

#### 9.6.1.6 Select REMOTE

**NOTE:** *When a refrigerant circuit is in LOCAL, its remote functions are disabled (including the unit's ON/OFF switch).*

#### 9.6.1.7 Make sure the remote control operates the unit properly

Use the remote control to do the following test.

Select STANDBY and turn on the refrigeration unit.

- The unit's compressor should be running.
- The unit's STANDBY indicator lamp should be lighted.
- The COLDEST LIQUID (TC #9) temperature should start getting colder.

Wait 30 minutes. Evacuate location of the cryosurface to at least 0.01 torr (1.33 Pa).

Switch to COOL.




- The unit's COOL indicator lamp should be lighted.
- The COIL OUT (TC #4) temperature should start getting colder.

Switch to DEFROST.

- The unit's DEFROST ACTIVE indicator lamp should be lighted.
- When DEFROST is complete, the unit's DEFROST COMPLETE and STANDBY indicator lamps should be lighted.

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

	<b>⚠ CAUTION</b>
	<b>EXTREME TEMPERATURES EXIST</b> Parts of the cryosurface may be hot; contact with the hot surface may result in minor or moderate injury. Do not touch the cryosurface.

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# 10

# Drawings

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## Overview

The Process & Instrumentation Diagrams and the Electrical Schematics on the following pages pertain to Models 550, 660, 670, and 1100 only.

## Contents

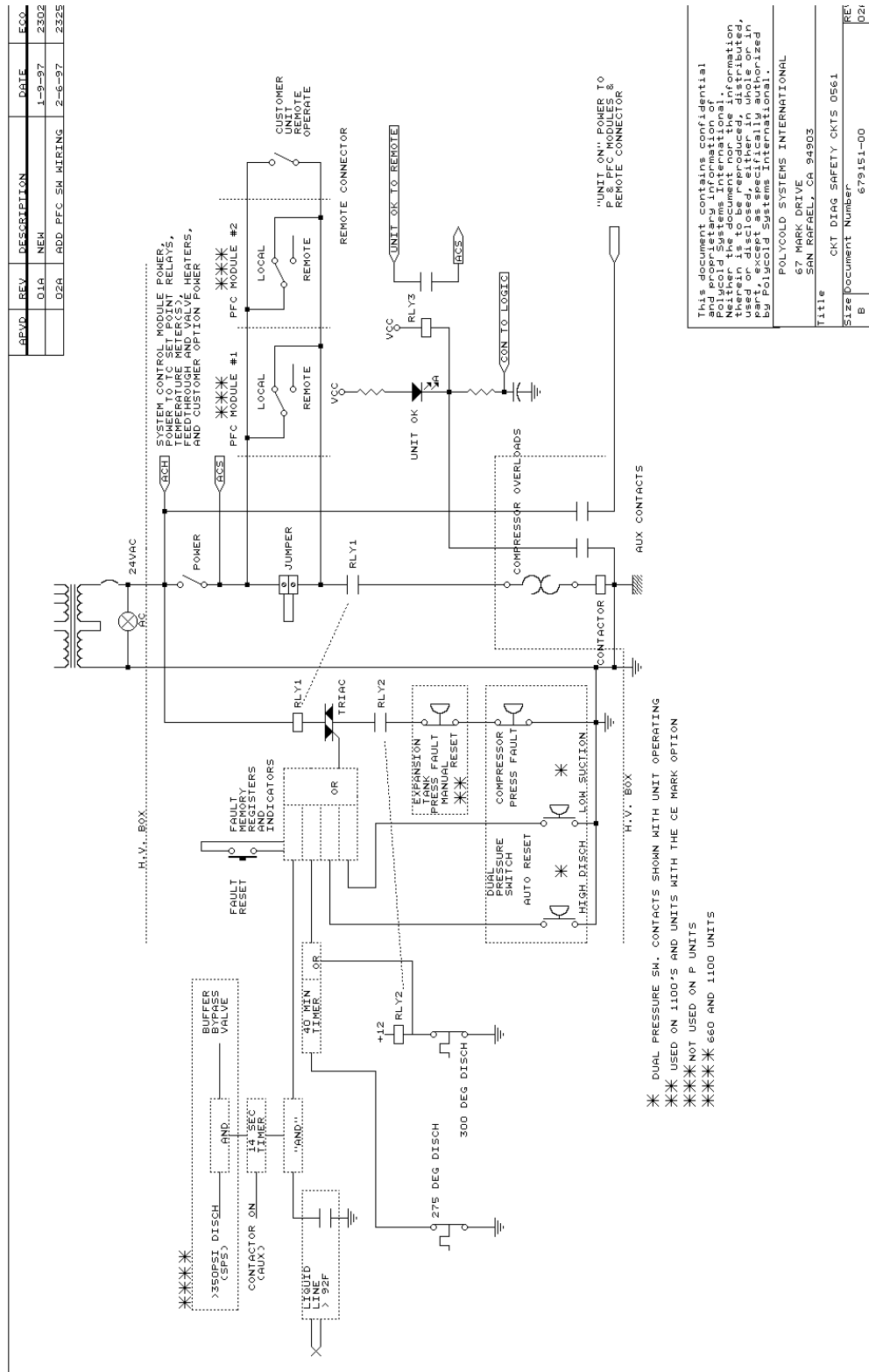
Figure 10-1: Cryopump Simplified Controls Diagram (6-2) .....	10-3
Figure 10-2: High Voltage Box (6-3) .....	10-4
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The Process & Instrumentation Diagrams and the Electrical Schematics on the following pages pertain to Models 550, 660, 670, and 1100 only.

Process & Instrumentation Diagrams and Electrical Schematics for additional Models are available in separate documents as listed in the table below.

*Table 10-1: Additional P & IDs and Electrical Schematics*

<b>Model</b>	<b>Document #</b>
PFC 551	825113-00
PFC 552	825114-00
PFC 661	825115-00
PFC 662	825116-00
PFC 672	825117-00
PFC 1101	825118-00
PFC 1102	825119-00



**Figure 10-1: Cryopump Simplified Controls Diagram (6-2)**

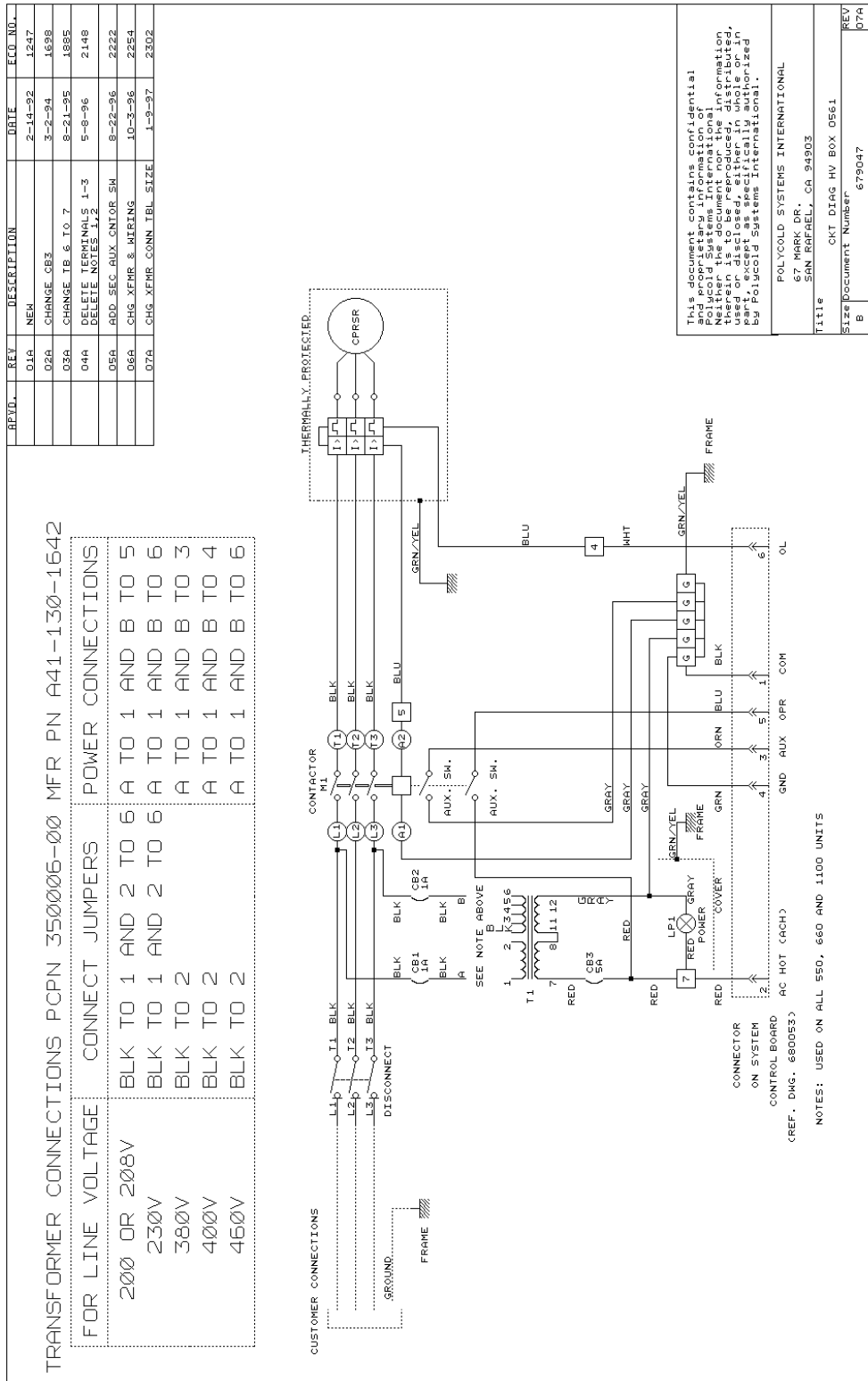
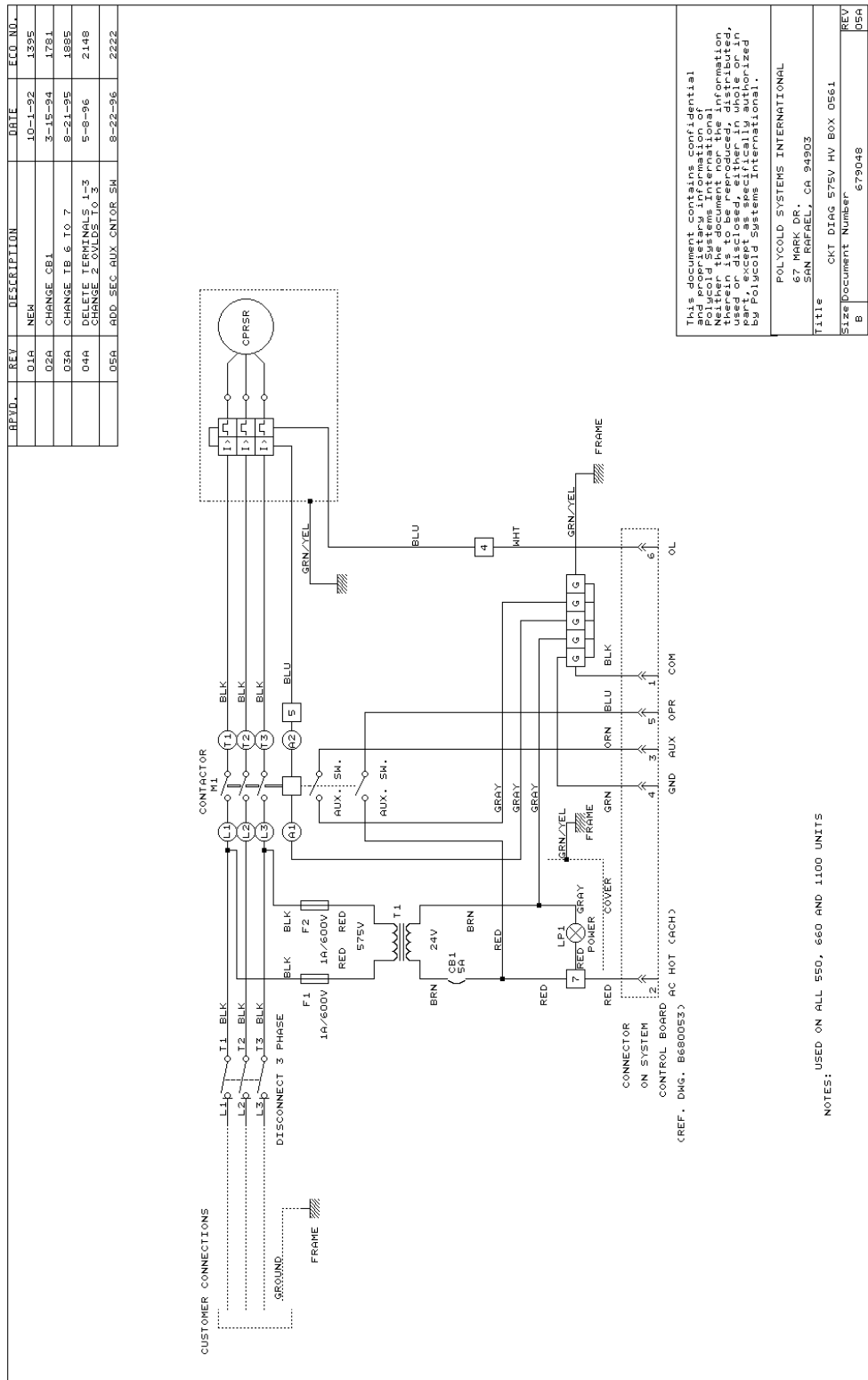


Figure 10-2: High Voltage Box (6-3)



**Figure 10-3: High Voltage Box—575 V Compressor Only (6-4)**

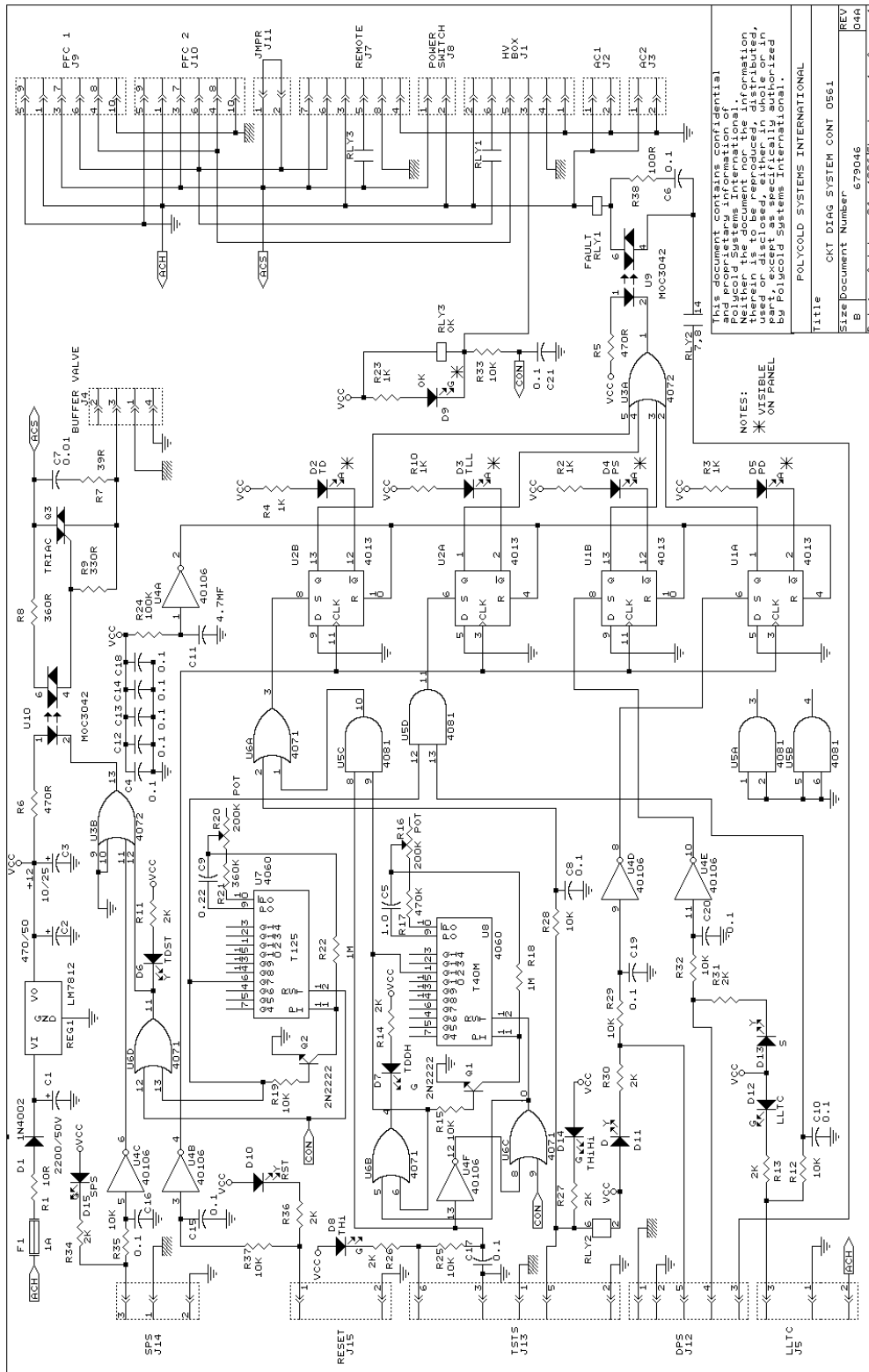


Figure 10-4: SYSTEM CONTROL Printed Circuit Board (6-5)



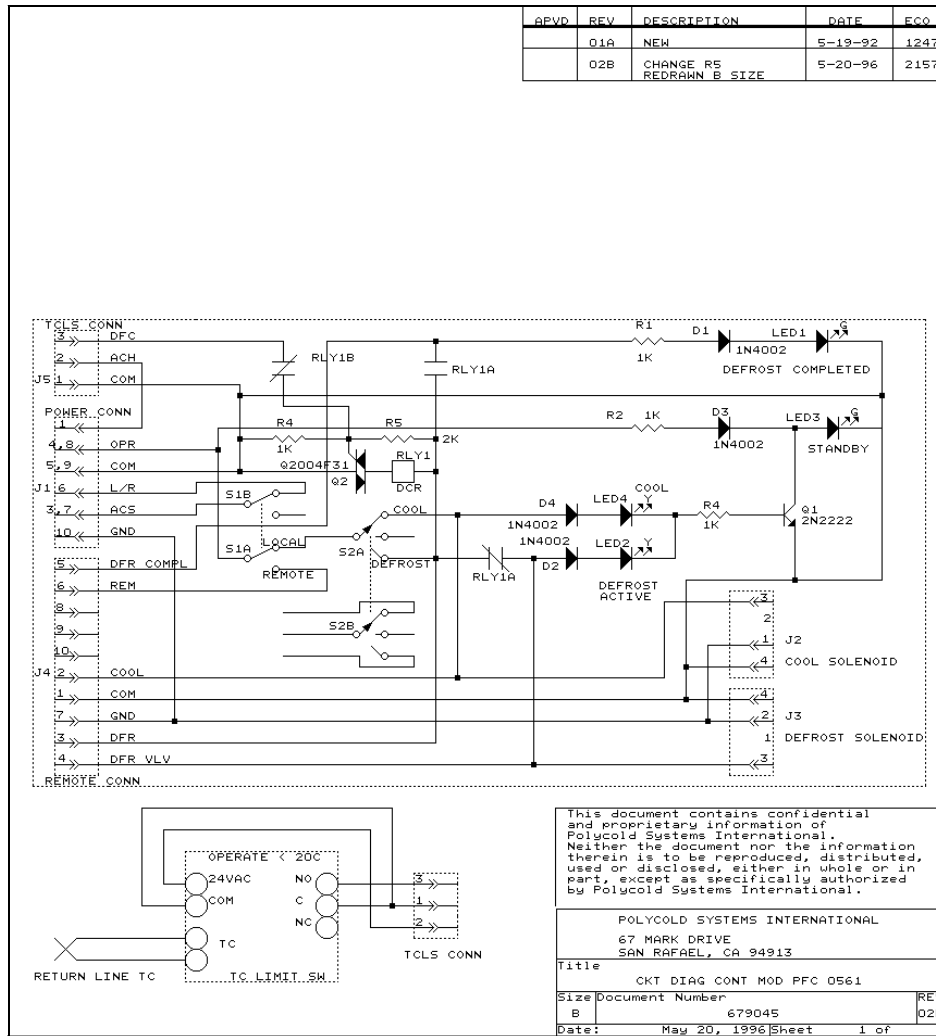


Figure 10-5: PFC Refrigerant Circuit Controls - Printed Circuit Board with Panel (6-7)

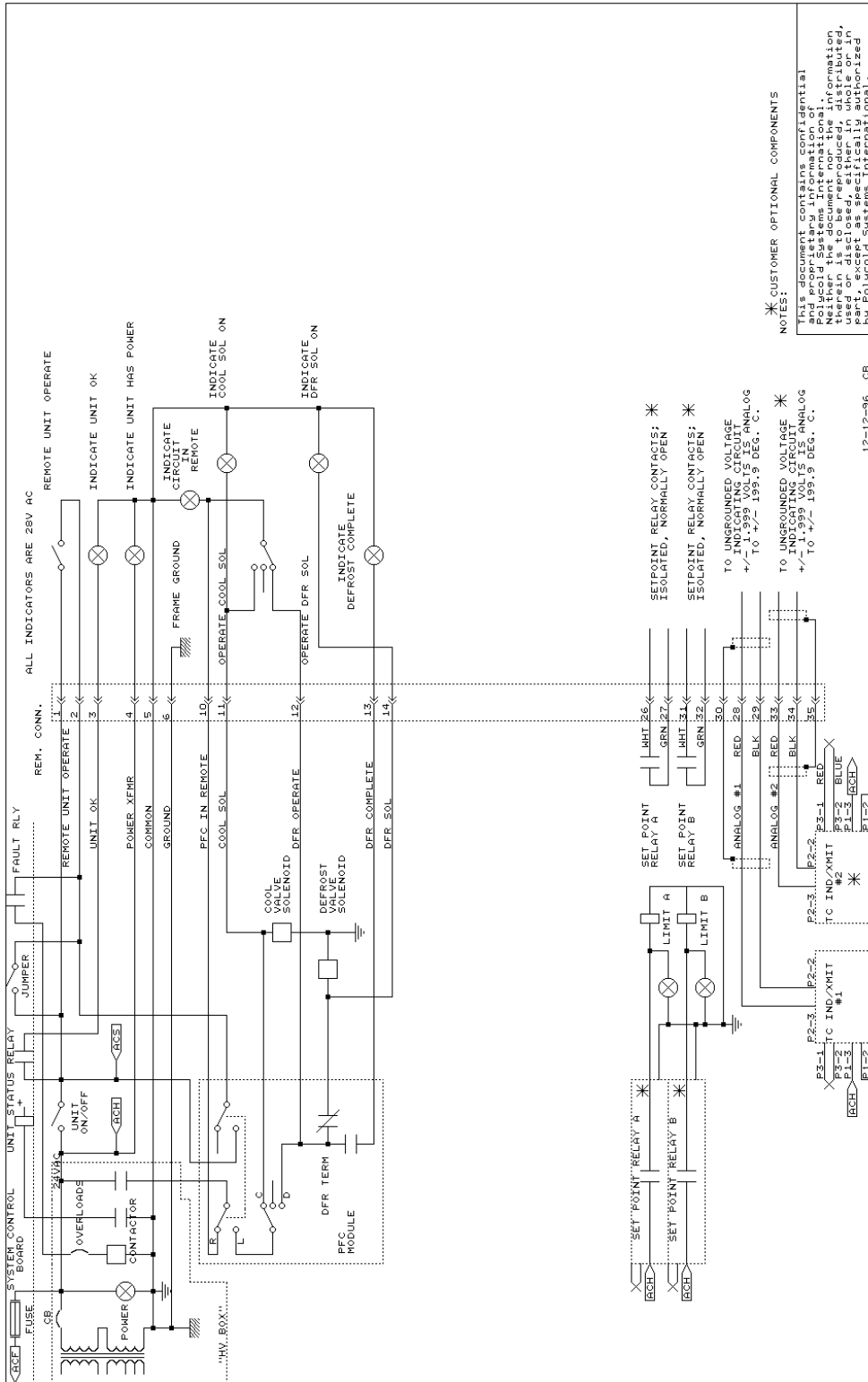


Figure 10-6: PFC Remote Connector Functions with Suggested Wiring (6-8)

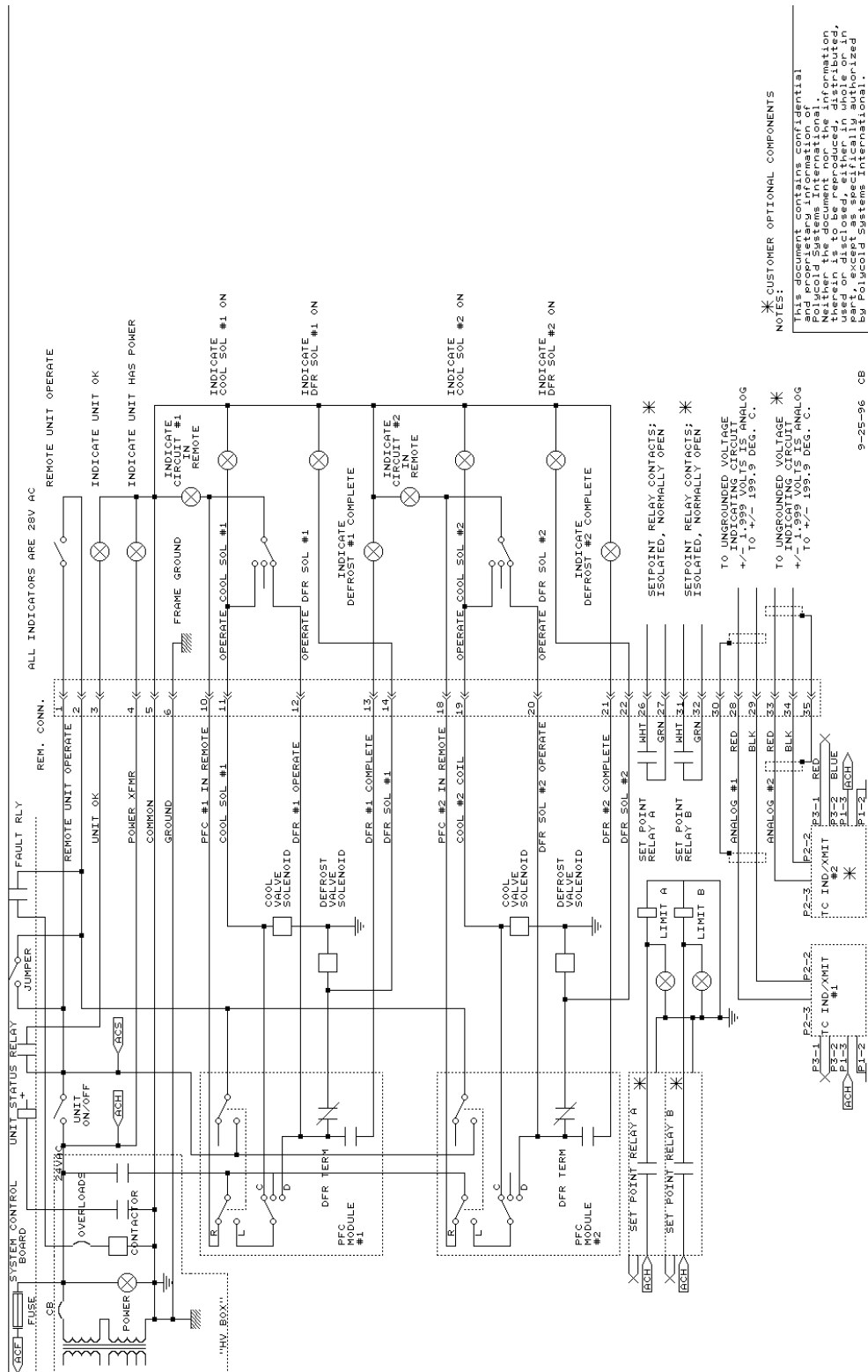


Figure 10-7: PFC/PFC Remote Connector Functions with Suggested Wiring (6-9)

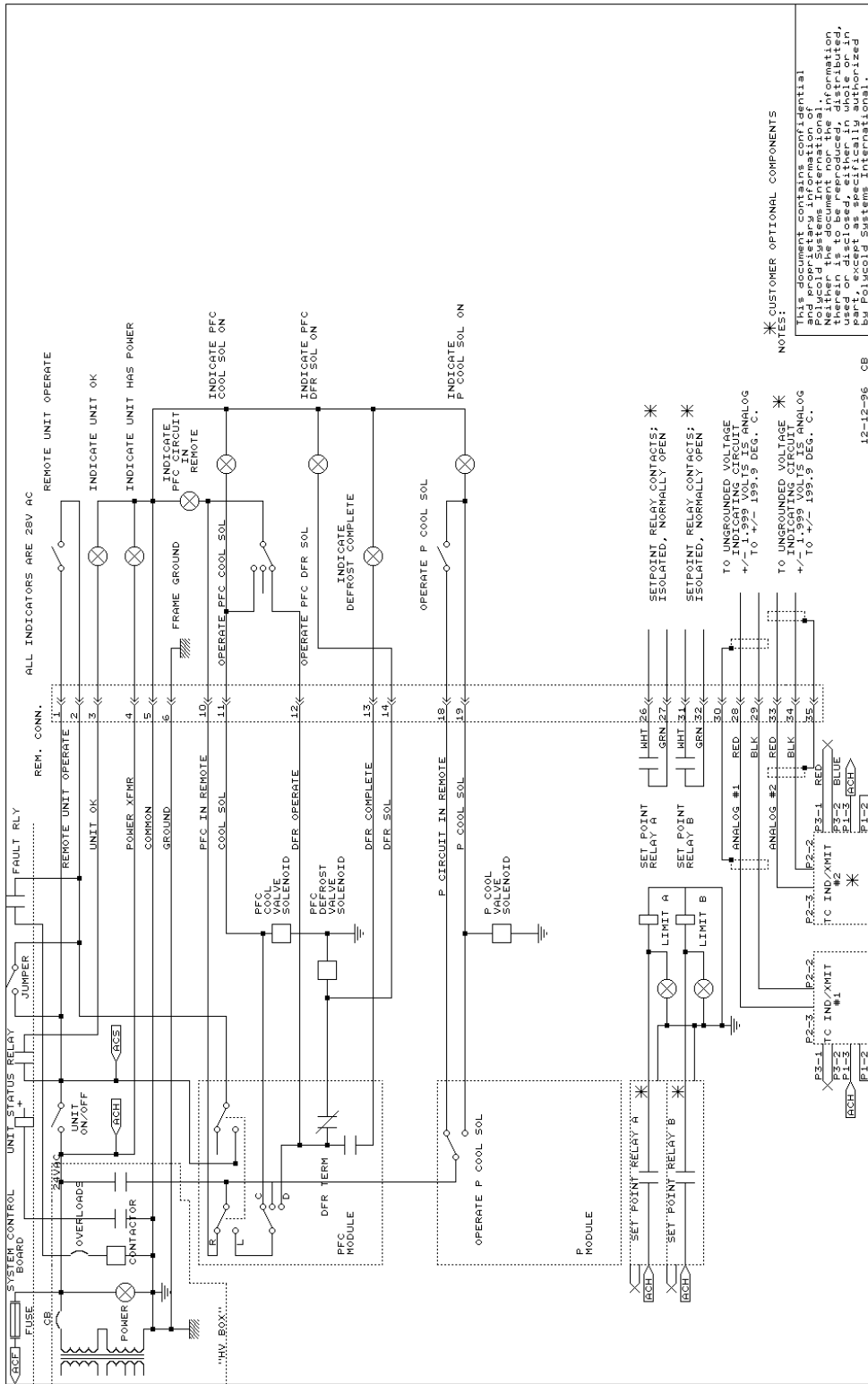


Figure 10-8: PFC/P Remote Connector Functions with Suggested Wiring (6-10)

## Glossary

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This Glossary provides a list of common terms and acronyms used in this document and their definitions.

- 3U:** U is a unit of height in electronic packaging of 1.75 in. 3U is three times that height (5.25 in.).
- Z Axis:** The axis of vertical motion. For a robot it is the “up and down” of the robot’s arms. For an elevator it is the “up and down” of the platform.
- 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. For 550s, 660s, and 1100s, the refrigeration unit must be off for 48 hours to obtain the balance pressure.
- CE:** European conformity.
- Coldest liquid:** A portion of the refrigerant circuit that obtains the lowest temperature prior to evaporation.
- Compressor:** A component in the refrigeration unit that raises the refrigerant pressure and causes the refrigerant to move through the circuit.
- Compressor compartment:** The lower portion of the refrigeration unit that contains the compressor and condenser.
- Condenser:** A component in the refrigeration unit that removes heat from the refrigerant vapor after it exits the compressor.

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<b>Cryopump:</b>	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).
<b>Cryosurface:</b>	The coil or baffle in the vacuum chamber that captures water molecules by freezing them to its surface.
<b>Discharge line:</b>	A portion of the refrigerant circuit containing high temperature, high pressure refrigerant just after it has exited the compressor.
<b>EC:</b>	European Community.
<b>EEC:</b>	European Economic Community.
<b>EMC:</b>	Electromagnetic compatibility.
<b>EN:</b>	European norm (or standard).
<b>Feed line:</b>	The copper tube in the refrigerant line that carries refrigerant from the refrigeration unit to the cryosurface.
<b>Field replacement charge:</b>	A refrigerant mixture that replaces the refrigerant in the cryopump.
<b>IEC:</b>	International Electro-technical Commission.
<b>I/O:</b>	Input / output.
<b>Liquid line:</b>	A portion of the refrigerant circuit containing high pressure refrigerant just after it has been cooled by the water-cooled condenser.
<b>Lower shelf:</b>	See “compressor compartment.”
<b>Manifold:</b>	The service manifold gauge set.
<b>NEC:</b>	National electrical code.
<b>NPT:</b>	National pipe thread.
<b>OFHC:</b>	Oxygen-free, high-capacity.
<b>Polycold stack:</b>	The upper portion of the refrigeration unit that is insulated with foam.
<b>Recharge:</b>	A procedure for replacing the refrigerant in a cryopump.

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<b>Refrigerant:</b>	A proprietary mixture of refrigerants made by Brooks Polycold Systems Inc.
<b>Refrigerant circuit:</b>	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.
<b>Refrigerant expansion tank:</b>	A tank inside the refrigeration unit that maintains the gaseous refrigerant at a safe pressure when the unit is not at operating temperature.
<b>Refrigerant line:</b>	The insulated feed and return lines that carry refrigerant to and from the cryosurface.
<b>Refrigeration unit:</b>	The machine containing the compressor, condenser, and Polycold stack that cools the refrigerant mixture to cryogenic temperatures.
<b>Return line:</b>	The copper tube in the refrigerant line that carries refrigerant from the cryosurface to the refrigeration unit.
<b>SAE:</b>	Society of Automotive Engineers.
<b>TC:</b>	Thermocouple.
<b>TC # ___:</b>	The position number of the TC SELECT switch that is located on the front of the refrigeration unit.
<b>Top-off charge:</b>	A refrigerant mixture that can be added to the refrigerant in the cryopump.
<b>TÜV:</b>	Technical Supervision Society; the organization responsible for verifying compliance with EN and IEC standards.
<b>UL:</b>	Underwriters Laboratories; the organization responsible for verifying compliance with NEC standards.

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