



On-Board[®] Cryopump Installation and Maintenance Manual



FOR SALES AND SERVICE PLEASE CALL:

PTB SALES

T :: 626.334.0500
service@ptbsales.com
www.ptbsales.com

DATE SERVICED: _____

VIEW OUR INVENTORY

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

AcuLigner™, Align™, AquaTran™, AutoTeach™, ATR™, AXM™, Basic Blue™, BiSymmetrik™, CenterSmart™, Cool Solutions™, Crate to Operate™, e-RMA™, e-Spares™, e-Volution™, FastRegen™, FIXLOAD™, FrogLeg™, InLigner™, InCooler™, Interface™, Jet Engine™, LowProfile™, M2 Nano™, Mini-Ion™, PASIV™, PowerPak™, PerformanceBlue™, PowerPak™, PowerTools™, QuadraFly™, Radius™, Radiant™, Radiant Express™, Reliance™, Reliance ATR™, RetroEase™, SCARA™, SmartPM™, SPOTLevel™, Synetics™, The New Pathway to Productivity™, Time Optimized Trajectory™, Time Optimal Trajectory™, Time Optimized Path™, TopCooler™, TopLigner™, Ultimate Blue™, VAC-407™, VacuTran™, Vacuum Quality Monitor™, VQM™, Vacuum Quality Index™, VQI™, and the Brooks logo are trademarks of Brooks Automation, Inc.

AcuTran®, AquaTrap®, Conduction®, Convector®, the Cool Solutions logo, Cryodyne®, Cryotiger®, Cryo-Torr®, Fusion®, GOLDLink®, Granville-Phillips®, Guardian®, GUTS®, Helix®, Jet®, Leapfrog®, MagnaTran®, MapTrak®, Marathon®, Marathon 2®, Marathon Express®, Micro-Ion®, MiniConvector®, On-Board®, Polycold®, Razor®, Simplicity Solutions®, the Simplicity Solutions logo, Stabil-Ion®, TrueBlue®, TurboPlus®, Vision®, Zaris®, and the Brooks Automation logo are registered U.S. trademarks of Brooks Automation, Inc.

All other trademarks are properties of their respective owners.

© 2013 Brooks Automation, Inc. All Rights Reserved. The information included in this manual is Proprietary Information of Brooks Automation and is provided for the use of Brooks Automation customers only and cannot be used for distribution, reproduction, or sale without the express written permission of Brooks Automation. This information may be incorporated into the user's documentation, however any changes made by the user to this information is the responsibility of the user.



For Technical Support:

| Location | GUTS® Contact Number |
|---------------|---|
| North America | +1-800-FOR-GUTS (1-800-367-4887) +1-978-262-2900 |
| Europe | +49-1804-CALL-GUTS (+49-1804-2255-4887) |
| Japan | +81-45-477-5980 |
| China | +86-21-5131-7066 |
| Taiwan | +886-3-5525225 |
| Korea | +82-31-288-2500 |
| Singapore | +65-6464-1481 |

Visit us online: www.brooks.com

January 11, 2013 Part Num 8040491 Revision AB

This technology is subject to United States export Administration Regulations and authorized to the destination only; diversion contrary to U.S. law is prohibited.

Printed in the U.S.A.

Table of Contents

Table of Contents

List of Figures

List of Tables

Cryopump Safety

| | |
|---|-----|
| Hazard Alerts | S-1 |
| Safety Icons | S-2 |
| Signal Words | S-2 |
| Safety Text | S-3 |
| References | S-3 |
| Cryopump Hazards | S-4 |
| Toxic, Corrosive, Dangerous Gases, or Liquids | S-4 |
| Flammable or Explosive Gases | S-5 |
| Electric Shock | S-5 |
| High Gas Pressure | S-6 |
| Regen Control Users Only | S-7 |
| Cryopump Oxygen Procedures | S-8 |
| Lifting Requirements | S-9 |

Section 1 - On-Board Cryopump Description

| | |
|--|------|
| Introduction | 1-1 |
| Installation, Operation, Troubleshooting, and Maintenance Procedures | 1-1 |
| Microprocessor-Based Control System | 1-1 |
| Remote Operation Options | 1-2 |
| Specifications | 1-6 |
| Theory of Operation | 1-19 |
| Cold Head | 1-19 |
| Vacuum Vessel and Arrays | 1-19 |
| Compressor Gas and Oil Flows | 1-19 |

Section 2 - Installation

| | |
|-----------------------------------|-----|
| Introduction | 2-1 |
| Keypad/Display Installation | 2-2 |
| Position A | 2-2 |

| | |
|---|------|
| Position B | 2-3 |
| Position C | 2-4 |
| Position D | 2-5 |
| On-Board Cryopump Installation | 2-6 |
| On-Board 500 Cryopump Installation | 2-7 |
| Vent Pipe Connection | 2-9 |
| Roughing Pump Connection | 2-10 |
| Rough Valve Gas Connection | 2-10 |
| Purge Gas Connection | 2-10 |
| Helium Line Connections | 2-10 |
| Auxiliary (AUX) TC Gauge Installation | 2-11 |
| Setpoint Relays | 2-11 |
| | 2-12 |
| Remote Keypad/Display Installation (Optional) | 2-12 |

Section 3 - Troubleshooting

| | |
|---------------------------|-----|
| Technical Inquiries | 3-2 |
|---------------------------|-----|

Section 4 - Maintenance

| | |
|---|------|
| Helium Circuit Decontamination | 4-1 |
| Background | 4-2 |
| Equipment/Tools Requirements | 4-3 |
| Method # 1 - Decontaminate all On-Board Cryopumps | 4-6 |
| Decontamination Alternatives | 4-10 |
| Method # 2 Decontamination of Only Cold Cryopumps | 4-11 |
| Step 1 - Method # 2. | 4-11 |
| Step 17 - Method # 2. | 4-11 |
| Method # 3 Grouped Decontamination Using Manifold | 4-11 |
| Step 5 - Method # 3. | 4-12 |
| Step 6 - Method # 3. | 4-12 |
| Step 10- Method # 3 | 4-12 |
| Steps 11 - 16 - Method # 3 | 4-12 |
| On-Board Cryopump Cleaning | 4-15 |

Index

List of Figures

List of Tables

List of Figures

| | |
|---|------|
| Figure 1-1: On-Board Cryopumps | 1-3 |
| Figure 1-2: On-Board Cryopumps | 1-4 |
| Figure 1-3: On-Board Cryopumps | 1-5 |
| Figure 1-4: Typical On-Board Cryopump System | 1-20 |
| Figure 1-5: Cutaway View of a Typical Flat On-Board Cryopump Vessel | 1-21 |
| Figure 1-6: Cutaway View of a Typical Straight On-Board Cryopump Vessel... | 1-22 |
| Figure 1-7: Typical Flat On-Board Cryopump Component Identification | 1-23 |
| Figure 1-8: Typical Straight On-Board Cryopump Component Identification ... | 1-24 |
| Figure 2-1: Block Diagram for On-Board Cryopump Installation | 2-1 |
| Figure 2-2: Keypad/Display Mounting Position A | 2-2 |
| Figure 2-3: Keypad/Display Mounting Position B | 2-3 |
| Figure 2-4: Keypad/Display Mounting Position C | 2-4 |
| Figure 2-5: Keypad/Display Mounting Position D | 2-5 |
| Figure 2-6: Lifting Bars | 2-7 |
| Figure 2-7: Setpoint Relays Connection and Pin Identification | 2-12 |
| Figure 4-1: Decontamination Flowchart | 4-4 |
| Figure 4-2: On-Board Cryopump Helium Supply and Return Lines | 4-8 |
| Figure 4-3: Maintenance Manifold Part Number 8032051G001 | 4-13 |
| Figure 4-4: Proper Helium Line Coupling Disconnection/Connection | 4-14 |

This Page Intentionally Left Blank

List of Tables

| | |
|--|------|
| Table 1-1: On-Board 4 Cryopump Specifications | 1-6 |
| Table 1-2: On-Board 4F Cryopump Specifications | 1-7 |
| Table 1-3: On-Board 6 Cryopump Specifications | 1-8 |
| Table 1-4: On-Board 8 Cryopump Specifications | 1-9 |
| Table 1-5: On-Board 8F Cryopump Specifications | 1-10 |
| Table 1-6: On-Board Enhanced 8F Cryopump Specifications | 1-11 |
| Table 1-7: On-Board 10 Cryopump Specifications | 1-12 |
| Table 1-8: On-Board 10F Cryopump Specifications | 1-13 |
| Table 1-9: On-Board 250F Cryopump Specifications | 1-14 |
| Table 1-10: On-Board 250FH Cryopump Specifications | 1-15 |
| Table 1-11: On-Board 400 Standard Capacity Cryopump Specifications | 1-16 |
| Table 1-12: On-Board 400 High Capacity Cryopump Specifications | 1-17 |
| Table 1-13: On-Board 500 ISO-K Cryopump Specifications | 1-18 |
| Table 3-1: Cryopump Troubleshooting Procedures | 3-2 |
| Table 3-1: Troubleshooting Procedures (continued) | 3-3 |
| Table 4-1: Methods of Decontamination | 4-1 |
| Table 4-2: Decontamination Tools and Equipment | 4-3 |

This Page Intentionally Left Blank

Cryopump Safety

Introduction

All On-Board[®], On-Board[®] IS, and Cryo-Torr[®] products are designed to provide extremely safe and dependable operation when properly used. This chapter describes safety hazard alerts used throughout this manual for the Brooks Automation cryopumps.

All personnel involved in the installation, operation, or maintenance of On-Board[®], On-Board[®] IS, and Cryo-Torr[®] products must follow the safety requirements presented in this manual, along with all safety requirements for the facility where the pump is installed, and all applicable national and international safety requirements.



Refer to **Contacting Brooks' Technical Support** at the front of this manual, or call your local Customer Support Center, for further assistance.

Hazard Alerts

The **On-Board Cryopump Installation and Maintenance Instructions** use industry standard hazard alerts to make you aware of hazardous conditions. Alerts are composed of three elements:

- Safety Icon(s)
- Signal Word
- Safety Text

Following is an example of a typical hazard alert, with safety icons, signal word, and text.


| | |
|---|---|
|  |  CAUTION |
| | Two-Person Lift Required This pump weighs ____ kilos/lbs. Lifting heavy loads can result in serious injury. Use a 2-person lift or a lifting aid when attempting to lift this pump. |

Safety Icons

Hazard alerts indicating a caution, warning, or danger to personnel contain Safety Icons that graphically identify the hazard involved.

Table S-1 illustrates the meaning of a typical safety icon.

Table S-1: Safety Icons

| Associated Signal Word | Icon | Indication |
|----------------------------|---|-------------------------------------|
| Caution, Warning or Danger |  | Indicates an electric shock hazard. |

The safety icons in this manual conform to ISO 3864 and ANSI Z535 standards.

Signal Words

All hazard alerts contain signal words that call attention to safety messages and designate the degree of hazard seriousness. The signal words used in this manual are Notice, Caution, Warning, and Danger. The meaning and formatting of each of these signal words follows.

NOTICE

Notice indicates a situation or unsafe practice which, if not avoided, **may result in equipment damage**. The Notice signal word is highlighted in blue.

CAUTION

Caution indicates a potentially hazardous situation or unsafe practice which, if not avoided, may result in minor or moderate personal injury. The Caution signal word is preceded by an iconic exclamation point, indicating additional information is in the manual, and it is highlighted in yellow.

WARNING

Warning indicates a potentially hazardous situation which, if not avoided, could result in serious injury or death. The Warning signal word is preceded by an iconic exclamation point, indicating additional information is in the manual, and it is highlighted in orange.



DANGER

Danger indicates a potentially hazardous situation which, if not avoided, will result in serious injury or death. The Danger signal word is preceded by an iconic exclamation point, indicating additional information is in the manual, and it is highlighted in red.

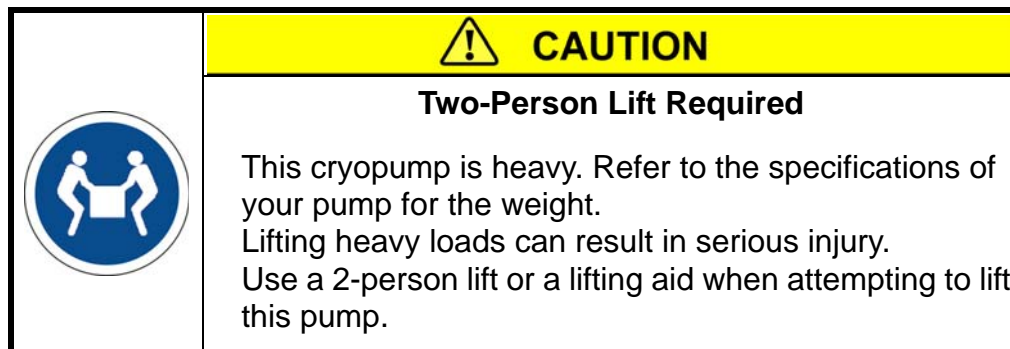
Safety Text

Hazard alert text follows a standard three-part format:

- identify the hazard,
- state the consequences if the hazard is not avoided,
- state how to avoid the hazard.

The order of hazard alert text is fixed.

The example below illustrates typical hazard alert text, presented in the correct order.



References

For more information about safety standards, refer to the following documents.

- ISO 3864-2: 2004 Graphical Symbols - Safety Colors and Safety Signs - Part 2: Design principles for product safety labels.
- ANSI Z535.4 Standard for Product Safety Signs and Labels




Cryopump Hazards

Observe the following safety precautions when installing, operating, troubleshooting, and maintaining the On-Board[®], On-Board *IS* and Cryo-Torr[®] equipment. If you have any doubts on using this equipment, refer to *Contacting Brooks' Technical Support* at the beginning of this manual.




Always follow all local, state, and national codes, as well as site-specific codes, when working with toxic/corrosive gases or liquids, flammable or explosive gases, and/or high voltage.

The following hazard alerts appear on the pump, in this manual, or both.




Toxic, Corrosive, Dangerous Gases, or Liquids

| | |
|---|--|
|  |  WARNING |
|  | <p>Toxic/Corrosive Gases</p> <p>Toxic and/or corrosive process gases or liquids pumped or captured by an On-Board, On-Board <i>IS</i>, or Cryo-Torr product could cause severe injury on contact.</p> <p>Always vent toxic/corrosive gases or liquids to a safe location using an inert purge gas.</p> <p>The customer is responsible for safely exhausting these gases.</p> <p>Clearly identify on the cryopump which toxic/corrosive gas or liquid is contained in the pump before storing or shipping it to Brooks Automation.</p> |



Flammable or Explosive Gases

| | |
|--|--|
|   |  WARNING |
| | <p style="text-align: center;">Flammable/Explosive Gases</p> <p>Flammable or explosive gases captured by an On-Board, On-Board /S, or Cryo-Torr pump can cause severe injury if ignited.</p> <p>Always purge the cryopump with an inert gas during regeneration.</p> <p>Always vent flammable or explosive gases to a safe location using an inert purge gas. Purging the cryopump's exhaust line might also be necessary. The customer is responsible for safely exhausting these gases.</p> <p>Do not install a hot filament type vacuum gauge on the high vacuum side of the isolation valve. This could be an ignition source for flammable gases in the product.</p> |

Electric Shock

| | |
|--|--|
|   |  WARNING |
| | <p style="text-align: center;">Electric Shock</p> <p>Electric shock can cause severe injury or death.</p> <p>Disconnect the high vacuum pump system from all power sources before making electrical connections between system components or before performing troubleshooting and maintenance procedures. Perform Lockout/Tagout as required by the facility where the equipment is installed.</p> |





High Gas Pressure

| | |
|---|---|
|  |  WARNING |
| | <p>High Gas Pressure</p> <p>High helium gas pressure is present in the cryogenic system and high pressure gas can be present within the cryopump. These high pressure gases can cause severe injury from propelled particles or parts.</p> <p>Do not modify or remove any pressure relief valve on the cryopump. Ensure that the path for the regenerated gas is unobstructed.</p> |

Take the following precautions when working with high gas pressure:

1. Normal making and breaking of the quick disconnect couplings can be done routinely. However, when a quick disconnect coupling needs to be replaced and separated from the helium flex or solid line, always bleed the helium charge down to atmospheric pressure before any disassembly.
2. During regeneration, a rapid expansion of the cryopumped species occurs within the cryopump. Restricting the flow through the exhaust port and exhaust line rapidly increases the pressure in the cryopump. This high internal pressure can cause severe injury from propelled particles or parts.



Regen Control Users Only

|  WARNING | |
|---|--|
|    | <p>Dangerous Gases</p> <p>During regeneration, cold gases vent through the roughing valve and roughing line and into the roughing pump. These gases can cause severe injury.</p> <p>Avoid contact with liquid nitrogen to exposed skin.</p> <p>Ensure the roughing systems are compatible with these gases.</p> |



Take the following precautions when installing the gas handling system, including roughing pump for toxic, corrosive, or dangerous gases.

- The roughing pump must be compatible with these gases
 - The discharge from the roughing pump may include these gases and should be vented in a safe manner
1. Use appropriately sized roughing lines to prevent over pressurization of the roughing line during the expansion of such gases
 2. Be sure that the roughing line is compatible with low temperatures
 3. Use roughing lines of sufficient length to allow the gases to warm adequately before entering the roughing pump
 4. Do not use fast regeneration after pumping large amounts of oxygen unless the roughing system is compatible with oxygen duty

Cryopump Oxygen Procedures

| | |
|---|--|
|  |  WARNING |
| | <p style="text-align: center;">Oxygen Combustion Hazard</p> <p>Combustion resulting from oxygen used as a process gas can cause severe injury.</p> <ol style="list-style-type: none"> 1. Ensure that there are no sources of ignition, such as hot filament vacuum gauges, on the cryopump side of the high vacuum valve operating during the warming or venting of the cryopump. 2. Perform inert gas purge regeneration cycles at flow rates recommended for cryopumps. 3. Regenerate as frequently as practical to minimize the amount of oxidizer present in the cryopump. |

Standard practice in the vacuum industry is that any system exposed to richer-than-air oxygen levels should be prepared for oxygen service per the manufacturer's recommendations. This includes the use of oxygen service lubrication oils in roughing pumps or dry roughing pumps.



| | |
|---|---|
|  |  WARNING |
| | <p style="text-align: center;">Explosion Hazard</p> <p>Explosion occurring from ozone in the cryopump can cause severe injury. Ozone can be an unforeseen by-product of oxygen processes.</p> <ol style="list-style-type: none"> 1. Reduce the oxygen flow rate to the lowest level that the process allows. 2. Shorten the time between regenerations. Daily regenerations may be required. Contact Brooks Automation Technical Support for assistance. 3. Ensure that there are no sources of ignition (for example, hot filament vacuum gauges) on the cryopump side of the high vacuum valve operating during the warming or venting of the cryopump 4. Perform inert gas purge regenerations at flow rates recommended for cryopumps. |



Signs of ozone presence are the following:

1. Crackling, popping sounds, as in electrical arcing, occurring within the first few minutes of a regeneration cycle;
2. Gas venting from the cryopump during regeneration that has a pungent smell similar to that present in an arc welding operation or after an electrical storm.

NOTE: A change in process can increase the amount of ozone present.

Lifting Requirements

| | |
|---|--|
|  |  CAUTION |
| | <p>Two-Person Lift Required</p> <p>This cryopump is heavy. Refer to the specifications of your pump for the weight. Lifting heavy loads can result in serious injury. Use a 2-person lift or a lifting aid when attempting to lift this pump.</p> |

| | |
|---|--|
|  |  CAUTION |
| | <p>Lifting Aid Required</p> <p>This cryopump is heavy. Refer to the specifications of your pump for the weight. Lifting heavy loads can result in serious injury. Always use a lifting aid when attempting to lift this pump.</p> |

This Page Intentionally Left Blank

Section 1 - On-Board Cryopump Description

Introduction

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

On-Board Cryopumps provide fast, clean pumping of all gases in the 10^{-3} to 10^{-9} Torr range. An On-Board Cryopump operates on the principle that gases can be condensed and held at extremely low vapor pressures, achieving high speeds and throughputs as described in [Table 1-1](#) through [Table 1-13](#).

The On-Board Cryopump is a highly-reliable and rugged unit that requires little maintenance. Since the On-Board Cryopump exposes no moving parts, operating fluids, or backing pumps to the vacuum, the possibility of system or process contamination from the On-Board Cryopump is eliminated.

Installation, Operation, Troubleshooting, and Maintenance Procedures

All personnel responsible for installing, operating, troubleshooting, or maintaining an On-Board Cryopump should become familiar with these procedures before attempting to perform them.

Refer to the Installation/Interface drawing for the cryopump being installed for specific pump layout and component information.

Microprocessor-Based Control System

The On-Board Cryopump is equipped with a microprocessor-based control system that allows you to monitor and control a wide range of vacuum system functions, such as cooldown, warm-up, and regeneration. Operations are performed on a keypad control/display panel mounted on the cryopump.

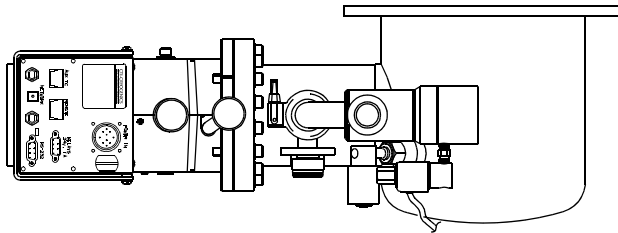
Refer to the **On-Board Cryopump Module Programming and Operation Instructions (8040410)** that came with your On-Board Cryopump for a complete description of the operational functions available.

Remote Operation Options

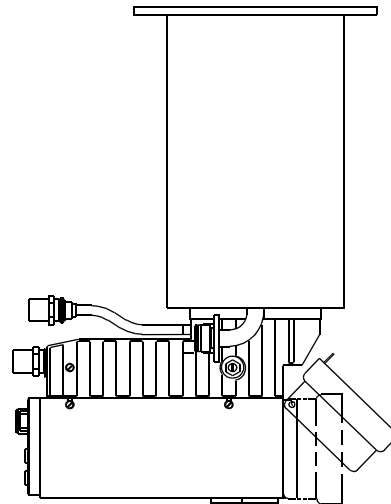
A remote keypad/display that provides the same functions as the basic On-Board keypad/display is available.

On-Board Cryopumps can be controlled remotely using either a BITBUS™ or RS-232 protocol. The most common implementation, used in multiple On-Board Cryopump process tools, is to network the On-Board Cryopumps using the BITBUS™ protocol. In this configuration, the networked On-Board Cryopumps are managed as a group by the On-Board Network Terminal, which coordinates group regeneration cycles and provides a standardized communication link to the process tool host controller. Using this approach, control of the networked On-Board Cryopumps is fully integrated with process tool control.

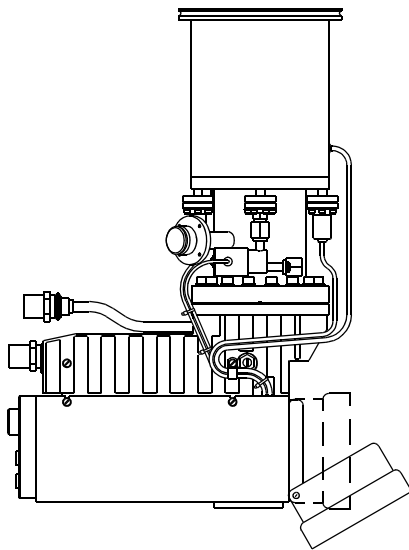
On-Board Cryopumps are available in the range of sizes and configurations shown in [Figure 1-1](#), [Figure 1-2](#), and [Figure 1-3](#). The specifications for each On-Board Cryopump are provided in [Table 1-1](#) through [Table 1-13](#).



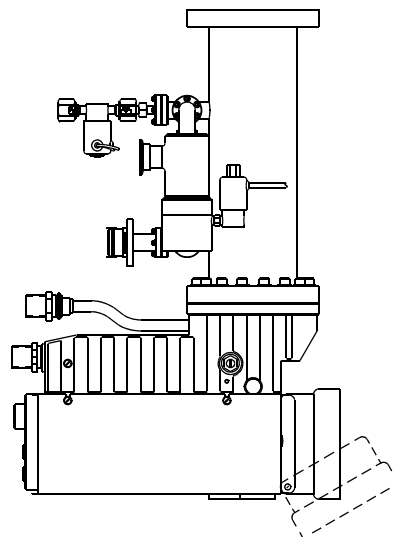
On-Board 8F



On-Board 8

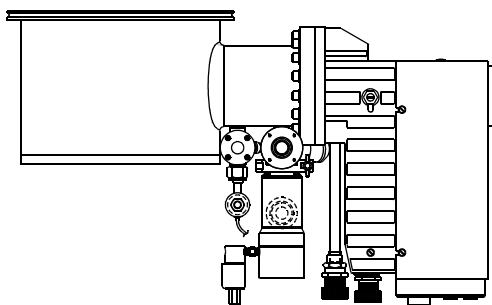


On-Board 6

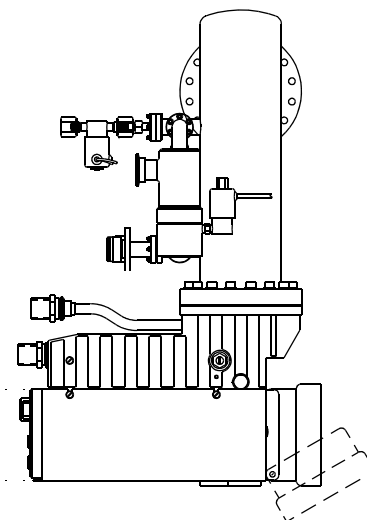


On-Board 4

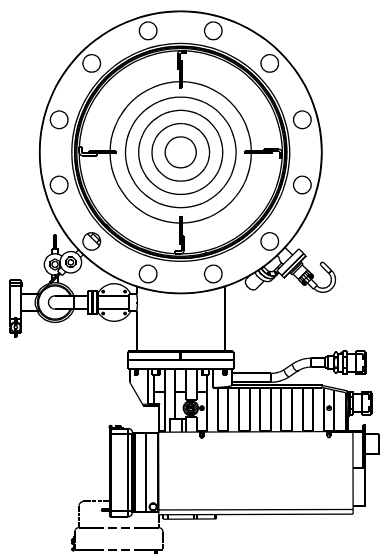
Figure 1-1: On-Board Cryopumps



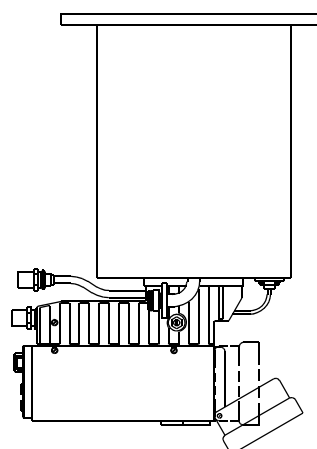
On-Board 250F



On-Board 4F

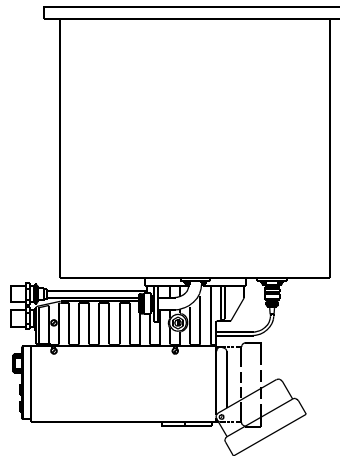


On-Board 10F

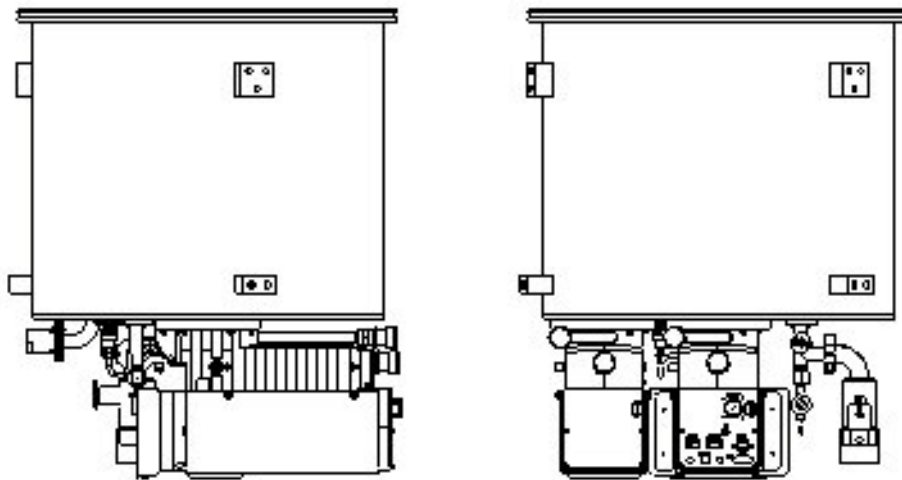


On-Board 10

Figure 1-2: On-Board Cryopumps



On-Board 400



On-Board 500

Figure 1-3: On-Board Cryopumps

Specifications

Table 1-1: On-Board 4 Cryopump Specifications

| Parameter | Specifications |
|-----------------------|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (Optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: | |
| Water | 1100 liters/sec |
| Air | 500 liters/sec |
| Hydrogen | 500 liters/sec |
| Argon | 420 liters/sec |
| Argon Throughput | 700 scc (9 Torr-liters/sec) |
| Capacity: | |
| Argon | 210 std. liters (no recovery metric) |
| Hydrogen | 100 std. liters (recovery to 10^{-7} in 30 sec. or less) 3 std. liters @ 5×10^{-6} Torr |
| Crossover | 100 Torr-liters |
| Regeneration Time | |
| Full (Typical) | Less than 84 minutes |
| Fast (Typical) | Less than 42 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 45 lbs. (20 kg) |

Table 1-2: On-Board 4F Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (Optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 1100 liters/sec 370 liters/sec 370 liters/sec 310 liters/sec |
| Argon Throughput | 700 scc (9 Torr-liters/sec) |
| Capacity: Argon Hydrogen | 210 std. liters (no recovery metric) 100 std. liters (recovery to 10^{-7} @ 30 sec. or less) 3 std. liters @ 5×10^{-6} Torr |
| Crossover | 100 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 84 minutes Less than 42 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 47 lbs. (21 kg) |

Table 1-3: On-Board 6 Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Purge Gas Connection | VCR-4 Female Nut |
| Integrated Hardware | Keypad/Display (Optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 2,500 liters/sec 800 liters/sec 1,200 liters/sec 650 liters/sec |
| Argon Throughput | 700 sccm (9 Torr-liters/sec) |
| Capacity: Argon Hydrogen | 500 std. liters 9 std. liters @ 5×10^{-6} Torr |
| Crossover | 100 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 162 minutes Less than 60 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 55 lbs. (25 kg) |

Table 1-4: On-Board 8 Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 4000 liters/sec 1500 liters/sec 2500 liters/sec 1200 liters/sec |
| Argon Throughput | 700 sccm (9 Torr-liters/sec) |
| Capacity: Argon Hydrogen | 1000 std. liters 17 std. liters @ 5×10^{-6} Torr |
| Crossover | 150 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 162 minutes Less than 60 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 55 lbs. (25 kg) |

Table 1-5: On-Board 8F Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 4000 liters/sec 1500 liters/sec 2200 liters/sec 1200 liters/sec |
| Argon Throughput | 700 sccm (9 Torr-liters/sec) |
| Capacity: Argon Hydrogen | 1000 std. liters (no recovery metric) 450 std. liters (recovery to 10^{-7} in 30 seconds or less) 12 std. liters @ 5×10^{-6} Torr |
| Crossover | 150 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 162 minutes Less than 60 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 52 lbs. (24 kg) |

Table 1-6: On-Board Enhanced 8F Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 4000 liters/sec 1500 liters/sec 2200 liters/sec 1200 liters/sec |
| Argon Throughput | 700 sccm (9 Torr-liters/sec) |
| Capacity: Argon Hydrogen | 1000 std. liters (no recovery metric) 750 std. liters (recovery to 10^{-7} in 30 seconds or less) 12 std. liters @ 5×10^{-6} Torr |
| Crossover | 150 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 162 minutes Less than 60 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 52 lbs. (24 kg) |

Table 1-7: On-Board 10 Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 9000 liters/sec 3000 liters/sec 5000 liters/sec 2500 liters/sec |
| Argon Throughput | 1500 scc/min. (19 Torr-liters/sec) |
| Capacity: Argon Hydrogen | 2000 std. liters 24 std. liters @ 5×10^{-6} Torr |
| Crossover | 300 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 132 minutes Less than 60 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 95 lbs. (43 kg) |

Table 1-8: On-Board 10F Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 9500 liters/sec 3600 liters/sec 6000 liters/sec 3000 liters/sec |
| Argon Throughput | 1500 scc/min. (19 Torr-liters/sec) |
| Capacity: Argon Hydrogen | 2000 std. liters 24 std. liters @ 5×10^{-6} Torr |
| Crossover | 300 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 132 minutes Less than 60 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 100 lbs. (45 kg) |

Table 1-9: On-Board 250F Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 6500 liters/sec 2200 liters/sec 3200 liters/sec 1800 liters/sec |
| Argon Throughput | 700 sccm (9 Torr-liters/sec) |
| Capacity: Argon Hydrogen | 1000 std. liters 16 std. liters @ 5×10^{-6} Torr |
| Crossover | 150 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 198 minutes Less than 90 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 58 lbs. (26 kg) |

Table 1-10: On-Board 250FH Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 1st Stage Heater 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 6500 liters/sec 2200 liters/sec 4500 liters/sec 1800 liters/sec |
| Argon Throughput | 700 sccm (9 Torr-liters/sec) |
| Capacity: Argon Hydrogen | 1000 std. liters 24 std. liters @ 5×10^{-6} Torr |
| Crossover | 150 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 198 minutes Less than 90 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 58 lbs. (26 kg) |

Table 1-11: On-Board 400 Standard Capacity Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 16,000 liters/sec 6,000 liters/sec 5,000 liters/sec 5,000 liters/sec |
| Argon Throughput | 500 scc/min (6 Torr-liters/sec) |
| Capacity Argon Hydrogen | 2500 std. liters 15 std. liters @ 5×10^{-6} Torr |
| Crossover | 300 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 228 minutes Less than 96 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 170 lbs. (77 kg) |

Table 1-12: On-Board 400 High Capacity Cryopump Specifications

| Parameter | Specifications |
|---|--|
| Rough Pump Connection | NW 25 ISO KF |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 2nd Stage Heater 2 Setpoint Relays RS-232 Interface |
| Pumping Speeds: Water Air Hydrogen Argon | 16,000 liters/sec 6,000 liters/sec 12,000 liters/sec 5,000 liters/sec |
| Argon Throughput | 500 scc/min (6 Torr-liters/sec) |
| Capacity Argon Hydrogen | 2500 std. liters 42 std. liters @ 5×10^{-6} Torr |
| Crossover | 300 Torr-liters |
| Regeneration Time Full (Typical) Fast (Typical) | Less than 228 minutes Less than 96 minutes |
| Dimensions | Refer to Installation/Interface Drawing |
| Weight | 170 lbs. (77 kg) |

Table 1-13: On-Board 500 ISO-K Cryopump Specifications

| Parameter | Chevron Array Specifications | |
|--|--|-----------------|
| Rough Pump Connection | NW 25 ISO KF | |
| Integrated Hardware | Keypad/Display (optional) Roughing Valve Purge Valve Cryopump TC Gauge 1st Stage Diode 2nd Stage Diode 2nd Stage Heater 2 Setpoint Relays RS-232 Interface | |
| Weight | 118.2 kg/ 260 lbs. | |
| Dimensions | Refer to Installation/Interface Drawing | |
| Vacuum Requirements | | |
| Crossover | torr-liters | 600 |
| Ultimate Pressure ¹ | torr | 7.5E-9 |
| Pumping Speed | | |
| Water | liters/sec | 30000 |
| Nitrogen ^{2,3} | liters/sec | 10000 |
| Hydrogen ^{2,3} | liters/sec | 12000 |
| Argon ^{2,3} | liters/sec | 8400 |
| Argon Throughput ^{2,3} | SCCM | 1000 |
| Pumping Capacity | | |
| Argon | std.liters | 6000 |
| Hydrogen | std.liters | 45 (@5E-6 Torr) |
| Regen/Cool down Time | | |
| Full (Typical) | Minutes | 225 |
| 1. At 38 C ambient radiation 2. At 20 C ambient radiation 3. At 20K Second Stage temperature | | |

Theory of Operation

Each On-Board Cryopump consists of a cold head and a vacuum vessel as shown in [Figure 1-5](#) and [Figure 1-6](#). An 80K condensing array, a 15K array, cold head station heaters, and an 80K radiation shield are located in the vacuum vessel. The cold station heaters and 15K array are secured to the cold head, which is welded to the vacuum vessel. The cold head provides cooling to the three arrays. Gases are removed from your vacuum chamber, thereby creating a vacuum when they are condensed or adsorbed on the cryogenically-cooled arrays.

Cold Head

The cold head consists of a two-stage cold head cylinder, which is part of the vacuum vessel, and the drive unit displacer assembly that together produce closed-cycle refrigeration at temperatures ranging from 60 to 120K for the first-stage cold station and 10 to 20K for the second-stage cold station, depending on operating conditions. Within the drive unit displacer assembly, the drive unit actuates the displacer-regenerator assembly located in the cold head cylinder and thereby controls the flow of helium into the cold head. Within the drive unit are located the crankcase and drive motor, which is a direct-drive constant-speed motor, operating at 72 rpm on 60 Hz power and 60 rpm on 50 Hz power.

During operation, high pressure helium from the compressor enters the cold head at the helium supply connector, and flows through the displacer-regenerator assembly, crankcase, and motor housing before exiting through the helium gas return connector and returning to the compressor. Helium expansion in the displacer-regenerator assembly provides cooling at the first and second stage cold stations.

Vacuum Vessel and Arrays

The 80K array, as shown in [Figure 1-5](#) and [Figure 1-6](#), condenses water and hydrocarbon vapors. The 15K array condenses nitrogen, oxygen, and argon while the specially processed charcoal of this array traps helium, hydrogen, and neon. The temperature of the cold head stations, to which the 15K array and 80K radiation shield are attached, is measured by temperature sensors and transmitted to the On-Board controller for display.

Compressor Gas and Oil Flows

Helium returning from the cryopump cold head enters the compressor and a small quantity of oil is injected into the gas stream, thereby overcoming helium's low specific heat and inability to carry heat produced during compression. Helium is then compressed and passed through a heat exchanger for removal of compression-caused heat.

The helium continues its flow through an oil-mist separator and a charcoal filter adsorber (cartridge), within the compressor, where oil and contaminants are removed. A differential pressure relief valve in the compressor limits the operating pressure differential between the helium supply and return lines, thereby allowing compressor operation without cold head operation. When cold head operation reaches a steady-state condition, further pressure regulation is unnecessary.

A typical On-Board Cryopump system is shown in [Figure 1-4](#).

The location of helium and electrical components of typical flat and straight On-Board Cryopumps are shown in [Figure 1-7](#) and [Figure 1-8](#) respectively.

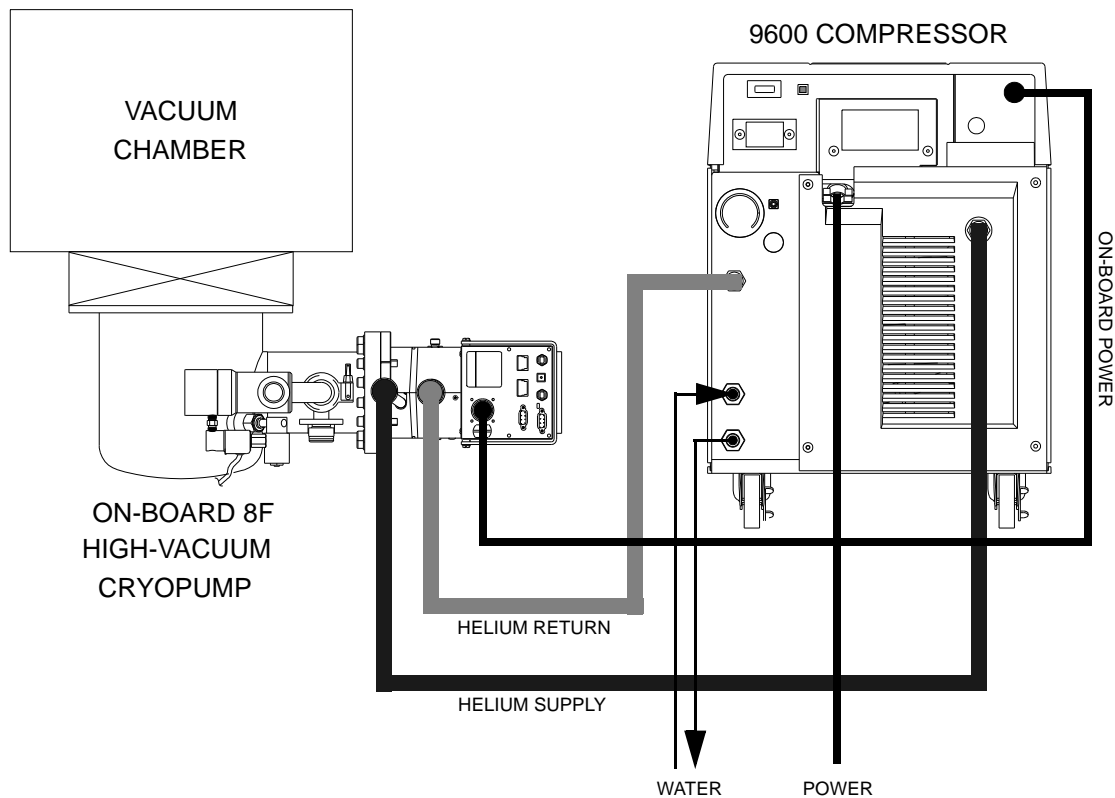


Figure 1-4: Typical On-Board Cryopump System

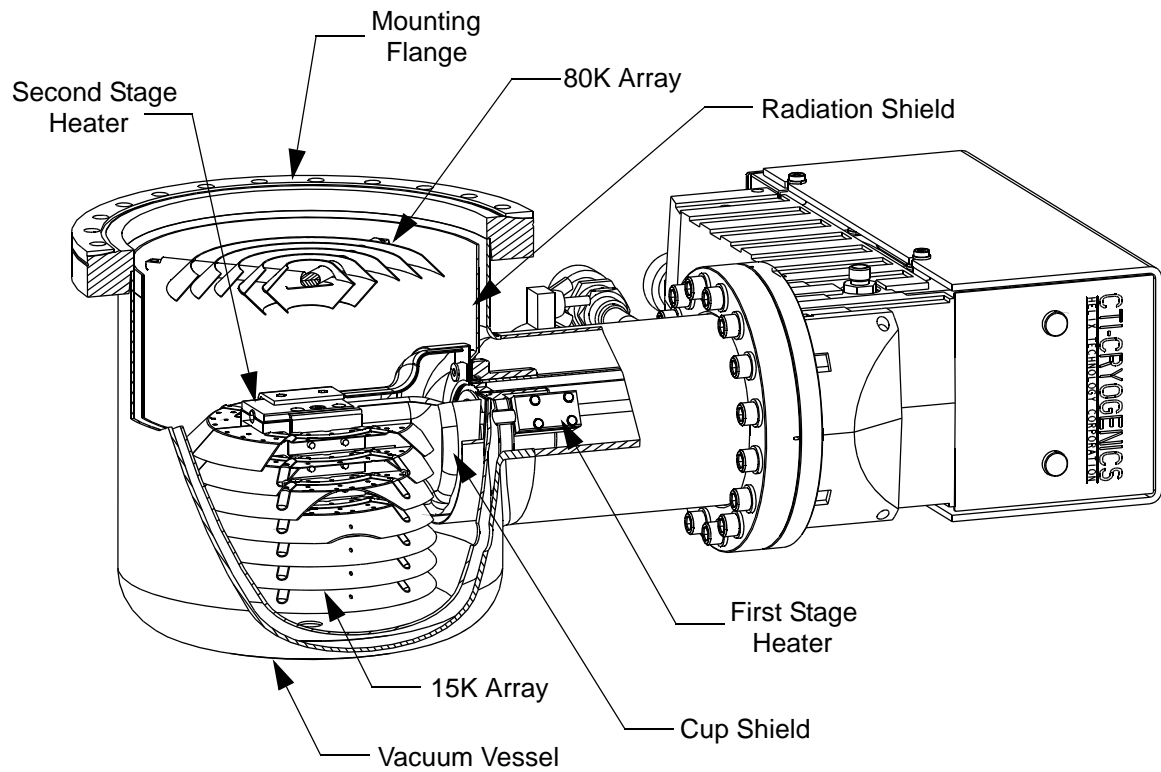


Figure 1-5: Cutaway View of a Typical Flat On-Board Cryopump Vessel

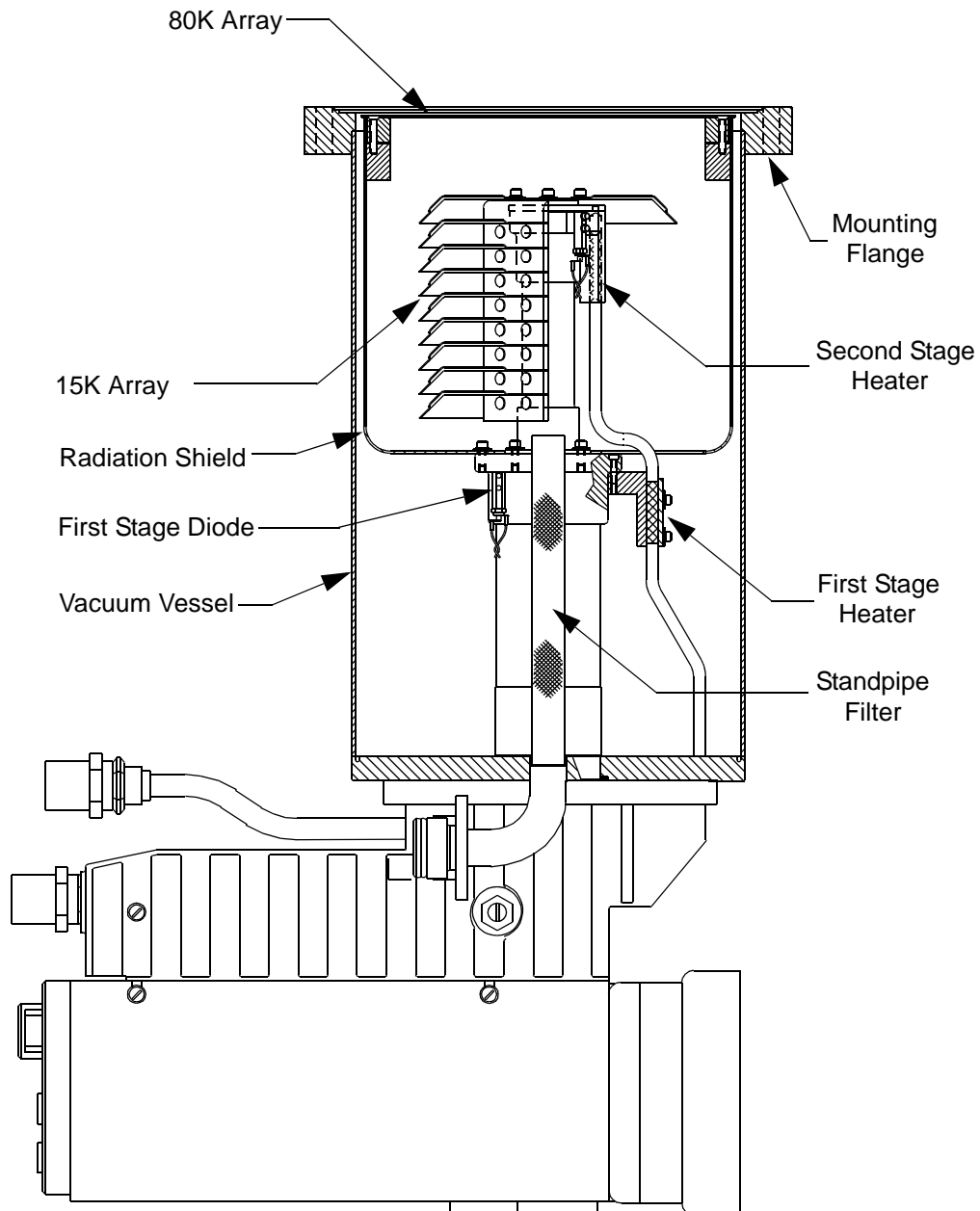
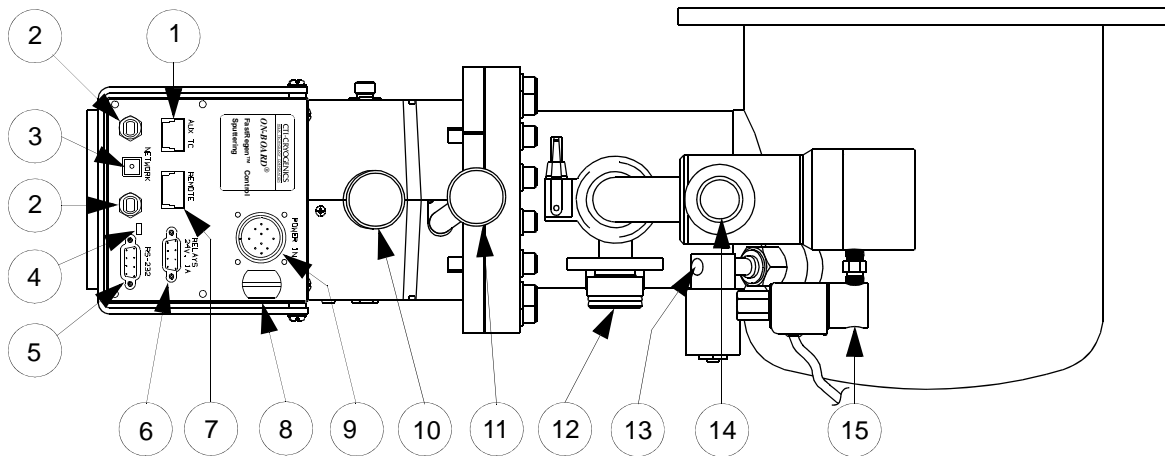


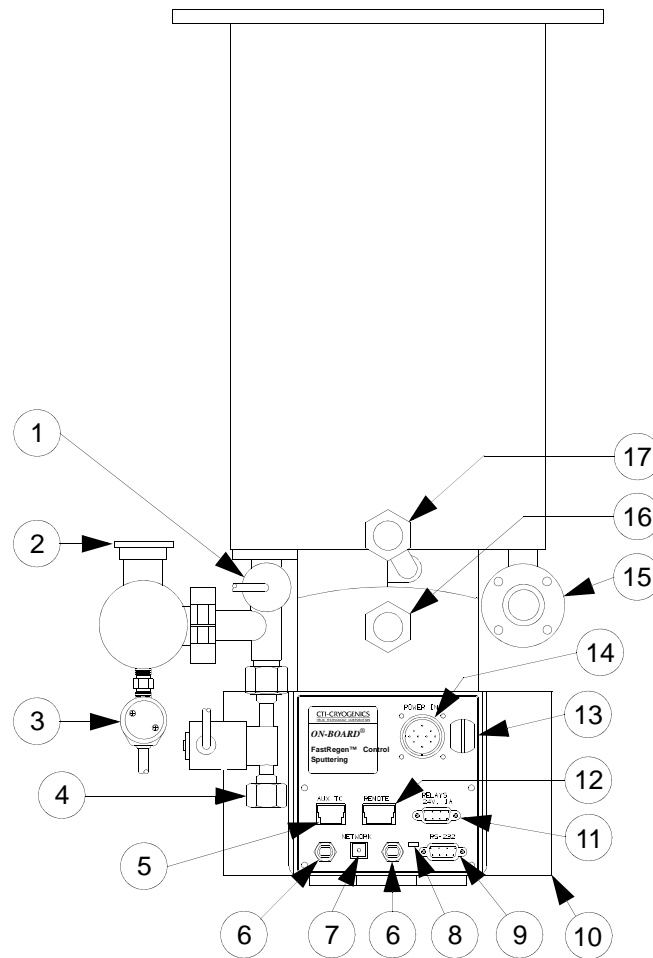
Figure 1-6: Cutaway View of a Typical Straight On-Board Cryopump Vessel



LEGEND

1. Auxiliary Thermocouple Gauge Connector
2. Network Connectors
3. Network Pump Identification Switch
4. Power Indicator Lamp
5. RS-232 Computer Interface Connector
6. Setpoint Relay Connector
7. Remote Keypad Connector
8. Safety Interlock Screw
9. Input Power Connector
10. Helium Return Connector
11. Helium Supply Connector
12. Pressure Relief Valve
13. Purge Gas Connection (10 - 25 psig or 40 - 80 psig) 1/8 NPT
14. Rough Pump Connection
15. Air Supply Connection (60 - 80 psi, 1/8 NPT)

Figure 1-7: Typical Flat On-Board Cryopump Component Identification



LEGEND

1. Thermocouple Gauge
2. Rough Pump Connection
3. Air Supply Connection (60 - 80 psig 1/8 NPT)
4. Purge Gas Connection (10 - 25 psig or 40 - 80 psig 1/8 NPT)
5. Auxiliary Thermocouple Gauge Connector
6. Network Connectors
7. Network Pump Identification Switch
8. Power Indicator Lamp
9. RS-232 Computer Interface Connector
10. Keypad/Display
11. Setpoint Relay Connector
12. Remote Keypad Connector
13. Safety Interlock Screw
14. Input Power Connector
15. Pressure Relief Valve
16. Helium Return Connector
17. Helium Supply Connector

Figure 1-8: Typical Straight On-Board Cryopump Component Identification

Section 2 - Installation

Introduction

Installation information is presented for experienced and inexperienced On-Board Cryopump system technicians. The flowchart in Figure 2-1 highlights the major tasks of On-Board Cryopump installation. Refer to Figure 2-1 and the appropriate installation procedure within this section for the type of On-Board Cryopump being installed.

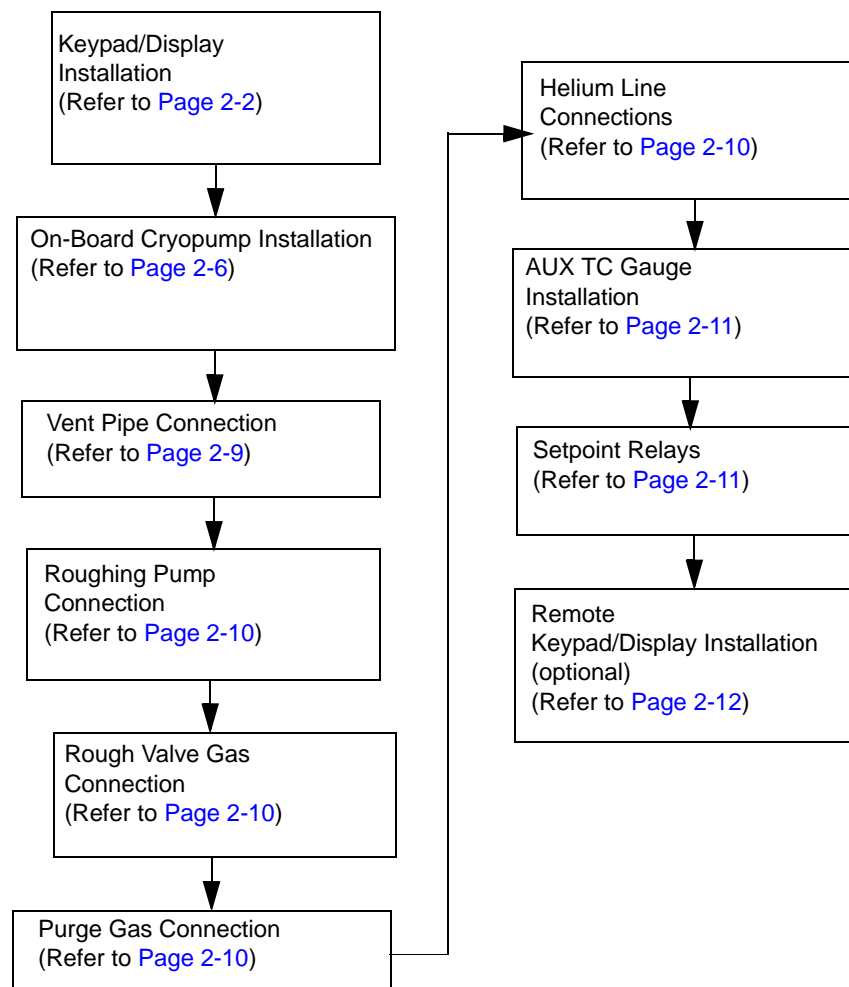


Figure 2-1: Block Diagram for On-Board Cryopump Installation

Keypad/Display Installation

The keypad/display can be installed on the On-Board Cryopump in four different positions, identified as positions A, B, C, and D.

Typically, the On-Board Cryopump is shipped with the keypad/display mounted in position A, as shown in [Figure 2-2](#). This is the orientation most likely to be used for the majority of installations. Installing the keypad/display in position B, C, or D is easy.

Position A

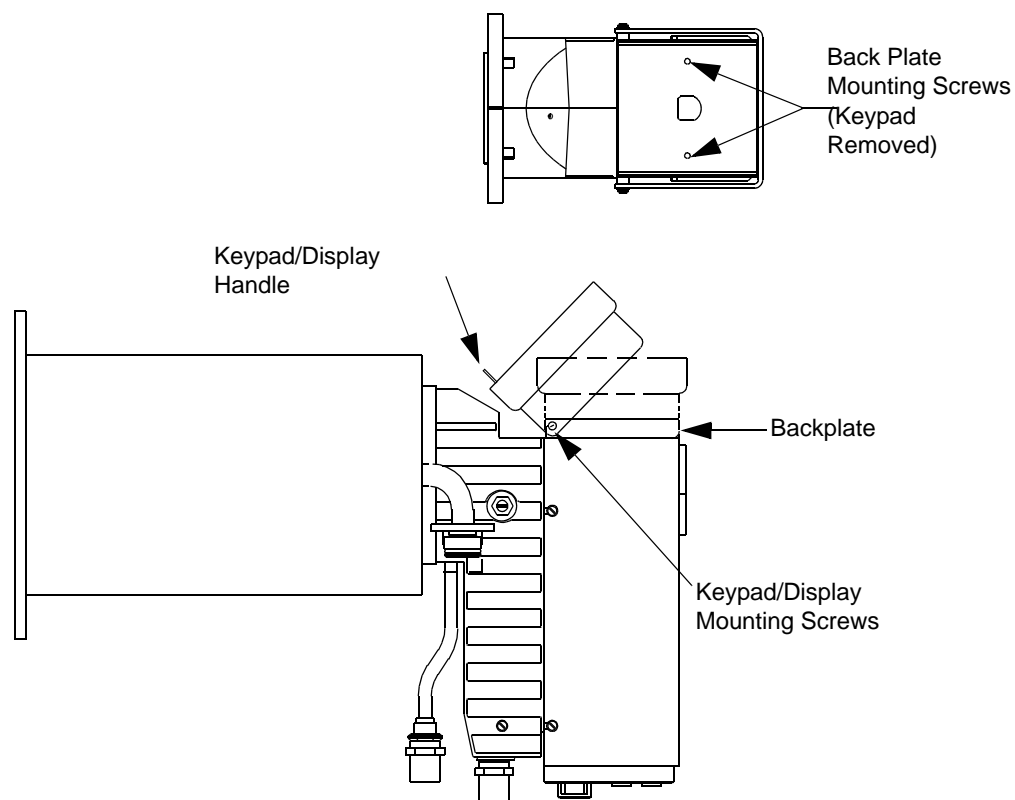


Figure 2-2: Keypad/Display Mounting Position A

Position B

Refer to [Figure 2-3](#) and the following procedure to install the keypad/display in position B.

1. Remove the 2 screws, washers, and nuts holding the keypad/display to the back plate.
2. Remove the 2 screws and washers holding the back plate.
3. Rotate the back plate, being careful not to strain the cable, so the keypad/display mounting screw holes are oriented as shown in [Figure 2-3](#).
4. Mount the back plate using the 2 screws and washers removed during step 2.
5. Remount the keypad/display using the 2 screws, washers, and nuts removed in step 1 as shown in [Figure 2-3](#).

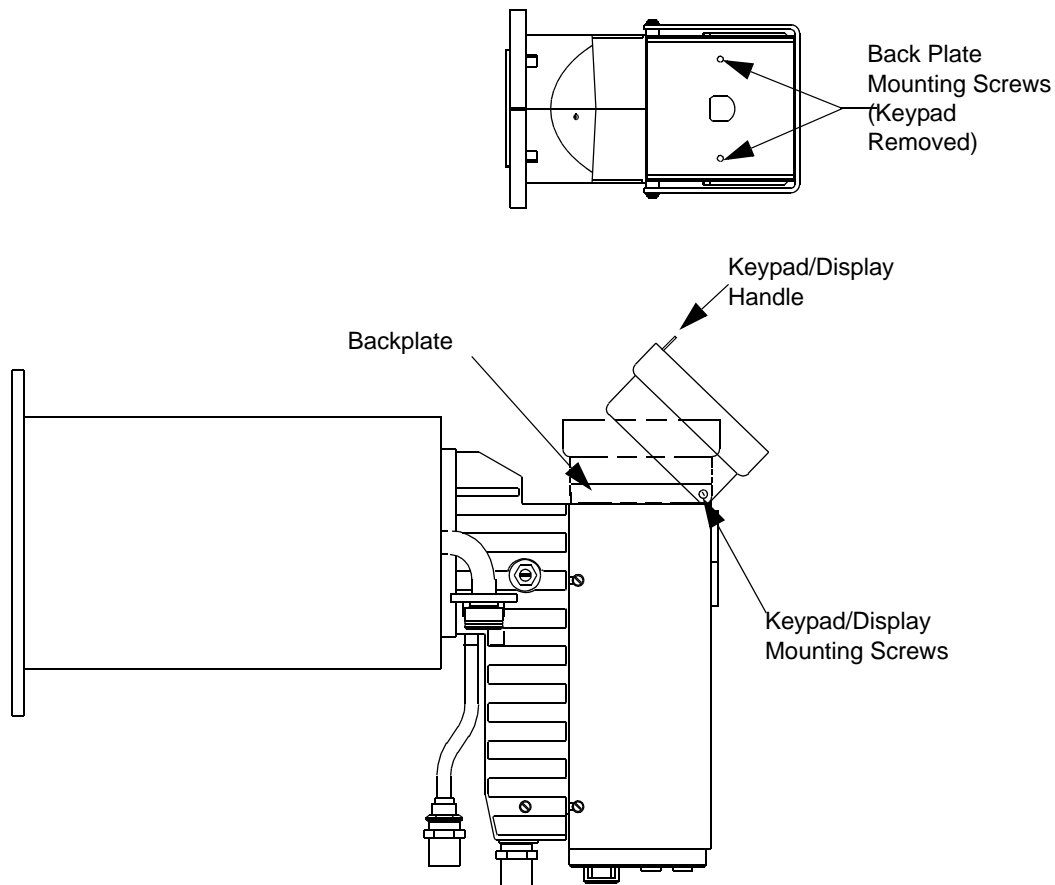


Figure 2-3: Keypad/Display Mounting Position B

Position C

Refer to [Figure 2-4](#) and the following procedure to install the keypad/display in position C.

1. Remove the 2 screws, washers, and nuts holding the keypad/display to the back plate.
2. Turn the keypad/display over.
3. Remount the keypad/display as shown in [Figure 2-4](#) using the 2 screws, washers, and nuts removed in step 1.

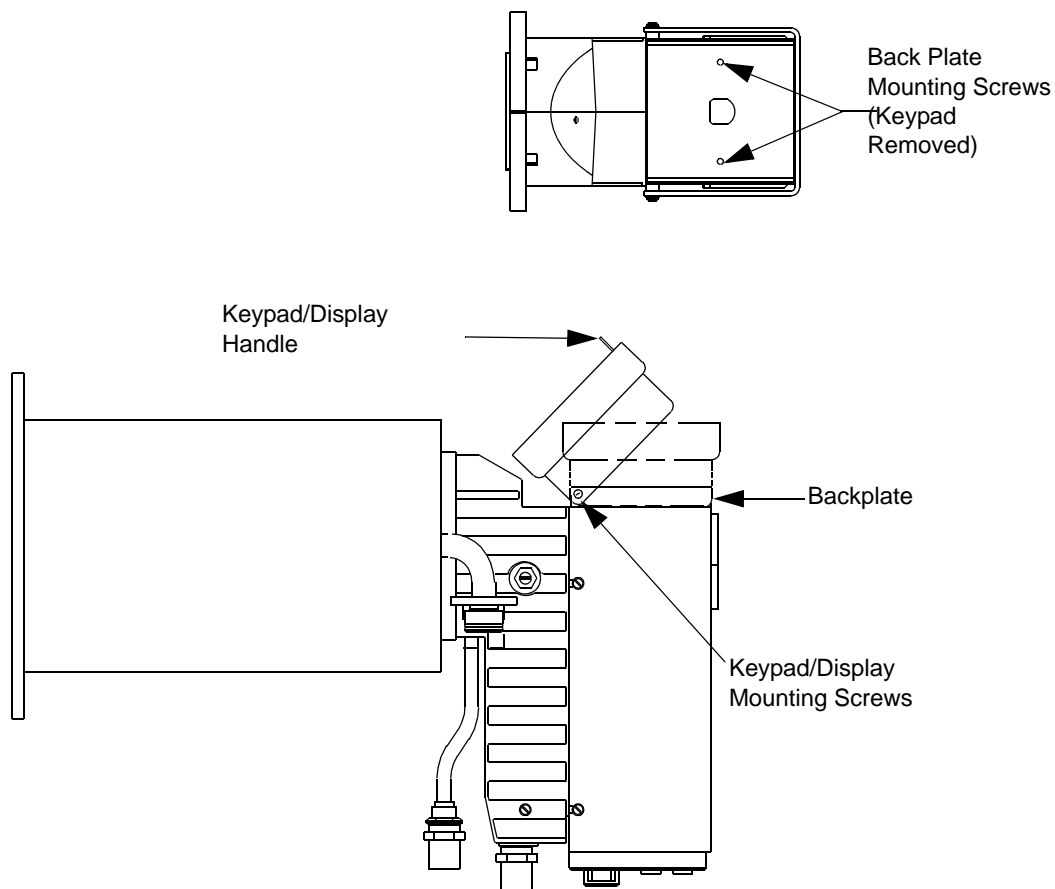


Figure 2-4: Keypad/Display Mounting Position C

Position D

Refer to [Figure 2-5](#) and the following procedure to install the keypad/display in position D.

1. Remove the 2 screws, washers, and nuts holding the keypad/display to the back plate.
2. Remove the 2 screws and washers holding the back plate.
3. Rotate the back plate, being careful not to strain the cable, so the keypad/display mounting screw holes are oriented as shown in [Figure 2-5](#).
4. Remount the back plate using the 2 screws and washers removed during step 2.
5. Remount the keypad/display using the 2 screws, washers, and nuts removed in step 1 as shown in [Figure 2-5](#).

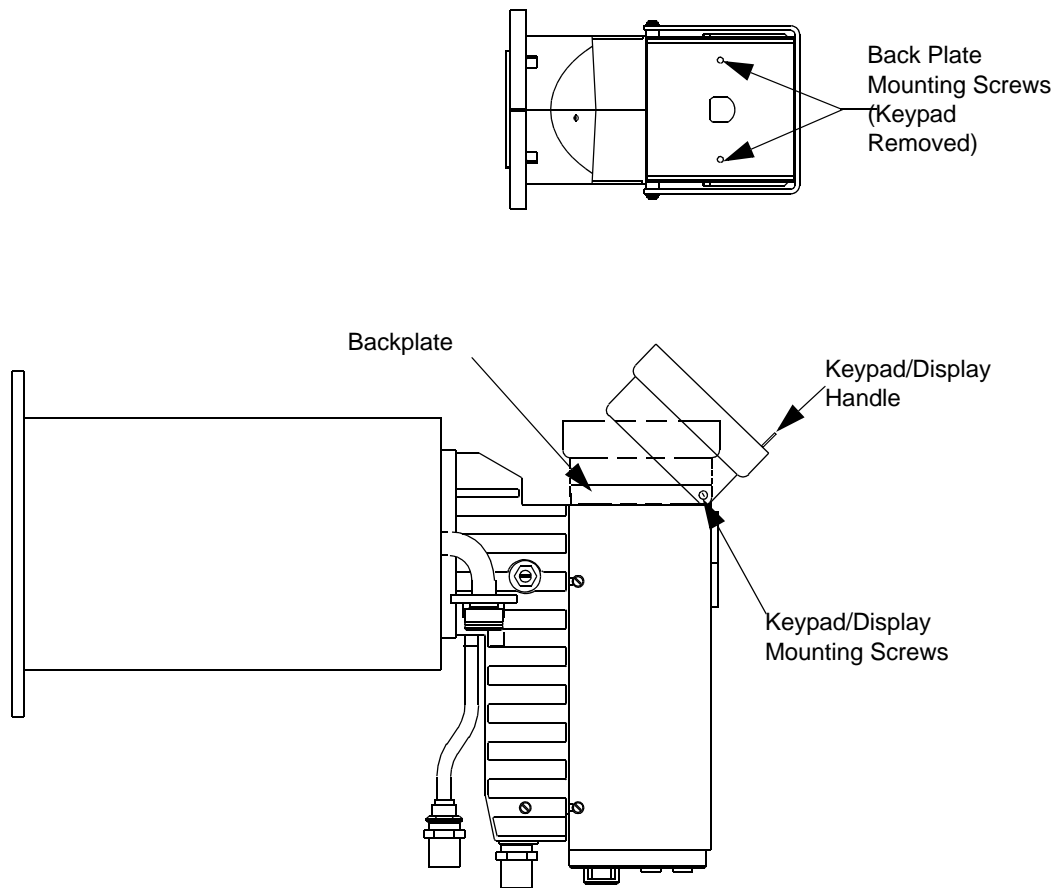


Figure 2-5: Keypad/Display Mounting Position D

On-Board Cryopump Installation

The following procedure does not apply to the On-Board 500 Cryopump. Refer to the [On-Board 500 Cryopump Installation](#) procedure to install these pumps.

The On-Board Cryopump may be installed in any orientation without affecting its performance.



Before mounting the On-Board Cryopump to the vacuum system, ensure that a high-vacuum isolation valve (Hi-Vac valve) is installed between the On-Board Cryopump and the vacuum chamber.

This valve isolates the On-Board Cryopump from the chamber during rough pumping, cooldown, and regeneration.

Install the On-Board Cryopump on the vacuum system as follows:

1. Remove the protective cover from the main flange of the On-Board Cryopump.
2. Clean all sealing surfaces and install the O-ring or metal seal gasket as appropriate.


Check with the OEM for proper cleaning materials.

| | |
|--|---|
|  |  CAUTION |
| | Two-Person Lift Required Certain model pumps weigh in excess of 24 kg/52 lbs. Lifting heavy loads can result in serious injury. Use a 2-person lift or a lifting aid when attempting to lift these pumps. |

3. Mount the On-Board Cryopump to the Hi-Vac valve or vacuum chamber mounting flange. Be sure all mounting bolts are secure.

On-Board 500 Cryopump Installation

Also refer to the *On-Board 500 Cryopump Quick Installation Guide* (174166).

| | |
|---|--|
|  | <p style="text-align: center;">⚠ CAUTION</p> <p style="text-align: center;">Tip Over/Heavy Object Hazard</p> <p>The On-Board 500 Cryopump weighs 118.2 kg/260 lbs.</p> <p>Lifting the On-Board 500 Cryopump by fewer than all 3 lift points can result in instability of the pump, leading to personnel injury.</p> <p>Always use a lifting aid when attempting to lift or move this pump.</p> |
|---|--|

1. When lifting the On-Board 500 Cryopump from the packaging container, always attach cables to each of the 3 lifting bars provided for the purpose.

Note: Each lifting bar is 1/4-inch thick with a 1-inch diameter hole and 1-inch clearance. Refer to [Figure 2-6](#).

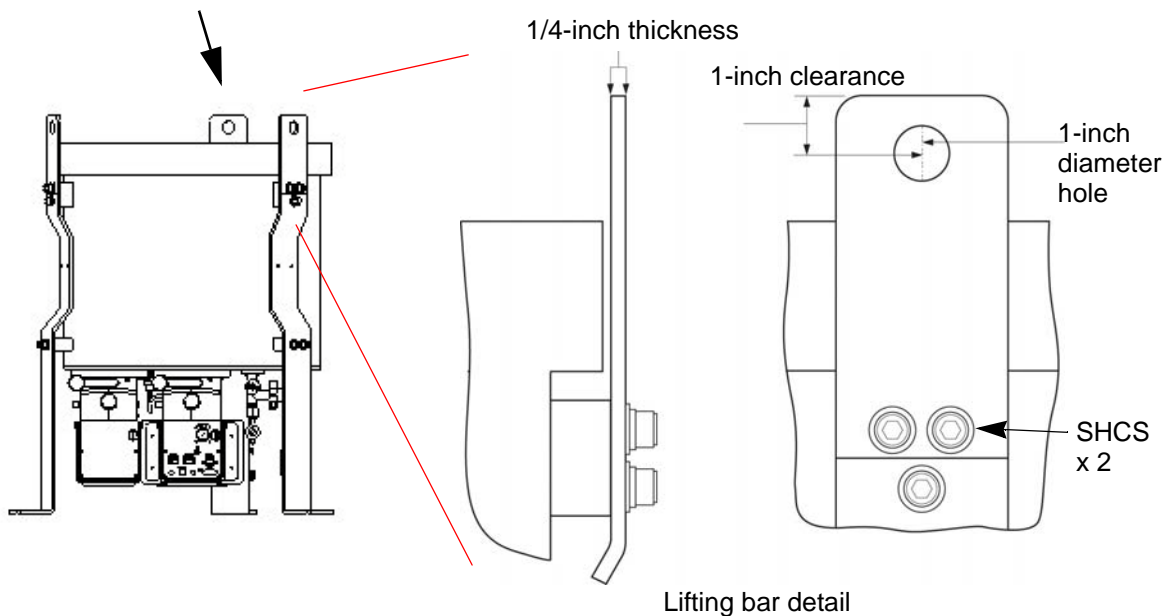


Figure 2-6: Lifting Bars

2. Transport the pump to the tool where it will be installed.
3. Before installing the cryopump on the tool, first remove the lifting bars from the support legs. Use a 3/8-inch Allen wrench to remove the 2 SHCSs, with washer and lock washer, that secure each of the 3 lifting bars. Refer to [Figure 2-6](#).

NOTICE

Cryopumps can be damaged by the use of a hoisting strap. When a hoisting strap is used, remove interference between the strap and the keypad and cables.





4. When installing the pump in a horizontal orientation, leave the support legs attached, cradle the vessel at the Center of Gravity, attach a separate cable to one support leg to maintain horizontal orientation, and use an overhead lifting device.
5. When installing the pump in a vertical orientation, use the support legs.
6. Remove the protective cover from the main flange of the On-Board Cryopump.
7. Clean all sealing surfaces and install the O-ring or metal seal gasket as appropriate.

Check with the OEM for proper cleaning materials.

8. Mount the On-Board Cryopump to the Hi-Vac valve or vacuum chamber mounting flange. Be sure all mounting bolts are secure.

Vent Pipe Connection

The On-Board Cryopump pressure relief valve can be vented directly into the room or can be connected to an exhaust system.

| | |
|---|---|
|    | <div style="background-color: orange; text-align: center; padding: 5px;">  WARNING </div> <p style="text-align: center;">Toxic, Flammable, Corrosive Gases</p> <p>Toxic, flammable, and/or corrosive process gases or liquids pumped or captured by an On-Board, On-Board /S, or Cryo-Torr product could cause severe injury on contact.</p> <p>Always vent toxic, flammable, and/or corrosive gases or liquids to a safe location using an inert purge gas. The customer is responsible for safely exhausting these gases.</p> <p>Clearly identify on the cryopump which toxic/corrosive gas or liquid is contained in the pump before storing or shipping it to Brooks Automation.</p> |
|---|---|

When toxic, corrosive, or flammable gases are pumped, a vent pipe must be connected to the On-Board Cryopump relief valve and directed to a safe location. When connecting a vent pipe to your On-Board Cryopump, the 1.30-inch diameter x 1.38-inch length volume of clearance around the relief valve must remain open for proper relief valve operation.

A Relief Valve Adapter Exhaust Kit (BROOKS- CRYOGENICS P/N 8080250K008) is available. Call your local customer support center for more information.

Note: The On-Board 500 Cryopump ships with an exhaust cap that provides the specified volume. The cap requires a 1/2-inch FMPT connection.

The enhanced On-Board 8F Cryopump installation kit includes a 6 foot (1.83 m) length of 1/2 inch ID (12.7 mm) polytube with associated fittings to allow venting of the cold exhaust as desired in cases where a hard plumbed manifold is not used.

NOTICE

For the enhanced On-Board 8F Cryopump, if an exhaust manifold is used, it must have a minimum ID of a 1/2 inch (12.7 mm).

Roughing Pump Connection

The roughing system must provide 10 cfm (measured at atmosphere and at each On-Board Cryopump) to successfully utilize On-Board FastRegen capability.

Connect your On-Board Cryopump to a roughing pump system using a roughing line with the largest inside diameter possible to minimize the roughing time required during start-up procedures prior to normal operation. The roughing pump should have a blank-off pressure of less than 20 microns.

The roughing pump connects to the On-Board Cryopump roughing valve as shown in [Figure 1-7](#) at Rough Pump Connection #14 or [Figure 1-8](#) at Rough Pump Connection #2. The valve will accept an ISO NW-25 flange.

1. Install the roughing pump line to the On-Board Cryopump roughing valve port using the clamp provided.
2. Ensure the clamp is tightened securely.

Rough Valve Gas Connection

Attach the gas supply line from a 60-80 psig gas supply to the 1/8 NPTF roughing valve fitting. Make sure to attach the gas supply line to the valve fitting that has a filter screen at the attachment connection.

Purge Gas Connection

Connect your purge gas supply line to the purge valve 1/8 NPTF fitting. Adjust the supply pressure to 10 - 25 psig or 40 - 80 psig, depending upon the label on the purge valve, yielding 1-2 cfm.

Helium Line Connections

Make the connections between the On-Board Cryopump and compressor. Refer to [Figure 1-7](#) or [Figure 1-8](#) while making the component interconnections.

1. Remove all dust plugs and caps from the supply and return lines, compressor, and On-Board Cryopump. Check all fittings.
2. Connect the helium-return line from the gas-return connector on the rear of the compressor to the gas-return connector on the On-Board Cryopump.
3. Connect the helium supply line from the supply connector on the cartridge to the gas-supply connector on the On-Board Cryopump.
4. Attach the supply and return line identification decals (BROOKS-CRYOGENICS supplied) to their respective connectors.

Verify proper helium supply static pressure as described in the Installation Section of the appropriate Compressor Manual.

Auxiliary (AUX) TC Gauge Installation

An auxiliary TC gauge tube, P/N 8112096, and an auxiliary TC gauge cable assembly, P/N 8112098G001, are available for purchase.

The auxiliary TC gauge reads vacuum between 1 and 1000 microns. The gauge comes with a 1/8 NPT pipe thread.

1. Screw the TC tube into a 1/8 NPT fitting.
2. Attach the auxiliary TC cable to the tube and to the connector on the On-Board module. Refer to [Figure 2-7](#).

Note: It may be necessary to zero the auxiliary TC gauge. Refer to the **On-Board Cryopump Module Programming and Operation Instructions (8040410)** for more information.

Setpoint Relays

The setpoint relays are two mechanical relays that are incorporated into the On-Board Cryopump for the User's application. The relays are rated at 1 amp at 25V AC/DC. The relays have both normally-open and normally-closed contacts. Connection to the relays is made through the 9-pin D connector labeled (Relays) on the connector plate on the On-Board Cryopump. Refer to [Figure 2-7](#) for pin identification.

Refer to **On-Board Cryopump Module Programming and Operation Instructions (8040410)** for instructions on programming the setpoint relays.

When the setpoint relays are used, connection to the relays (R1 and R2) is made via the setpoint relay connector located at the rear of the On-Board controller. If your On-Board Cryopump configuration requires use of the setpoint relays, refer to [Figure 2-7](#) and proceed as follows:

1. Determine whether your On-Board equipment requires setpoint relay contacts to be either in a normally-open or normally-closed position for your application.
2. Referring to [Figure 2-7](#), prepare a 9-pin DSub mating connector, meeting MIL DTL 24308/1-1 and equipment requirements.
3. Connect the setpoint relay receptacle to its connector located on the On-Board controller.
4. Program the relays as described in the appropriate **On-Board Cryopump Module Programming and Operation Instructions (8040410)**.

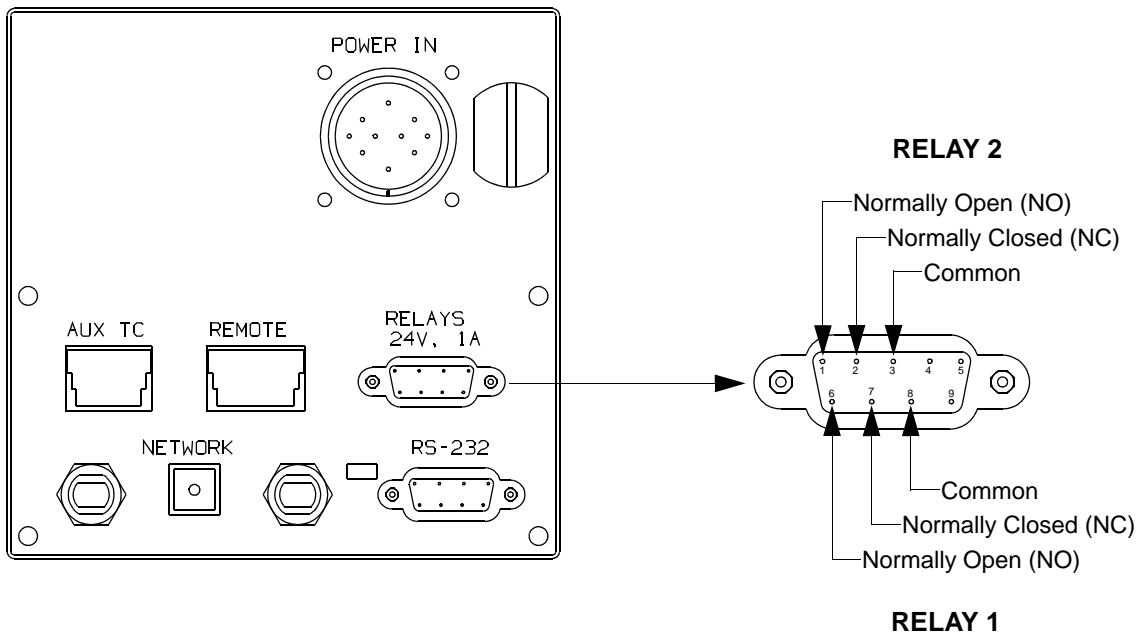


Figure 2-7: Setpoint Relays Connection and Pin Identification

Remote Keypad/Display Installation (Optional)

The On-Board Cryopump can be operated both from a remote and from an attached keypad/display.

The remote keypad/display is a 19-inch rack-mountable unit.

1. Mount the unit to a rack.
2. Connect the unit to the REMOTE connector on the On-Board Cryopump Module using the cable supplied with the remote keypad.

NOTICE

When installing remote keypad cable, care should be taken to route the cable away from power cables and any equipment that may generate excessive EMI conditions

Section 3 - Troubleshooting

Introduction

The primary indication of trouble in a vacuum pumping system is a rise in base pressure of your vacuum chamber. A rise in the base pressure may be caused by a leak in the vacuum system, a fault in the On-Board Cryopump, or by saturation of the 15K cryo-adsorbing charcoal array within the On-Board Cryopump (regeneration may be necessary). If the On-Board Cryopump temperature is below 20K it should pump at rated capacity; a high base pressure is usually caused by an air-to-vacuum leak in the system.

If you suspect a leak in your vacuum system, isolate the On-Board Cryopump by closing the Hi-Vac valve and leak check your vacuum chamber. If no leaks are found, a leak may be present below the Hi-Vac valve (cryopump). Leak checking below the Hi-Vac valve should be performed with the On-Board Cryopump shut off and at room temperature. Leak checking while the On-Board Cryopump is operating may mask leaks that are present (due to the ability of the cryopump to pump helium). If no leak is found, refer to the cryopump troubleshooting procedures summarized in [Table 3-1](#).

The problems presented in [Table 3-1](#) are followed by possible causes and corrective actions. The causes and corresponding actions are listed in their order of probability of occurrence.

Maintaining a log of certain parameters during normal operation is a valuable tool for troubleshooting the cryopump. The log may contain many parameters; however, the following minimum parameters should be included: the cooldown time to 20K, the roughing time to 50 μ , the time to base pressure at crossover, the time between regeneration cycles, and the compressor pressure reading.

Technical Inquiries

Please refer to Contacting Brooks' Technical Support in the front of this manual.

Table 3-1: Cryopump Troubleshooting Procedures

| Problem | Possible Cause | Corrective Action |
|---|--|---|
| High base pressure of vacuum system, and a cryopump temperature <i>below</i> 20K. | Air-to-vacuum leak in vacuum system or in cryopump. | Check cryopump relief valve for proper seating. Check cryopump for leaks. Check vacuum chamber and Hi-Vac valve for leaks. |
| | High partial pressure of noncondensables (helium, hydrogen, or neon) within the cryopump because the 15K array has reached full capacity. | Regenerate the cryopump as described in the appropriate On-Board Cryopump Module Programming and Operation Instructions (8040410) . |
| | One of the arrays is loose, thereby preventing good thermal contact with its cold station on the cold head. | Warm the cryopump to ambient temperature, and retighten the arrays to 15-20 inch/pounds. |
| High base pressure of vacuum system, and a cryopump temperature <i>above</i> 20K. | Decrease in cryopump cold head performance. | If the helium return pressure gauge reads below the normal operating return pressure 100-120 psig (690-827 kPa), add gas as described in the appropriate compressor manual. |
| | High partial pressure of non-condensables (helium, hydrogen, or neon) within the cryopump because the 15K array has reached full capacity. | Regenerate the cryopump as described in the appropriate On-Board Cryopump Module Programming and Operation Instructions (8040410) . |
| | Excessive thermal load on frontal array. | Reduce the thermal radiation load by 1) shielding the cryopump or 2) lowering the temperature of the radiating surface. |

Table 3-1: Troubleshooting Procedures (continued)

| Problem | Possible Cause | Corrective Action |
|--|--|---|
| Cryopump fails to cool down to the required operating temperature or takes too long to reach that temperature (20K). | Low helium supply pressure. | Add gas as described in the appropriate compressor manual. |
| | Compressor problems. | Refer to the appropriate compressor manual. |
| | Leak in vacuum system or cryopump. | Check the cryopump relief valve for proper seating. Check cryopump for leaks. Check vacuum system for leaks. |
| | Incomplete regeneration may not have fully cleaned the adsorbing array. Partial pressures of non-condensables (hydrogen, neon or helium) may remain. | Regenerate the cryopump as described in the appropriate On-Board Cryopump Module Programming and Operation Instructions (8040410) . |
| No display. | No power to On-Board cryopump. | Check electrical connections; be sure the power switch at the compressor controller is turned on. Check fuses. If power is turned on, try turning it off and on to reboot the electronics. Change electronics module. |
| Display does not update, and/or keys do not function. | Electronics has locked up. | Try to reboot the system by turning the On-Board power switch located at the compressor controller off and on. Replace the On-Board electronic module. |
| Rough valve clicks but does not open and close. | Too little or no air pressure to drive valve. | Increase air pressure to 60 psig minimum, 80 psig maximum. |

This Page Intentionally Left Blank

Section 4 - Maintenance

Helium Circuit Decontamination

The information in [Section 4 - Maintenance](#) will guide you through the process of removing gaseous contamination from an On-Board Cryopump helium circuit by freezing the contaminant in the coldhead of the On-Board Cryopump. A contaminated helium circuit will cause the On-Board Cryopump to operate in a noisy manner, typically referred to as *ratcheting*, which degrades On-Board Cryopump performance.

Separate decontamination of the compressor is only required if the compressor has been opened to atmosphere or the helium pressure in the compressor has dropped to zero.

Three methods of decontamination are described in [Table 4-1](#) and on the following pages. These methods all have isolating gaseous contamination in common by freezing them in one or more cold On-Board Cryopumps. The method to be used will most likely be determined by the amount of time available for the decontamination.

Table 4-1: Methods of Decontamination

| Method | Starting Condition | Estimated Time | Effectiveness of Decontamination |
|---|--|---|---|
| 1. Cooldown and Sequential decontamination of all On-Board Cryopumps | Requires all On-Board Cryopumps to be cold. | After all On-Board Cryopumps are cold, 45 minutes to decontaminate the first On-Board Cryopump. 30 minutes for each additional On-Board Cryopump. | Maximum |
| 2. Decontamination of only cold On-Board Cryopumps | Only one On-Board Cryopump needs to be cold. | 45 minutes to decontaminate the first <i>cold</i> On-Board Cryopump. 30 minutes for each additional <i>cold</i> On-Board Cryopump. | Acceptable |
| 3. Simultaneous decontamination of all On-Board Cryopumps using helium manifold | Only one On-Board Cryopump needs to be cold. | 45 minutes | Acceptable (may need to be repeated in several months). |

If the On-Board Cryopump does not reach its normal operating temperature (below 20K), then that performance degradation may be caused by any of the following:

- a. Helium gas contamination
- b. Poor vacuum

c. Thermal load on the On-Board Cryopump arrays

Performing a Fast or Full regeneration cycle will *not* remove gaseous contamination from an On-Board helium circuit. Unless the decontamination procedure is performed, the noisy On-Board Cryopump condition will repeat itself within one - four weeks.

Background

The On-Board Cryopump contains a cryogenic refrigerator assembly called a *coldhead*. There is no way to visually inspect the internal components, so it is best to detect problems by listening for unusual sounds. If the coldhead runs quietly at start up, but begins to make a *ratcheting* noise after the On-Board Cryopump is cooled down, then contaminated helium is the most probable cause.

All gases other than helium can freeze in the coldhead. During manufacturing of On-Board Cryopump systems, gaseous impurities are removed using stringent manufacturing control. The delivered system contains sufficiently low concentrations of gaseous impurities so they are not of concern.

It is possible, over long periods of operation, that additional gaseous contaminants can be released. These gases, along with any air that is added accidentally during installation, will collect in the coldhead as frozen gas. The frozen gas may partially block the regenerator. This increases the amount of torque required to drive the displacer mechanism to the point that the motor noise, that is, the *ratcheting*, may increase and result in coldhead motor stalling.

These gaseous contaminants can be removed by first freezing them in the coldhead, then disconnecting the helium supply and return lines, warming the coldhead followed by de-pressurizing and pressurizing the helium gas in the coldhead to remove them. The use of this decontamination procedure will return most On-Board Cryopumps to proper operation without the need for removal of the On-Board Cryopump from the tool.

It is strongly recommended that this procedure be performed as soon as possible after the ratcheting noise appears to minimize mechanical loading on the On-Board Cryopump drive mechanism.

If any additional help is needed, refer to **Contacting Brooks' Technical Support** in the front of this manual.

Equipment/Tools Requirements

Read this procedure before attempting to perform the steps.

The following tools and equipment must be available to perform this decontamination procedure. If you do not have this equipment, refer to **Contacting Brooks' Technical Support** in the front of this manual to order the equipment needed.

Table 4-2: Decontamination Tools and Equipment

| BROOKS-CRYOGENICS Part Number | Description | Quantity |
|-------------------------------|--|----------|
| 8080250K003 | Maintenance Manifold Kit | 1 |
| 7021002P001 | Charging Hose | 1 |
| 8043079G060 | Flexline, 5-foot (acceptable to use longer lines) | 2 |
| - | Ultra Pure Helium (99.999%) | - |
| 571716 | 1-inch Open End Wrench | 1 |
| 571717 | 1 1/8-inch Open End Wrench | 1 |
| 571718 | 1 3/16-inch Open End Wrench | 1 |
| 8080015K001 | Keypad/display | 1 |
| 8031403 | 0-400/0-3000 psig Regulator | 1 |

For best results, BROOKS-CRYOGENICS suggests the use of a dedicated helium bottle, regulator and charge line which are never separated.

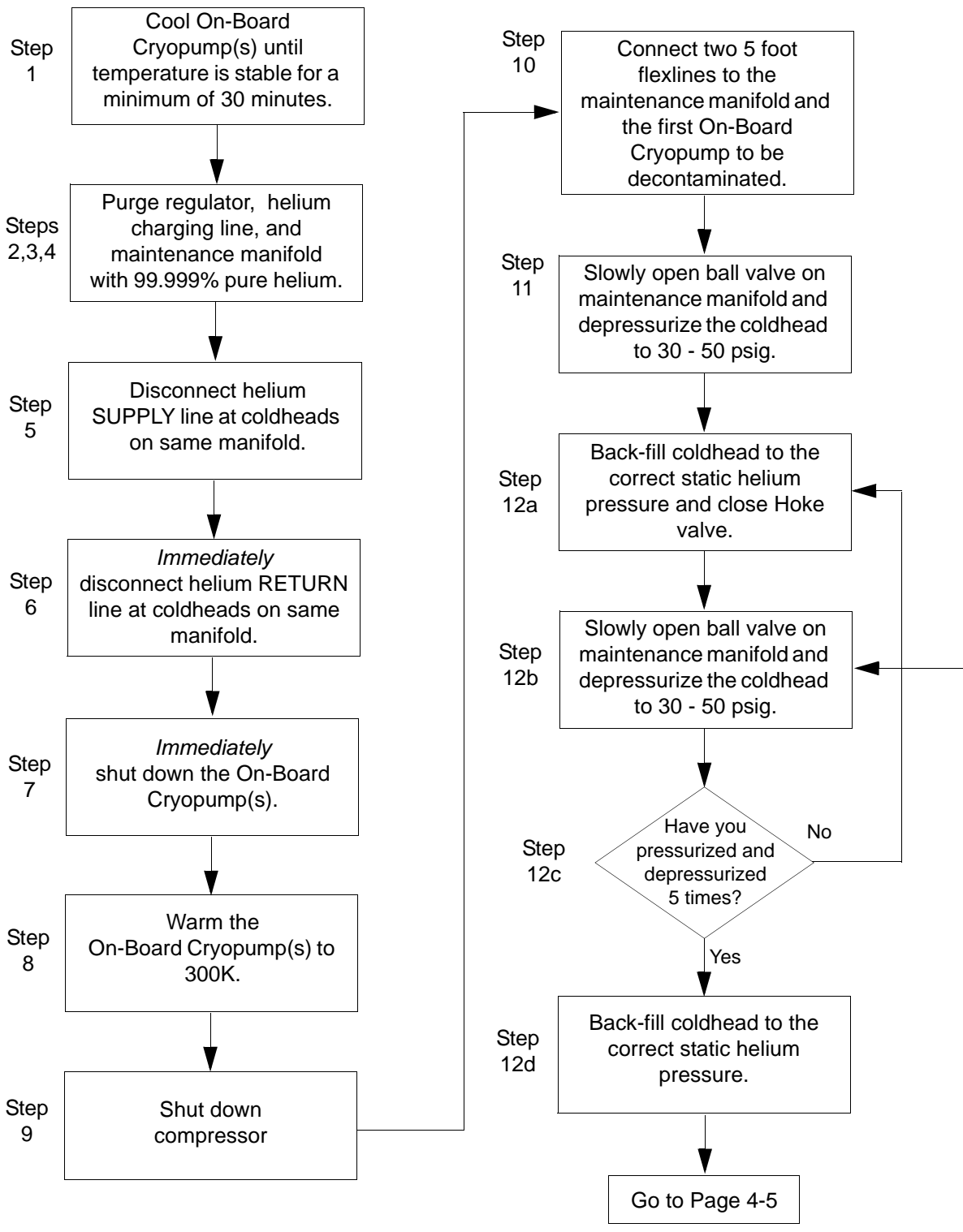


Figure 4-1: Decontamination Flowchart

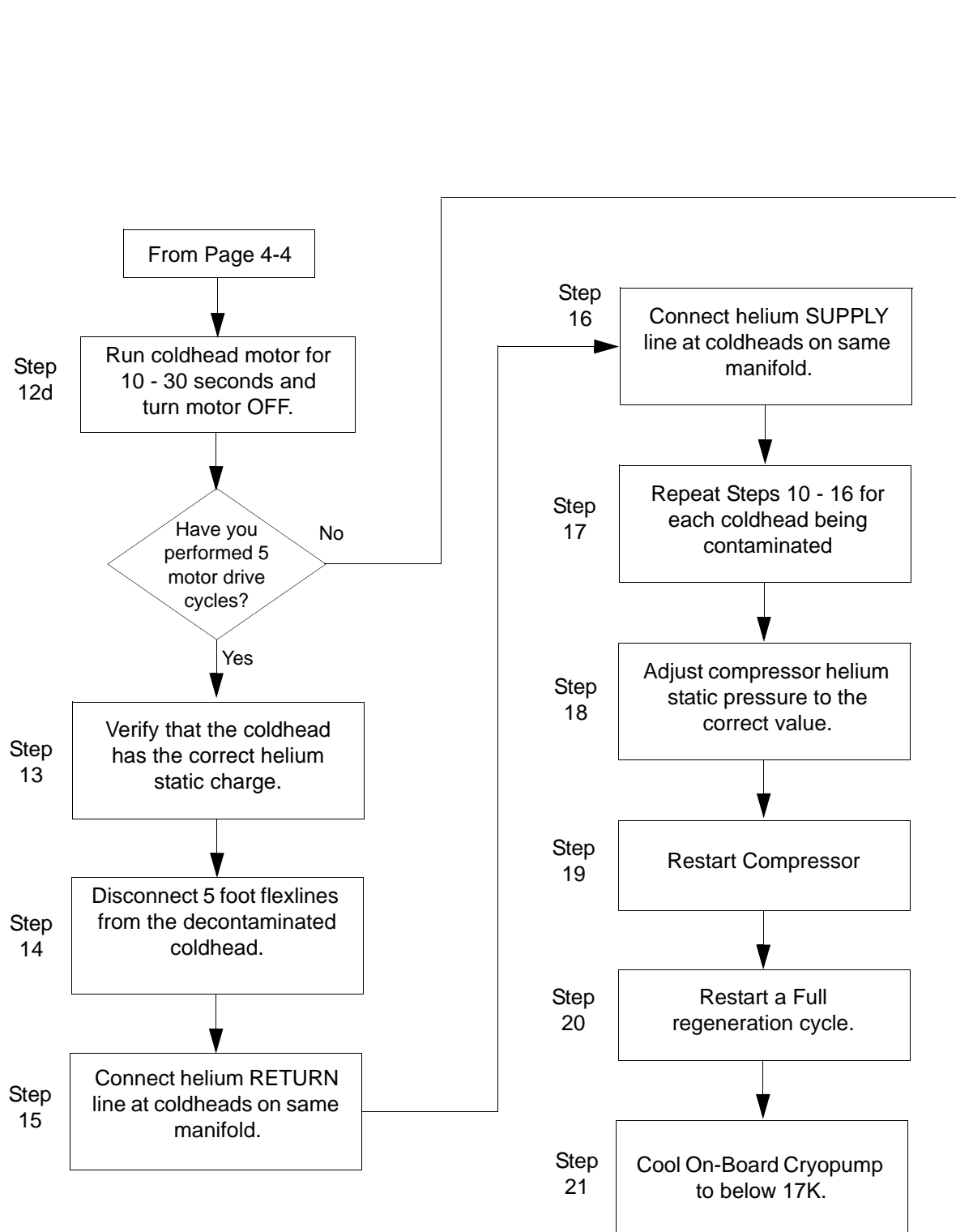




Figure 4-1: Decontamination Flowchart (continued)

Method # 1 - Decontaminate all On-Board Cryopumps

Use this procedure to remove gaseous contamination from the helium circuit by cooling each On-Board Cryopump so that the gaseous contamination is frozen in the coldhead. Each On-Board Cryopump is then decontaminated in sequence.

Method 1 is flowcharted in [Figure 4-1](#).

| | |
|---|--|
|  |  WARNING |
| | <p>High Gas Pressure</p> <p>High helium gas pressure is present in high vacuum pump systems and can cause severe injury from propelled particles or parts.</p> <p>Do not modify or remove any pressure relief valve on the cryopump. Make sure that the path for the regenerated gas is unobstructed.</p> |

1. Ensure that all On-Board Cryopumps on the same manifold have been running with second stage below 25K for at least 30 minutes. If not, then cool down the remaining On-Board Cryopumps and run them for 30 minutes minimum after reaching 25K to trap contaminants in the coldhead.
 - a. Continue with Step 2 even if any pump does not cool below 25K, because its performance may already be affected by contamination.
 - b. Close the high vacuum valves to isolate the On-Board Cryopumps from the vacuum chamber.

When Step 1 is complete, all of the coldheads are cool and the contaminant gases are frozen in the coldhead.

Steps 2 - 4 are required to ensure that the regulator, charging line and the maintenance manifold will be purged of air and that the air trapped in the regulator will not diffuse back into the helium bottle. For best results, BROOKS-CRYOGENICS suggests the use of a dedicated helium bottle, regulator and charge line which are never separated.

2. Attach a regulator (0-400/0-3000 psig) and charging line to a helium bottle (99.999% pure). DO NOT OPEN THE BOTTLE VALVE AT THIS TIME.

3. Purge the regulator and charging line as described in Steps a through d below. Use only 99.999% helium gas.
 - a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm, turn the adjusting knob so that the regulator is barely open.
 - b. Slowly open the bottle valve, and purge the regulator and line for 10 to 15 seconds. Keep the helium flowing to prevent re-contamination.
 - c. Loosely connect the charge line to the closed Hoke valve on the maintenance manifold. Refer to [Figure 4-3](#).
 - d. Continue to purge the charge line for 30 seconds, and tighten the charge line flare fitting onto the Hoke valve while the helium is flowing.
4. Open the ball valve using the extended handle. Open the Hoke valve. Purge the manifold for 30 seconds, close the ball valve, then close the Hoke valve.

Once Step 4 has been completed, all of the coldheads are cold, the gaseous contaminant is frozen in the coldhead, the maintenance manifold is filled with clean helium and connected to the helium bottle.

The helium SUPPLY line should be disconnected first to prevent the crosshead relief valve from opening.

5. While each On-Board Cryopump is still operating, disconnect the helium SUPPLY line at all of the coldheads on the same manifold. The On-Board Cryopump helium supply line is shown in [Figure 4-2](#).

NOTICE

Be sure to use two wrenches to ensure that the self sealing coupling adapter does not back out during disassembly. Refer to [Figure 4-4](#).

6. Immediately after Step 5, and while each On-Board Cryopump is still operating, disconnect the helium RETURN line at all of the coldheads on the same manifold. The On-Board Cryopump helium return line is shown in [Figure 4-2](#).

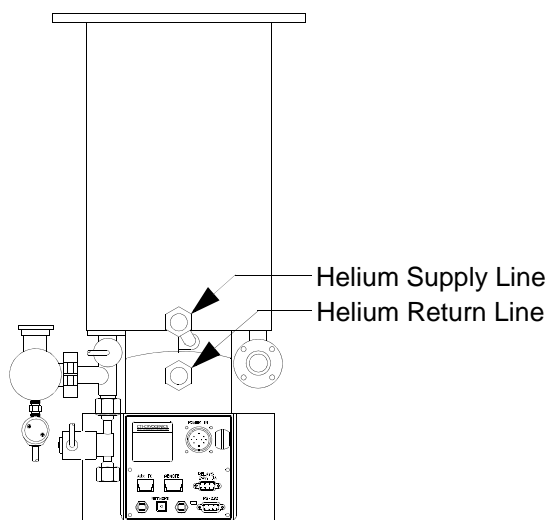


Figure 4-2: On-Board Cryopump Helium Supply and Return Lines

7. Immediately after Step 6, shut down all of the On-Board Cryopumps as described in the appropriate **On-Board Module Programming and Operation Instructions** manual.
8. Warm the On-Board Cryopumps to 300K as follows:
 - a. Regenerate each On-Board Cryopump to be decontaminated by pressing the REGEN button, followed by 1 then 2 on the Network Terminal keypad.
 - b. When the pumps reach 300K, discontinue the regeneration cycle by pressing REGEN and 0. Repeat this process on each pump.

After Step 8 has been completed, all of the coldheads have been cooled and the contaminant gases frozen in the coldhead. Helium gas lines have been disconnected at the coldheads, and the coldheads warmed up to 300K. The next step is to remove the contaminant from each coldhead in sequence.

9. Shut down the compressor.
10. Connect the two helium flexlines to the maintenance manifold and the coldhead of the first On-Board Cryopump to be decontaminated

NOTICE

Be sure to use two wrenches to ensure that the self sealing coupling adapter does not back out during disassembly. Refer to [Figure 4-4](#).

11. De-pressurize the coldhead to between 30 and 50 psig (200 and 330 kPa) by slowly opening the ball valve and allowing the helium to bleed out slowly.

NOTICE

Reducing the coldhead pressure below 30 psig (200 kPa) may introduce more contaminants into the helium circuit.

12. Perform the following Steps in sequence:

Refer to appropriate Compressor Installation, Operation, and Maintenance Instructions for the correct static helium charge pressure.

- a. Back-fill the coldhead with helium to the correct static charge pressure by adjusting the regulator to the required pressure, and opening the Hoke valve on the manifold. Close the Hoke valve when the pressure is correct.
- b. De-pressurize the coldhead to between 30 and 50 psig (200 and 330 kPa) by slowly opening the ball valve and allowing the helium to bleed out slowly. Do not reduce the pressure to less than 30 psig or the coldhead may be further contaminated.
- c. Perform the flushing Steps 12a and 12b four more times.
- d. Again back-fill the coldhead to the correct static charge pressure and run the coldhead drive motor for 10 to 30 seconds by using the remote keypad. Ensure the network cable is removed and press CONTROL and 1 to turn the motor on. Press 0 to turn the motor off.
- e. Repeat Steps b - d four times. There are a total of 5 drive motor runs with five flushes each for a total of 25 flushes.

Refer to appropriate Compressor Installation, Operation, and Maintenance Instructions for the correct static helium charge pressure.

13. Verify that the coldhead has the correct helium static charge pressure.
14. Disconnect the 5-foot flexlines from the decontaminated coldhead supply and return connectors.
15. Reconnect the system helium RETURN line to the return connector

on the coldhead as shown in [Figure 4-2](#).

16. Reconnect the system helium SUPPLY line to the supply connector on the coldhead as shown in [Figure 4-2](#).

Once Step 16 has been completed, the decontamination of the first On-Board Cryopump is completed and charged to the correct pressure with clean helium. The remaining coldheads need to be decontaminated.

17. Repeat Steps 10 - 16 for each coldhead being decontaminated.
18. Once Step 17 has been completed, the On-Board Cryopumps are ready to be cooled down. Adjust the compressor pressure to the correct charge pressure.

Refer to the appropriate Compressor Installation, Operation, and Maintenance Instructions for the correct static helium charge pressure value and adjustment procedure.

The charging adapter can be inserted into any helium line at the tool to simplify the final adjustment of system pressure. It should be removed after final pressure adjustment.

19. Restart the compressor.
20. Start a Full Regeneration cycle on all the On-Board Cryopumps to prepare the vacuum side of the On-Board Cryopump.
21. Allow the On-Board Cryopumps cryopumps to cool to below 17K.

If *ratcheting* in the On-Board Cryopump reappears, refer to **Contacting Brooks' Technical Support** in the front of this manual for additional technical assistance.

Decontamination Alternatives

Method # 1 is the most effective procedure for removing gaseous contaminants from the helium circuit. By this method, all On-Board Cryopumps are first cooled down and the contaminant frozen. Each On-Board Cryopump is decontaminated in sequence.

If time is critical, then Method # 2 is an alternate procedure for decontamination. This procedure will also remove gaseous contaminant in the system.

Method # 2 Decontamination of Only Cold Cryopumps

Method # 2 is based on Method # 1.

If certain On-Board Cryopumps are warm in Step 1 then they can remain at room temperature (i.e. over 290K). With the compressor on and cold On-Board Cryopumps left on, run these “warm” On-Board Cryopumps for 5 minutes. Running these “warm” On-Board Cryopumps for a short time will move any concentrated contaminant out of these coldheads into the compressor. The contaminants will then be carried to the cold On-Board Cryopumps where they will be frozen.

In Method # 2, the following Steps **replace** the corresponding Steps in Method # 1:

Step 1 - Method # 2

Any On-Board Cryopumps on the same manifold which are running should have been running below 25K for at least 30 minutes. Any pumps warmer than 290K should be kept warm.

- a. Continue with Step 2 even if any pump does not cool below 25K (its performance may already be affected by contamination).
- b. Close the high vacuum valves to isolate the On-Board Cryopumps from the vacuum chamber.

Step 17 - Method # 2

Repeat Steps 10 - 16 for each On-Board Cryopump which is not above 290K.

Method # 3 Grouped Decontamination Using Manifold

Method # 3 is based on Method # 1.

The time required to decontaminate each On-Board Cryopump in Method #1 after it is cooled and warmed up is about 30 minutes. If time is not available to decontaminate each On-Board Cryopump in sequence, then the alternate is to decontaminate all On-Board Cryopumps together; in other words, *Grouped Decontamination*. At least one of the On-Board Cryopumps must be cold. The decontamination is performed from the compressor side of the common supply and return manifolds.

In Method # 3 the following Steps **replace** the corresponding Steps in Method # 1.

Step 5 - Method # 3

While each On-Board Cryopump is still operating, disconnect the helium SUPPLY line at the compressor side of the common supply manifold at the tool.

Step 6 - Method # 3

While each On-Board Cryopump is still operating, disconnect the helium RETURN line at the compressor side of the common supply manifold at the tool.

Step 10- Method # 3

Verify that the compressor is off. Connect the two 5-foot helium flexlines to the maintenance manifold and the compressor side of the common supply and return manifold.

NOTICE

Be sure to use two wrenches to ensure that the self sealing coupling adapter does not back out during disassembly. Refer to [Figure 4-4](#).

Steps 11 - 16 - Method # 3

All connections are to the manifold, not the individual coldheads. All coldhead drive motors are to be run for 10 to 30 seconds using the remote keypads per Step 12d. At the end of Step 16, all of the On-Board Cryopumps are decontaminated.

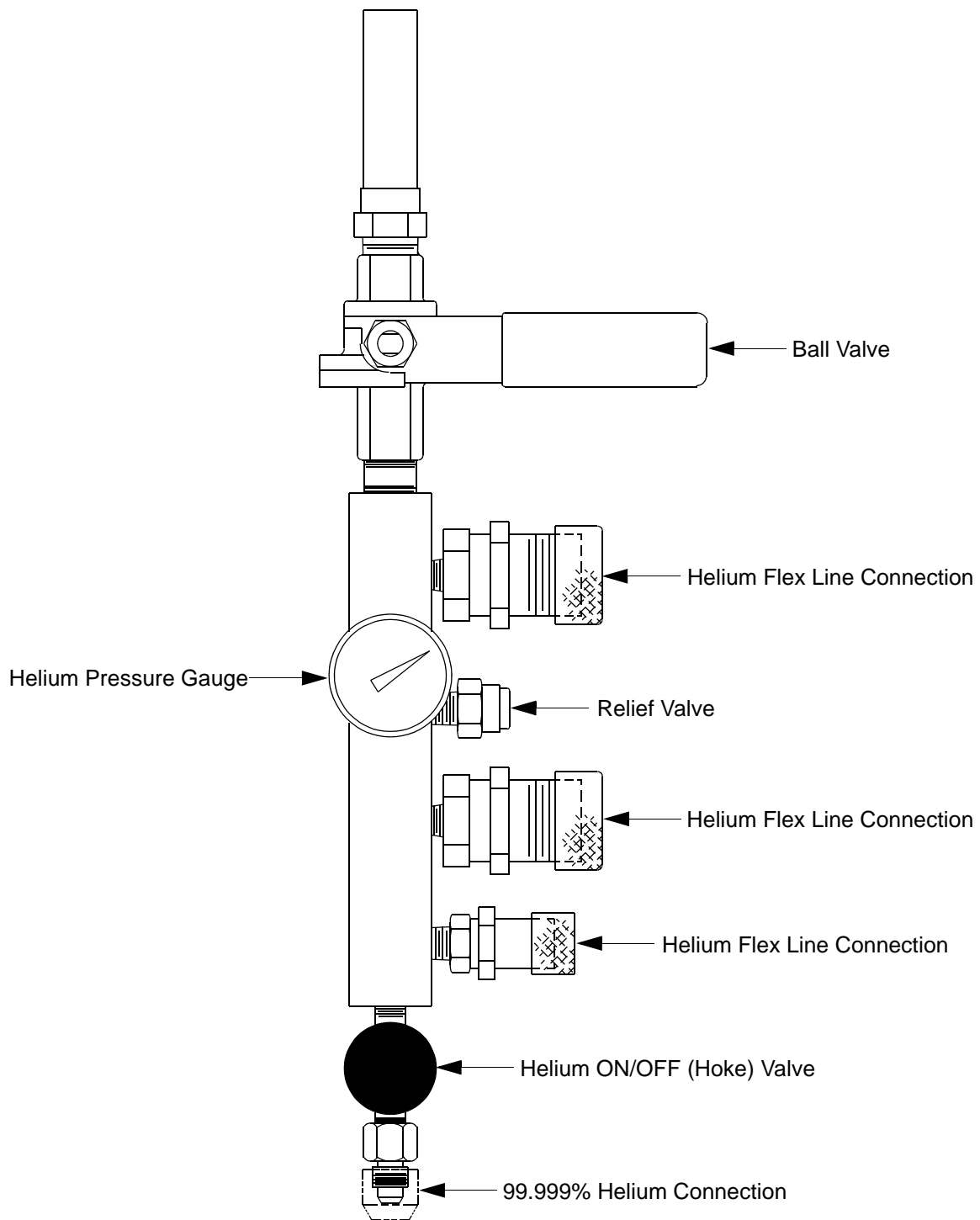


Figure 4-3: Maintenance Manifold Part Number 8032051G001

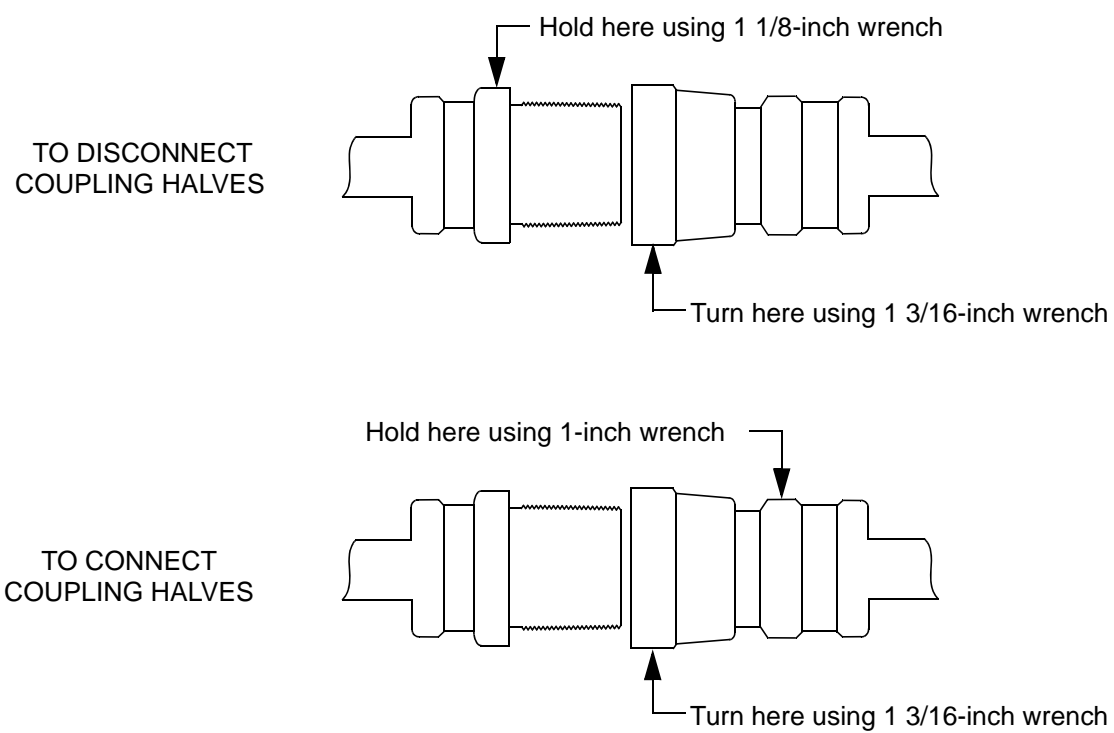





Figure 4-4: Proper Helium Line Coupling Disconnection/Connection

On-Board Cryopump Cleaning

| |  WARNING |
|--|--|
|   | <p>Toxic/Corrosive Gases</p> <p>Toxic and/or corrosive process gases or liquids pumped or captured by an On-Board, On-Board /S, or Cryo-Torr product could cause severe injury on contact.</p> <p>Always vent toxic/corrosive gases or liquids to a safe location using an inert purge gas. The customer is responsible for safely exhausting these gases.</p> <p>Clearly identify on the cryopump which toxic/corrosive gas or liquid is contained in the pump before storing or shipping it to Brooks Automation.</p> |

Cleaning the arrays or other interior surfaces of the On-Board Cryopump vacuum vessel is seldom required because dust buildup does not affect performance, and the special copper alloy cryo-condensing arrays are nickel plated for corrosion resistance.

When cleaning the arrays and other interior surfaces, do the following:

1. Confirm that an adequate supply of indium gasket material, P/N 7100001G006, is available to replace gaskets inadvertently damaged during disassembly.
2. Carefully disassemble the components in the vacuum vessel, including the arrays and radiation shield, to avoid damage to the indium gaskets.
3. Clean the interior surface of the vacuum vessel, the 80K condensing array, and the 80K radiation shield as follows:
 - a. Wash each item in strong soap or detergent solution and hot water.
 - b. Rinse the items in *clean hot water*.
 - c. Air or oven dry all items at 150° F (66° C) maximum before reinstalling into the On-Board Cryopump

NOTICE

Do not clean the 15K cryo-adsorbing array because you may severely contaminate the adsorbent in the cleaning process.

4. Wearing lint-free gloves, reassemble the On-Board Cryopump.
5. Replace any indium gasket damaged during disassembly.

A

Auxiliary TC gauge installation, 2-11

C

Cold head, 1-19

Coldhead, 4-2

Compressor gas and oil flows, 1-19

D

Decontaminating

alternatives, 4-10

cold cryopumps, 4-11

tools required, 4-3

using manifold, 4-11

Decontaminating the circuit, 4-1

H

Helium circuit decontamination, 4-1

Helium line connections, 2-10

I

Installation

introduction, 2-1

K

Keypad

remote operations, 1-2

Keypad and display

installation, 2-2

Keypad and display installation

position A, 2-2

position B, 2-3

position C, 2-4

position D, 2-5

M

Maintenance, 4-1

Microprocessor control

On-Board Cryopump, 1-1

O

- On-Board 10 Cryopump
specifications, 1-12
- On-Board 10F Cryopump
specifications, 1-13
- On-Board 250F Cryopump
specifications, 1-14
- On-Board 250FH Cryopump
specifications, 1-15
- On-Board 4 Cryopump
specifications, 1-6, 1-7
- On-Board 400 Cryopump
standard capacity specifications, 1-16
- On-Board 400 High Capacity Cryopump
specifications, 1-17
- On-Board 500 Cryopump Installation, 2-7
- On-Board 6 Cryopump
specifications, 1-8
- On-Board 8 Cryopump
specifications, 1-9
- On-Board 8F Cryopump
enhanced specifications, 1-11
specifications, 1-10
- On-Board Cryopump
microprocessor control, 1-1
- On-Board cryopump
cold head, 1-19
compressor gas and oil flows, 1-19
theory of operation, 1-19
vacuum vessel and arrays, 1-19
- On-board cryopump
description, 1-1
installation, 2-6
- On-board cryopump installation
auxiliary TC gauge installation, 2-11
helium line connections, 2-10
purge gas connection, 2-10
rough valve gas connection, 2-10
roughing pump connection, 2-10
vent pipe connection, 2-9
- On-board cryopumps
decontaminating, 4-6

P

- Purge gas connection, 2-10

R

- Remote keypad and display installation, 2-12
- Remote operations, 1-2
- Rough valve gas connection, 2-10
- Roughing pump connection, 2-10

S

- Safety precautions, S-1
- Setpoint relays
connecting, 2-11
- Specifications
 - On-Board Cryopump, 1-6, 1-7, 1-8, 1-9,
1-10, 1-11, 1-12, 1-13, 1-14, 1-15,
1-16, 1-17

T

- Troubleshooting, 3-1

V

- Vacuum vessel and arrays, 1-19
- Vent pipe connection, 2-9