Quantum Design

Physical Property Measurement System

Hardware Manual

Part Number 1070-150, B-1

Quantum Design
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USA
Technical support (858) 481-4400
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Fourth edition of manual completed August 2004.

Trademarks

U.S. Patents

4,791,788	Method for Obtaining Improved Temperature Regulation When Using Liquid Helium Cooling
4,848,093	Apparatus and Method for Regulating Temperature in a Cryogenic Test Chamber
5,311,125	Magnetic Property Characterization System Employing a Single Sensing Coil Arrangement to Measure AC Susceptibility and DC Moment of a Sample (patent licensed from Lakeshore)
5,647,228	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber
5,798,641	Torque Magnetometer Utilizing Integrated Piezoresistive Levers

Foreign Patents

U.K.	9713380.5	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber

Safety Instructions

⚠ No operator-serviceable parts are inside. Refer servicing to qualified personnel.	⚠ For continued protection against fire hazard, replace fuses only with same type and rating of fuses for selected line voltage.

Observe the following safety guidelines when you use your system:

- To avoid damaging the system, verify that the system power requirements match the alternating current (AC) power available at your location. If the system has not been configured for the correct power available at your location, contact your local service representative before you proceed with the system installation.
- To prevent electrical shock, verify that the equipment is properly grounded with three-wire grounded plugs.
- To prevent electrical shock, unplug the system before you install it, adjust it, or service it.
- Do not spill food or liquids on the system or its cables.
- Refer to the section titled "Safety Precautions" before you install or operate this system. Direct contact with cryogenic liquids, materials recently removed from cryogenic liquids, or exposure to the boil-off gas, can freeze skin or eyes almost instantly, causing serious injuries similar to frostbite or burns.
- Wear protective gear, including clothing, insulated gloves, and safety eye protection, when you handle cryogenic liquids.
- Transfer liquid helium only in areas that have adequate ventilation and a supply of fresh air. Helium gas can displace the air in a confined space or room, resulting in asphyxiation, dizziness, unconsciousness, or death.
- Keep this system away from radiators and heat sources. Provide adequate ventilation to allow for cooling around the cabinet and computer equipment.
- Refer to the manuals for the supplied computer and monitor for additional safety warnings and notices before you operate the system.

Regulatory Information

- This apparatus has been tested to the requirements of the EMC Directive 89/336/EEC.
- This apparatus is defined as ISM Group 1, Class A and B equipment per EN 50011:1991 (industrial and light industrial environment limits of radio frequency emission).
- This apparatus has been tested to the requirement of the Low Voltage Directive 73/23/EEC.
- See the EU Declaration of Conformity for additional regulatory information regarding your PPMS.

Quantum Design

Physical Property Measurement System

Cryopump High-Vacuum Option User's Manual

Part Number 1083-150, C-2

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Third edition of manual completed November 2004.

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CE

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- To prevent electrical shock, unplug the system before you install it, adjust it, or service it.
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- Wear protective gear, including clothing, insulated gloves, and safety eye protection, when you handle cryogenic liquids.
- Transfer liquid helium only in areas that have adequate ventilation and a supply of fresh air. Helium gas can displace the air in a confined space or room, resulting in asphyxiation, dizziness, unconsciousness, or death.
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C O N T E N T S

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P R E F A C E

Contents and Conventions

P.1 Introduction

This preface contains the following information:

- Section P.2 discusses the overall scope of the manual.
- Section P.3 briefly summarizes the contents of the manual.
- Section P.4 illustrates and describes conventions that appear in the manual.

P.2 Scope of the Manual

This manual discusses the Physical Property Measurement System (PPMS) Cryopump High-Vacuum option. This manual illustrates the cryopump hardware, explains how to install the cryopump, and explains how to use the cryopump to initiate high vacuum.

P.3 Contents of the Manual

- Chapter 1 introduces the Cryopump High-Vacuum option and illustrates the option hardware.
- Chapter 2 explains how to install the cryopump in the PPMS and how to remove the cryopump from the PPMS.
- Chapter 4 contains troubleshooting and maintenance procedures.
- Index is a guide to information organized by key terms and phrases.

P.4 Conventions in the Manual

File menu	Bold text identifies the names of menus, dialogs, options, buttons, and panels used in the PPMS MultiVu and VSM software.
File >> Open	The >> symbol indicates that you select multiple, nested software options.
STATUS	**Bold** text and all CAPITAL letters distinguish the names of keys located on the front panel of the Model 6000 PPMS Controller.
`.dat`	The `Courier` font distinguishes characters you enter from the PC keyboard or from the Model 6000 PPMS Controller front panel. It also indicates file and directory names and computer code.
<Enter>	Angle brackets < > distinguish the names of keys located on the PC keyboard.
<Alt+Enter>	A plus sign + connecting the names of two or more keys distinguishes keys you press simultaneously.
Important	Text is set off in this manner to signal essential information that is directly related to the completion of a task.
Note	Text is set off in this manner to signal supplementary information about the current task; the information may primarily apply in special circumstances.

CAUTION!

Text is set off in this manner to signal conditions that could result in loss of information or damage to equipment.

WARNING!

Text is set off in this manner to signal conditions that could result in bodily harm or loss of life.

WARNING!

Text is set off in this manner to signal electrical hazards that could result in bodily harm or loss of life.

CHAPTER 1

Introduction

1.1 Introduction

This chapter contains the following information:

- Section 1.2 discusses the theory of operation for the PPMS Cryopump High-Vacuum option.
- Section 1.3 illustrates the PPMS Cryopump system hardware.
- Section 1.4 discusses safety precautions for the PPMS Cryopump system.
- Section 1.5 has information for contacting Customer Service at Quantum Design.

1.2 Theory of Operation

The PPMS Cryopump High-Vacuum option pumps helium gas from the PPMS sample chamber in order to provide high vacuum. By reaching base pressures near 0.1 mTorr (1 mP), the system is able to achieve thermal isolation for measurement options such as PPMS Heat Capacity (Model P650) and the PPMS Helium-3 Refrigerator System (Model P825).

1.2.1 Pumping Element

The cryopump uses a charcoal sorption pump maintained at liquid-helium temperatures as the active pumping element. The sorption pump is located at the bottom of a stainless steel tube that penetrates through the top plate of the PPMS probe into the belly of the helium dewar (see Figure 1-1). The cold helium gas and liquid in the dewar provide the cooling. During routine sample chamber operations—that is, pumping, venting, sealing, and purging—the sorption pump is always cold and pumping. The cryopump uses a large orifice flapper valve, located on the PPMS top plate, to isolate the sorption pump from the sample chamber during non-high-vacuum chamber operations. A smaller isolation solenoid valve, also located in the top-plate assembly, isolates the sample chamber from the Model 6000 pumping line.

When the system receives a high vacuum request and it is in the proper state (i.e., the sample chamber has been vented, the isolation solenoid has been opened, and the sample space has been pumped out by using the Model 6000 pumping line), it automatically performs the following operations: When the pressure is below about 10 Torr (1 kP), the system closes the isolation solenoid and opens the large flapper valve, thus exposing the sample chamber to the sorption pump. The system monitors the pressure after the chamber has been exposed and indicates high vacuum when the pressure has stabilized at its minimum value.

The isolation solenoid is normally closed. The system opens it when the PPMS sample space is pumped on or vented. When the chamber has been purged, the system closes the isolation solenoid again.

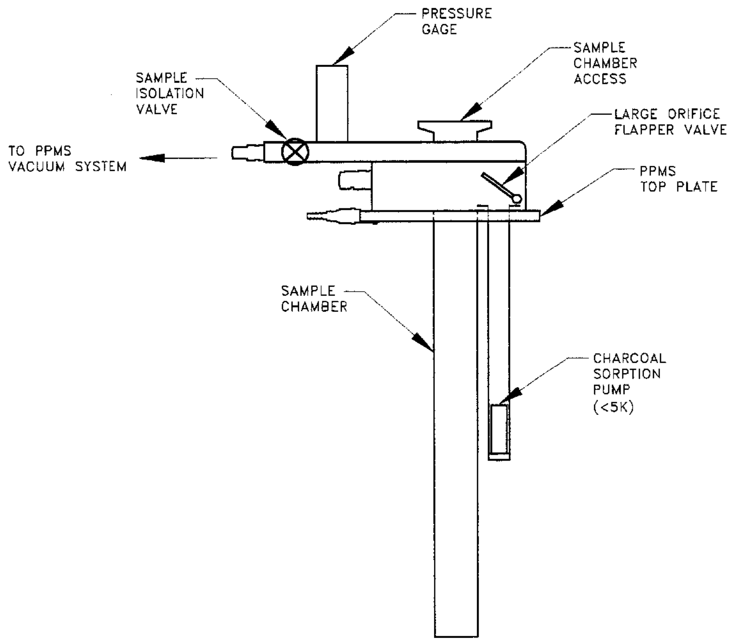

Figure 1-1. Cryopump assembly

1.2.2 Pump Regeneration

Because of the limited capacity of a sorption pump, it is necessary to periodically regenerate the pump in the cryopump system by heating it to liberate the adsorbed helium gas. Typically, the system only needs an in-dewar regeneration. The in-dewar regeneration procedure takes a brief amount of time and is automated through the use of a heater attached to the sorption pump. However, it is important to note that you must manually initiate the regeneration by using the front panel of the Model 6000 PPMS Controller or the PPMS MultiVu software.

Usually the system operates many weeks or months without requiring a regeneration of the pump. The actual time between regeneration operations depends on the number of chamber operations and the amount of water vapor allowed into the sample chamber. Occasionally it will be necessary to perform an out-of-dewar regeneration, in which the entire cryopump assembly is removed from the dewar through the top plate. This procedure takes somewhat longer than the in-dewar procedure, but because the regeneration heater only liberates helium gas, the out-of-dewar regeneration is used to remove water or nitrogen.

Section 4.3 discusses the regeneration process in detail, including factors that will cause a need for the out-of-dewar regeneration.

1.3 Hardware

Table 1-1. Major hardware components shipped with the PPMS Cryopump option

HARDWARE	PART NUMBER	ILLUSTRATION
Cryopump Head Assembly	4083-201	Figure 1-2
Blanking Plate	HPNW40C	Figure 1-3, Item A
Centering Ring	HPNW40B	Figure 1-3, Item B
Cryopump Pumpout Fixture	4083-208	Figure 1-3, Item C
with O-Ring	VON2-224	Figure 1-3, Item D
Cover, Left Side Cryopump	4083-205	Figure 1-4, Item A
Cover, Right Side Cryopump	4083-206	Figure 1-4, Item B
Extension Cap (EverCool systems)	4083-234	Figure 2-7
Sample Space Plug	4083-059	Figure 1-4, Item C
Sample Chamber Baffle Assembly	4078-113	Figure 1-5
Blank Plate Weldment	4078-105	Figure 1-5, Item A
Contact Baffle Assembly	4083-010	Figure 1-5, Item B
Cryopump Cable Assembly	3083-308	Figure 1-6
Expansion Circuit Board	3076-015	Figure 1-7
Port Expansion Box	4076-060	Figure 2-3
Auxspare-to-Expansion-Board Cable	3076-018	
Cable Assembly Jumper	3085-101	
PAL for Motherboard		
Updated ROMs		

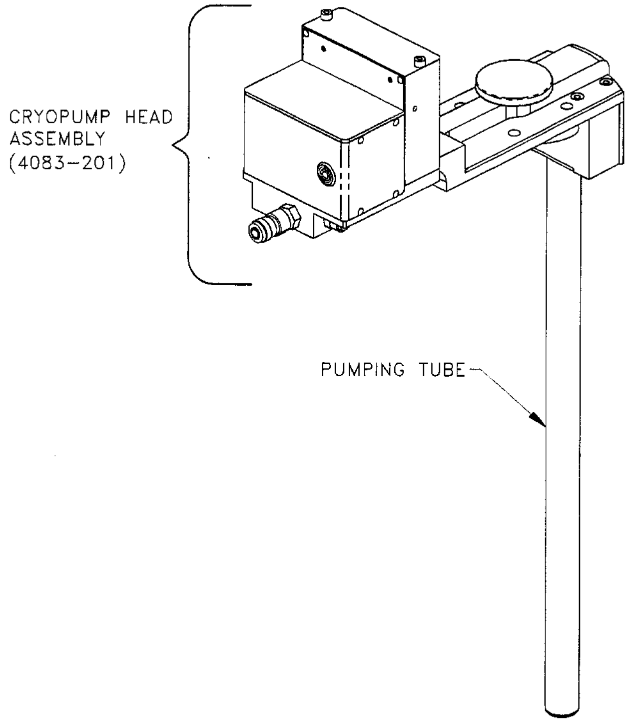

Figure 1-2. Cryopump head assembly and pumping tube

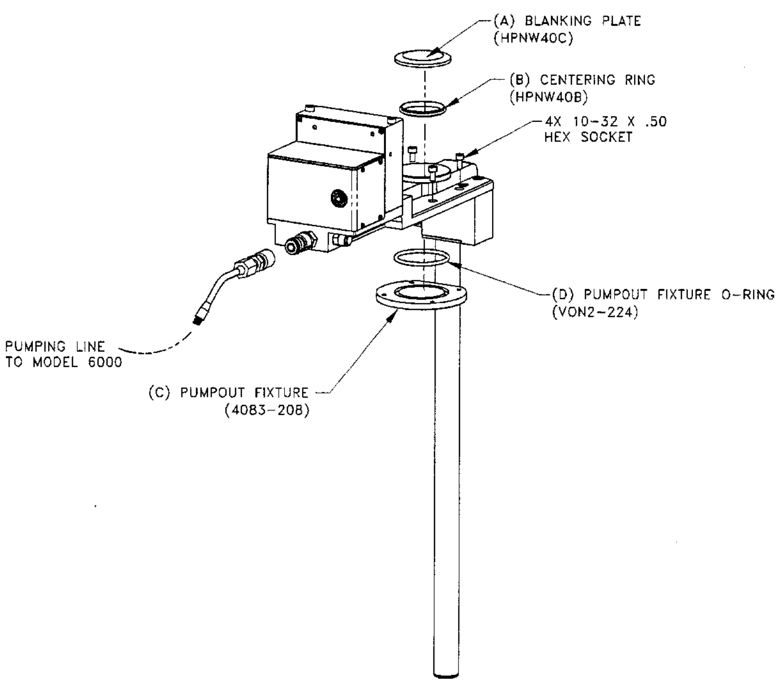

Figure 1-3. Pumpout fixture and blanking plate

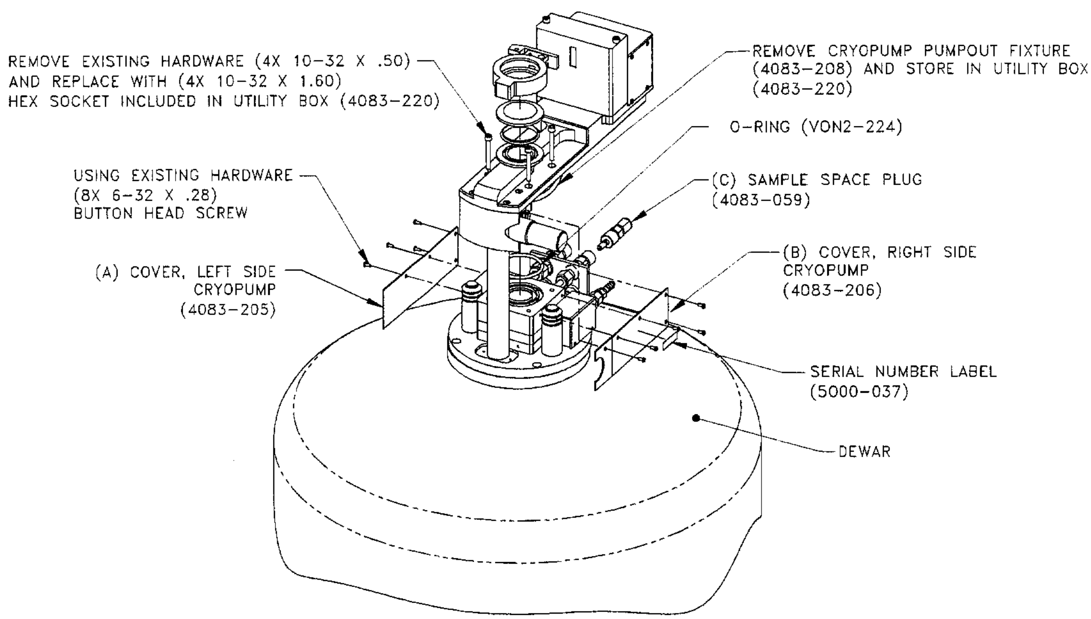

Figure 1-4. Exploded view of installed cryopump

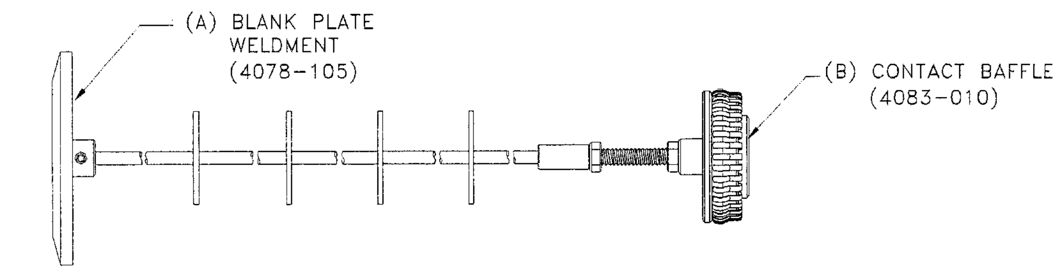

Figure 1-5. Sample-chamber baffle assembly with contact baffle

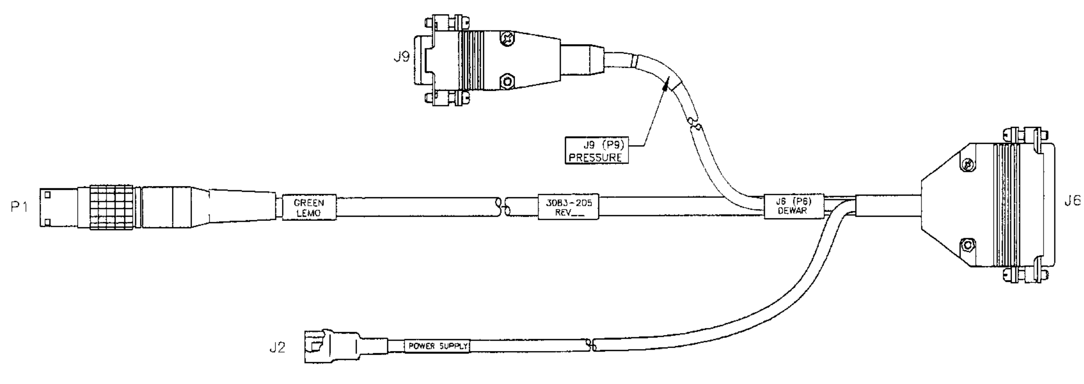

Figure 1-6. Cryopump cable

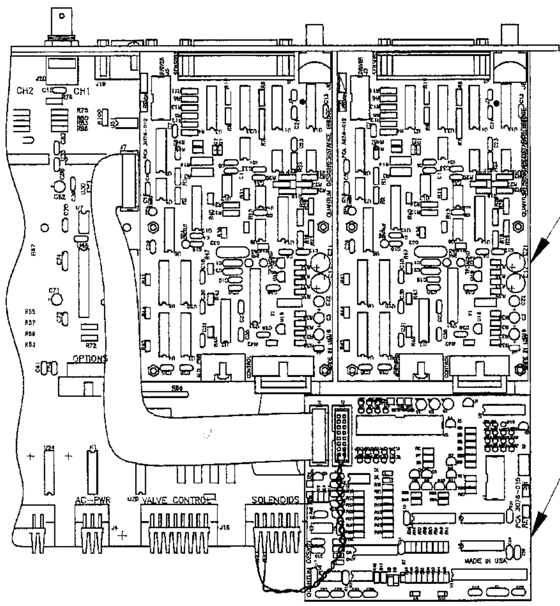

Figure 1-7. Expansion circuit board and enhanced user bridge board in Model 6000

1.4 Safety Precautions

WARNING!

The Cryopump option is used in conjunction with the Physical Property Measurement System (PPMS), so you should be aware of the safety considerations for all the equipment. PPMS-related safety precautions include those for the use of superconducting magnets and for the use of cryogenic liquids, as is reviewed below and in the *Physical Property Measurement System: Hardware Manual.*

Above all, Quantum Design and its staff ask that you use standard safe laboratory procedures.

- Use common sense.
- Pay attention to the state of the system and to your surroundings.
- If the system appears to be behaving abnormally, investigate to see if there is a malfunction. If necessary, take the appropriate action (e.g., troubleshoot, shut down the system, contact Quantum Design).
- Supervise inexperienced users and train them in general electrical safety procedures.

The PPMS has safety features to prevent accidents from causing injury or serious equipment damage. *If you use the equipment in a manner that is not specified by Quantum Design, the protection afforded by the equipment may be impaired.*

1.4.1 Magnets

WARNING!

Any person who wears a pacemaker, electrical medical device, or metallic implant must stay at least 5 m (16.5 ft.)[1] from the PPMS dewar. In addition, personnel should keep all ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar. Verify that all magnetic fields are at zero (0) before you handle the VSM linear motor transport in any way.

The following precautions should be followed to ensure the safety of personnel who work with or around a PPMS with a superconducting magnet. This material is covered in more depth in Chapter 1 of the *Physical Property Measurement System: Hardware Manual.*

- Verify that any person who has a metallic implant or is wearing a pacemaker or electrical or mechanical medical device stays at least 5 m (16.5 ft.) from the PPMS dewar. Large magnetic fields are dangerous to anyone who has a metallic implant or is wearing a pacemaker or other electrical or mechanical medical device.

  Important: The automated control system can turn on the magnet while the system is unattended. Furthermore, the three-dimensional magnetic field of the PPMS will penetrate nearby walls, the ceiling, and the floor. Therefore, your safety considerations should include such adjacent spaces.

- Keep all iron, nickel, and other ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar. Large magnets, such as the PPMS superconducting magnets, can attract iron and other ferromagnetic materials with great force. The observable effects of magnetic fields are listed in Chapter 1 of the *Physical Property Measurement System: Hardware Manual.*

[1] At the current time (November 2004), 5 m should be a large enough distance to protect wearers of metallic implants or medical devices from most magnetic fields produced by Quantum Design magnets. However, the safe distance from newer magnets (in development) could be greater. Hence, personnel who work with and around the superconducting magnets should review thoroughly documentation for new equipment.

1.4.2 Cryogens

> **WARNING!**
>
> Always wear protective clothing and ensure that the room has good ventilation when you work with cryogenic materials such as liquid helium and liquid nitrogen. These precautions will protect you against cryogenic material hazards: (1) they can expand explosively when exposed to room temperature; (2) they can cause serious burns.

- Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium, liquid nitrogen, or other cryogens.
- Avoid wearing loose clothing or loose gloves that could collect cryogenic liquids next to the skin. The extreme cold of liquid and gaseous cryogens can cause serious burns and has the potential to cause loss of limbs.
- Use cryogens only in well-ventilated areas. In the event a helium container ruptures or there is a helium spill, vent the room immediately and evacuate all personnel. In a poorly ventilated area, helium can displace the air, leading to asphyxiation. Because helium rises, well-vented rooms with high ceilings generally provide the safest setting for working with it.

1.4.3 Electricity

> **WARNING!**
>
> The PPMS is powered by nominal voltages between 100 V to 240 V AC. These voltages are potentially lethal, so you should exercise appropriate care before opening any of the electronics units, including turning off the equipment and disconnecting it from its power source.

- Turn off and unplug all electronic equipment before removing any equipment covers.
- Keep electrical cords in good working condition and replace frayed and damaged cords.
- Keep liquids away from the workstations.

1.5 Contacting Quantum Design

If you have trouble with your PPMS or Cryopump option, please contact your local Quantum Design service representative for assistance. Your service representative will ask you to describe the problem, the circumstances involved, and the recent history of your system.

United States

Quantum Design World Headquarters
6325 Lusk Boulevard
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1-800-289-6996
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Service for Taiwan, Hong Kong, Singapore

CHAPTER 2

Installation and Removal

2.1 Introduction

This chapter contains the following information:

- Section 2.2 explains how to install the cryopump in the PPMS.
- Section 2.3 explains how to remove the cryopump from the PPMS.
- Section 2.4 explains how to reinstall the cryopump.

2.2 Installing the Cryopump

WARNING!

Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you install or remove the cryopump from the dewar or when you work with liquid helium, liquid nitrogen, or any other cryogen. For more information about cryogenic safety, refer to Section 1.4.2 and to the *Physical Property Measurement System: Hardware Manual*.

The Cryopump High-Vacuum option is shipped with an accessories box (Figure 2-1) that holds tools and hardware, such as the items that are installed in or removed from the PPMS during installation of the cryopump. The accessories box contains the following items: cryopump side panels, a blanking plate, a plug removal tool, a 5/32-inch hex Allen key, a 5/64-inch Allen wrench, assorted screws, and a container of Apiezon M-grease.

We strongly recommend that you review a set of procedures before you begin them (e.g., installation, removal). For instance, a review will facilitate the installation and help you prevent air from being cryopumped into the dewar.

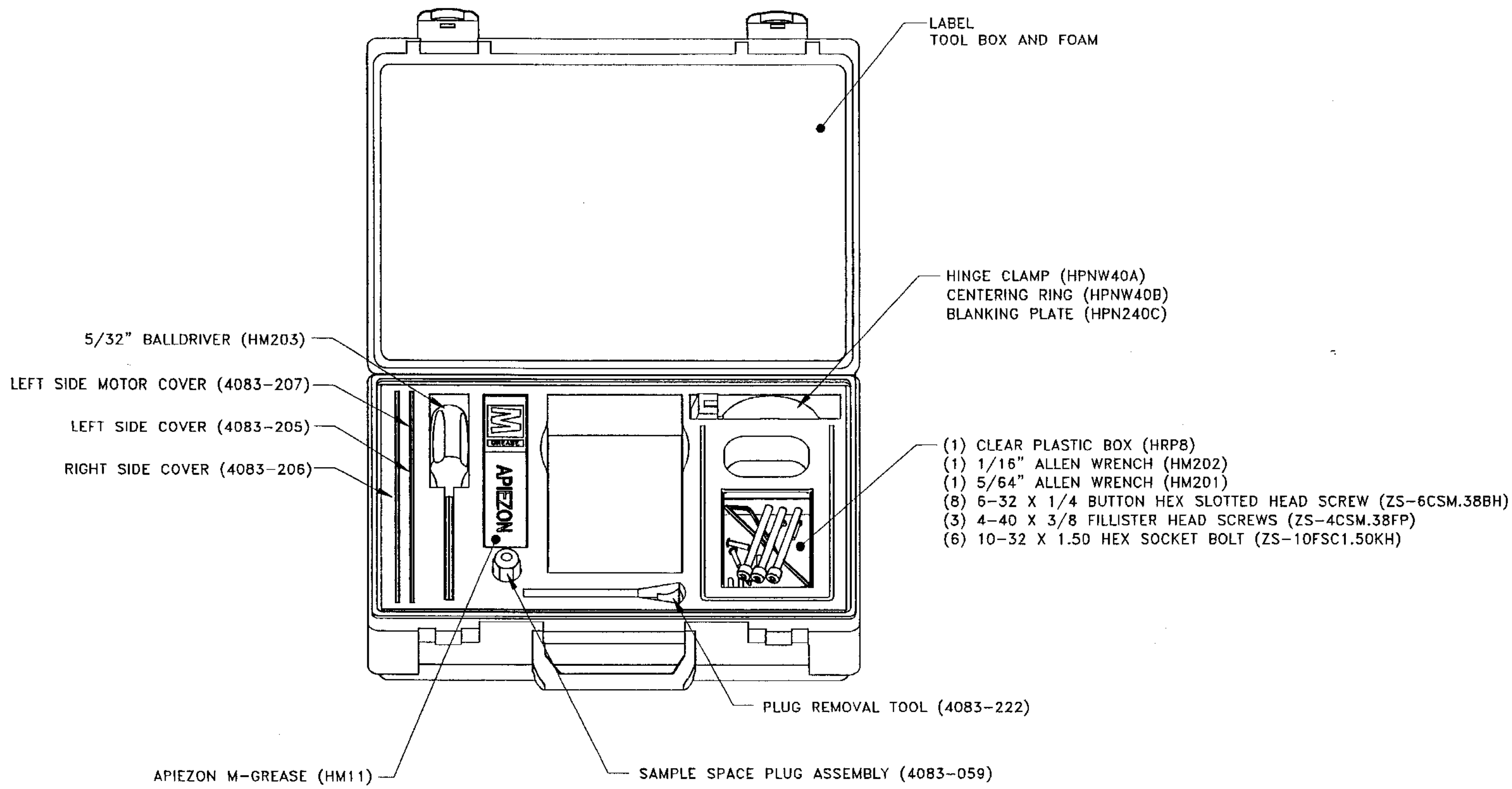


Figure 2-1. Accessories box for the Cryopump High-Vacuum option

CAUTION!

In the following procedures, it is important to maintain the sample chamber at or above room temperature. This will prevent the condensation and cryopumping of air into the chamber if it is opened to the atmosphere.

2.2.1 Unpack the Cryopump

CAUTION!

Always hold the head of the cryopump carefully and with two hands. Never hold the cryopump by the tube, because the head is heavy and the tube is thin, so the tube can be easily bent and damaged. If the tube is bent, you will not be able to insert it into the dewar.

1. Remove the cryopump system from the packing crate.
2. Verify that you have received all system components. Table 1-1 lists the major hardware components that are shipped with the cryopump.
3. Run the *Heater Continuity Diagnostic Test* to verify that the regeneration heater was not damaged during shipping. If the system does not pass this test, contact Quantum Design.

   Heater Continuity Diagnostic Test
   At room temperature, check continuity between Pins 7 and 8 on the green Lemo connector. The value should be 100 $\Omega \pm 5\Omega$. Then check Pin 7 to ground (chassis) for infinite resistance and Pin 8 to ground for the same (refer to the cryopump wiring diagram in Section 4.4 of this manual).

2.2.2 Prepare for Installation

1. Set the PPMS system temperature to 320 K.
2. Vent the system continuously.
3. Put the system in standby mode.
4. Install any software that accompanied the Cryopump option. To install the software, run `setup.exe` from the installation disk(s). The Cryopump option requires PPMS MultiVu version 1.2 or later in order to take full advantage of the cryopump features.

2.2.3 Power Down and Change the EPROMs

If you received new EPROMs, you must install them in the Model 6000 PPMS Controller. The Cryopump option requires EPROMs version 1.80 or later. Complete the following steps to install the EPROMs.

Figure 2-2. PPMS 32-bit Tools icon

1. Back up the ROM configuration information by running the ROM configuration utility as follows:
   (*a*) Double-click on the **PPMS 32-bit Tools** icon on the PC desktop.
   (*b*) Run the Romcfg32 utility.
   (*c*) Select the **Diag (all Configs including above)** check box.
   (*d*) Select the **Read Configuration** button.
   (*e*) Specify a file name for the configuration you are saving, and select **OK**.
   (*f*) Wait for the program status at the bottom left corner of the screen to change from "reading" to "idle."
2. Turn off power to the Model 6000.
3. Remove the power cord from the Model 6000.
4. Remove the lid from the PPMS electronics cabinet.
5. Remove the lid from the Model 6000.
6. Locate the CPU board. When you face the front of the electronics cabinet, the CPU board is the board the furthest to the left and it has the GPIB connected at its back.
7. Remove the two EPROMs from the CPU board.
8. Install the two new EPROMs into the CPU board.
9. Keep the power disconnected from the Model 6000.

2.2.4 Install the Expansion Circuit Board

CAUTION!

Work carefully while the cover is off the top of the Model 6000 PPMS Controller, and avoid dropping hardware inside the unit. If hardware is dropped inside the Model 6000, it *must* be retrieved before you restore power to the Model 6000, or it could be severely damaged.

Note: The following procedures involve working with circuit boards. If there is no one available who is experienced with circuit boards, contact Quantum Design for assistance.

To enable the Model 6000 to communicate with the cryopump hardware, the Cryopump/Helium-3 expansion circuit board must be installed in the Model 6000, as explained below.

1. Locate the CPU board in the Model 6000. When you face the front of the electronics cabinet, the CPU board is the board the furthest to the left and it has the GPIB connected at its back.
2. Remove the CPU board by disconnecting the cables, back-panel screws, and fasteners holding the board onto the five standoffs. The large board beneath the CPU board is the motherboard.

3. Check for any chips previously installed in the U55 socket in the motherboard. If the U55 socket is empty, proceed to step 4. If there is already a chip in the socket, its label should read "PPMS_SEL2." If the revision and the "CKSUM" numbers are identical to those on the upgrade chip included with this option, no chip replacement is necessary. If the revision or the "CKSUM" numbers are different between the two chips, replace the chip in the motherboard with the upgrade chip.
4. Hold the "PPMS_SEL2" PAL chip so that the notch on it faces left, indicating that pin 1 is in the correct position.
5. Use gentle pressure to insert the "PPMS_SEL2" PAL chip into the "U55" socket on the exposed circuit board. Work carefully so that you do not bend pins; bent pins require new motherboards. Once the PAL chip is inserted, visually inspect it to verify that there are no bent pins.
6. Reinstall the CPU board.
7. Remove any board installed in the "P3–Option" slot on the Model 6000.
8. Install the expansion circuit board (part number 3076-015) in the location indicated in Figure 2-3. Proceed as follows: (*a*) remove the nut and washer holding the lower right corner of the mother-board, (*b*) attach the provided standoff, (*c*) install the expansion board into the standoff, and then (*d*) reinstall the washer and nut.

   If the standoff does not stand vertically, you may need to bend it to make it straight. The expansion circuit board will not fit unless the standoff is straight. The two connectors on the underside of the board should completely engage the connectors on the motherboard.

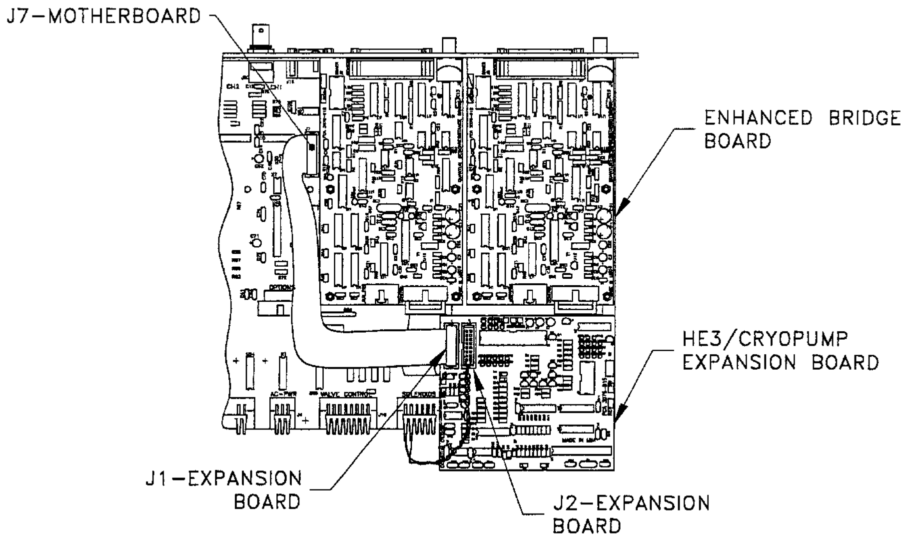


Figure 2-3. Installing the expansion circuit board in the Model 6000

9. Locate the 16-pin connector at the "J7-Aux-Spare" position on the motherboard. *To proceed with the installation, a connector must already be plugged into this position.* Contact Quantum Design if nothing is plugged into the "J7-Aux-Spare" position.
10. Remove the connector plugged into the "J7-Aux-Spare" position on the motherboard, and plug it into the "J2" connector on the expansion circuit board as shown in figure 2-2.
11. Install the "Auxspare-to-Expansion Board" ribbon cable (part number 3076-018) between the "J1" connector on the expansion board and the "J7-Aux-Spare" connector on the motherboard as shown in figure 2-2. Do not let the ribbon cable touch the large resistors above the "Valve Control" connector; these resistors can get very hot. You may want to run the cable under the system bridge board.
12. Reinstall the board you removed from the "P3–Option" slot.

2.2.5 Power Up the Model 6000 and Restore the Configuration

1. Replace the lid on the Model 6000.
2. Reattach the power cord.
3. Turn on power to the Model 6000.
4. Restore the ROM configuration information as follows:
   a. Locate and run the Romcfg32 utility if it is not still running,
   b. Select the **Send to PPMS >> Send Config** menu item, and
   c. Specify the file name you saved above in section 2.2.3.
5. Set the PPMS system temperature back to 320 K and vent the system continuously.

2.2.6 Connect the Pumping Line and Cables

1. Remove the cable and any associated in-line dongles attached to the "P6–Dewar" connector on the back of the Model 6000.
2. Locate the port expansion box (part number 4076-060, Figure 2-4) that comes with the Cryopump option and attach it to the "P6–Dewar" connector.

   The port expansion box is a simple splitter box that allows the existing dewar cable to share the "P6–Dewar" connector with the cryopump cable.

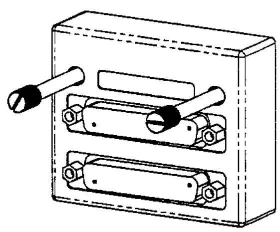


Figure 2-4. Port expansion box

3. Affix the "P6–Dewar" sticker to the port expansion box if the sticker is not already on the box.
4. Reattach the dewar cable and any dongles you disconnected in step 1 to the port expansion box. Refer to Figure 2-5.
5. Place the cryopump head assembly (part number 4083-201) on the edge of a smooth, flat table or work surface that is near the PPMS dewar and electronics cabinet. Position the cryopump head assembly so that the pumping tube hangs straight down over the edge of the table, and make certain you do not scratch the bottom surface of the assembly. Figure 1-2 identifies the cryopump head assembly and the pumping tube.
6. Referring to Figure 2-5, connect the sample space pumping line as follows:
   (*a*) Detach the sample space pumping line from the PPMS probe.
   (*b*) Plug the pumping line into the port at the bottom of the back panel on the cryopump top plate assembly.
   (*c*) Insert the sample space plug (part number 4083-059) into the fitting from which the pumping line was removed.

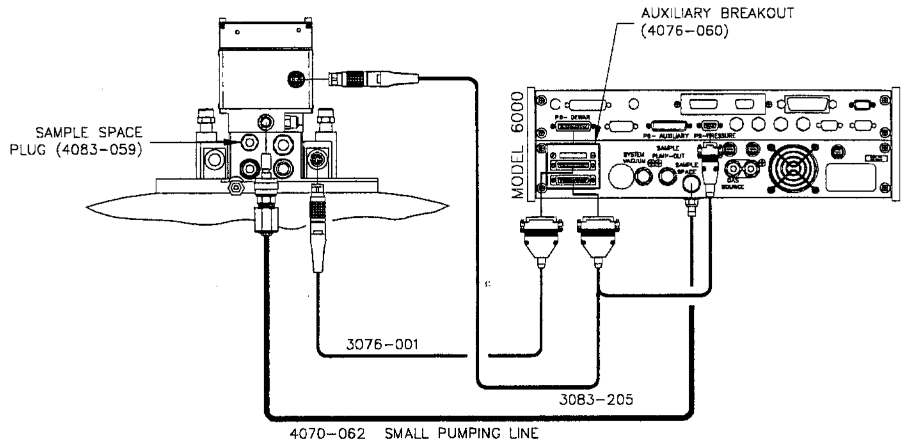


Figure 2-5. Cryopump connection diagram

7. Referring to Figure 2-5, connect the cryopump cable (part number 3083-205, Figure 2-6) as follows:
   a. Plug the 25-pin backshell connector into the "P6–Dewar" port expansion box on the Model 6000.
   b. Plug the 9-pin backshell connector into the "P9–Pressure" port on the Model 6000.
   c. Plug the Lemo-type connector with the green, color-coded band into the cryopump head.

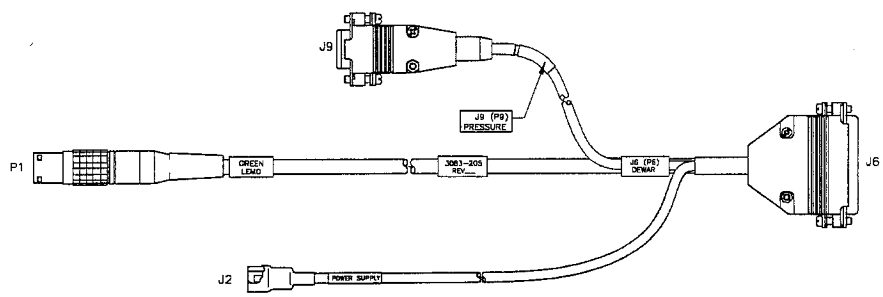


Figure 2-6. Cryopump cable

8. Attach the vacuum gauge power supply as follows:
   a. Plug in any power strip that has been shipped to you (required with older PPMS electronics cabinets. If your system uses an older 220-V cabinet, you must unplug a cable from the existing power strip before you can plug in the new power strip.
   b. Connect the vacuum gauge power supply to the cryopump cable. Automatic voltage detection in the vacuum gauge power supply will only allow the power supply that is compatible with your system.
   c. Connect the vacuum gauge power supply to the system's power strip. If an IEC attachment cable has been shipped to you, plug one end into the power supply and one end into the power strip. If a second attachment cable has been shipped to you, use this cable to connect the new power strip to the old power strip.
9. Use the Model 6000 **CONFIG** menu to configure the Model 6000 for cryopump operation.
   a. Select **CONFIG >> 6. Hardware >> 5. High Vacuum.**
   b. Under **Type of System**, select **Cryopump**.
   c. Press <Alt+Enter> to save the change.

10. Next, use the Model 6000 **CONFIG** menu to activate the cryopump (Pirani) pressure gauge (instead of the Model 6000 internal pressure gauge).
    a. Select **CONFIG>>6. Hardware>>4. Pressure Sensor**

       The Model 6000 display will now show the **Sensor**, **Units**, and **Units/V** settings.
    b. Use the directional keys on the Model 6000 to select "Pirani" for the **Sensor** type. When you are finished, the display should be similar to the example below.

SENSOR:	**PIRANI**
UNITS:	**TORR**
UNITS/V:	**TABLE**

    c. Press <ALT+ENTER> to save the changes.

2.2.7 Regenerate the Charcoal

Note: You will perform an out-of-dewar[1] regeneration of the system before the cryopump is installed or whenever the charcoal has become saturated with non-helium gases.

1. Verify that the cryopump pumpout fixture (part number 4083-208) is attached to the bottom side of the sample chamber opening on the cryopump (refer to Figure 2-7). Four 10-32 × 3/8 socket-head screws attach the pumpout fixture, with the O-ring facing upward, to the cryopump. The screws should be finger tight.
2. Referring to Figure 2-7, sse the blanking plate (see Figure 2-7, part number HPNW40C) and associated centering ring (part number HPNW40B) to cover the top orifice of the cryopump.

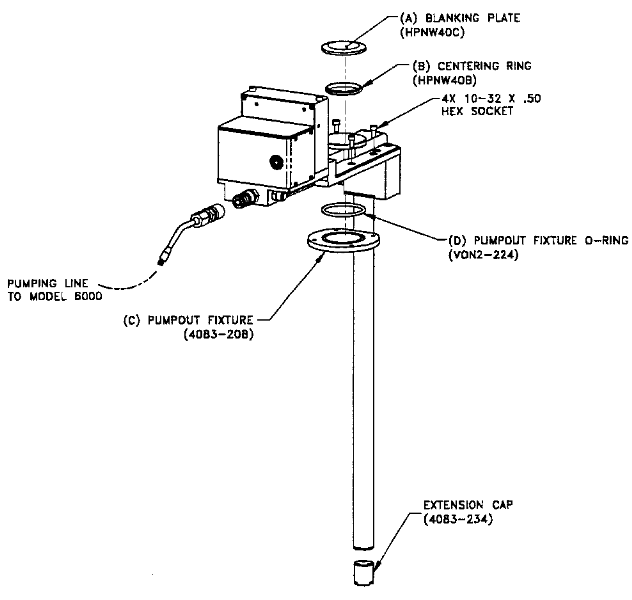


Figure 2-7. Exploded view of pumpout fixture and blanking plate (HPNW40C). Note the extension cap for [1]the cryopump pumping tube, which is used **only with the EverCool option** (see Section 2.2.9)

[1] The out-of-dewar regeneration is sometimes referred to as a warm regeneration.

3. Use the Model 6000 **CTRL** menu to initiate the out-of-dewar regeneration by selecting **CTRL >> 3. Immediate Operations >> 14. CryoReg >> Regenerate with CryoPump in Room**. The flapper valve opens and the system is pumped out. Then the flapper valve closes and the cryopump system is regenerated. This process takes at least 30 seconds. The out-of-dewar regeneration does not use the regeneration heater. You may follow the status of the regeneration by selecting **CTRL >> 1. Interactive Control >> 4. Pump**.

   When regeneration is complete, the message "Vented" appears in all menus that identify the status of the sample chamber. Note that you can run the out-of-dewar regeneration process multiple times.
4. Remove the top blanking plate (HPNW40C).
5. Remove the four 10-32 × 3/8 socket-head screws that attach the pumpout fixture to the cryopump, then remove the pumpout fixture.

We recommend that you review Sections 2.2.8 and 2.2.9 before you begin the procedures. This should prepare you to perform the steps without allowing air to be cryopumped into the dewar.

2.2.8 Remove the PPMS Top Plate Assembly

1. Verify that the system is at room temperature.
2. Connect the sample space pumping line to the PPMS probe head if the sample space pumping line is not already connected (refer to Section 2.2.6).
3. Set the system to vent continuously if it is not already venting.
4. Remove any baffles that are in the sample chamber.
5. Remove the sheet metal housing by undoing the eight screws that attach it to the sides of the PPMS top plate assembly (refer to Figure 2-8). Save the screws for Step 10 below. You also will use these screws in the event you remove the cryopump and re-install the sheet metal housing.
6. Remove the four 10-32 screws that attach the PPMS top plate assembly to the PPMS probe and save them to use in Step 11 below. Then remove the top plate assembly.

   You can bolt the pumpout fixture that is used for regeneration to the PPMS top plate for storage. This storage site will protect the surface of the pumpout fixture and the O-ring seal. (Torquing down the screws is unnecessary; it is sufficient to insert them into the top plate.
7. Verify that the O-ring at the mouth of the sample chamber is clean. Clean the O-ring if necessary.
8. Remove the two Phillips-head screws attaching the blank plate (part number 4078-092) to the opening to the dewar (refer to Figure 2-8). Store the screws in the accessories box for later.
9. **EverCool systems**: Attach the extension cap (4083-254) to the end of the cryopump with some Apiezon M-grease between the cryopump and extension cap (refer to Figure 2-7).
10. Using the eight screws from the sheet-metal housing (Step 5), install the left and right side covers (part numbers 4083-205 and 4083-206) by referring to Figure 1-4 for guidance. The side covers protect the sample chamber wires.
11. Apply Apiezon M-grease to the threads of the four 10-32 screws you removed in Step 6. These screws will be used to hold down the cryopump manifold. Do this *before* you install the cryopump.

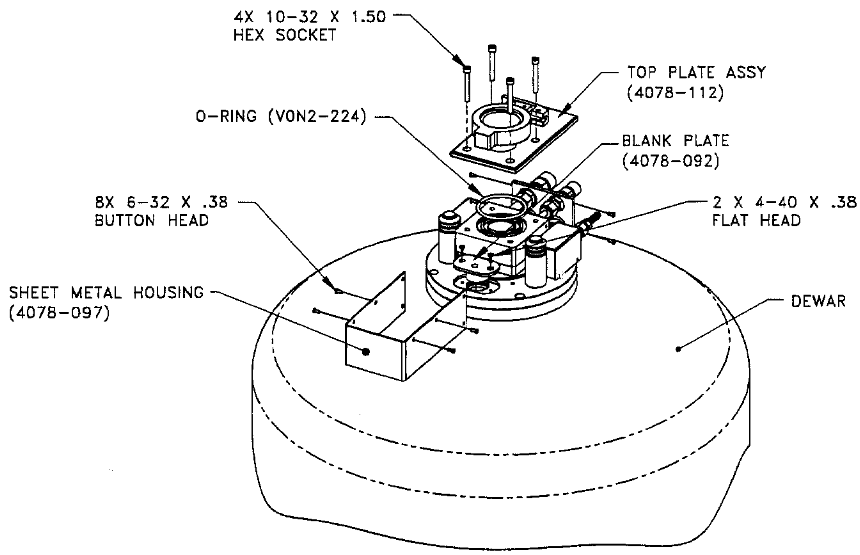


Figure 2-8. Removing the PPMS top plate assembly

12. In the next step, you will remove the blank plate that covers the sample chamber opening. ***To prevent air cryopumping into the dewar through the opening***, be prepared to insert the cryopump into this opening as soon as you remove the blank plate (see Step 1, Section 2.2.9).

13. Use the plug removal tool, which is the long screw in the middle of the blank plate (4078-092), to remove the blank plate from the opening to the dewar

2.2.9 Install the Cryopump

> **CAUTION!**
>
> Handle the cryopump carefully by holding the head with two hands. Use your finger to put a small amount of vacuum grease on the inside surface of the O-ring. It is not necessary to remove the o-ring. Carefully insert the tube ***straight*** into the dewar. This tube is thin and easily bent, and a bent tube would prevent the cryopump from working.

1. Working slowly and carefully, slide the cryopump pumping tube into the opening to the dewar.

   Important: You will conserve helium if you insert the cryopump slowly. Watch the amount of gas that boils off during the insertion and slow down the process further if you want to reduce the amount of boil-off.

2. Continue inserting the cryopump until the four 10-32 screws that hold down the cryopump manifold can be inserted and tightened. Use a 5/32-inch hex Allen key to tighten the screws very well so that they compress the O-ring on the sample chamber.

3. Assembly the sample chamber baffle assembly (part numbers 4078-113, 4078-105, 4083-010) and insert the baffle assembly into the top opening of the sample chamber. Figure 2-9 shows the dewar with the cryopump installed.

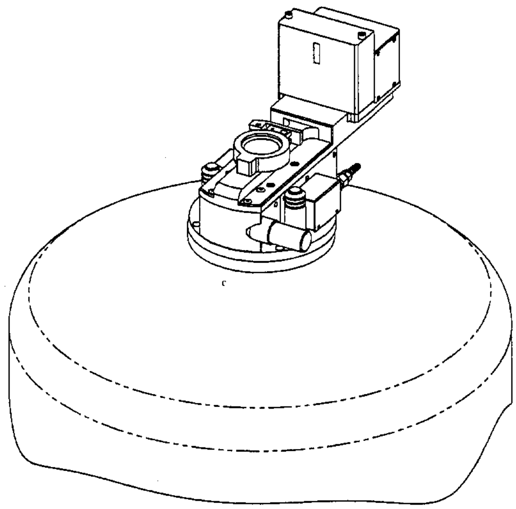


Figure 2-9. Cryopump installed in PPMS

4. Purge the system.
5. After you install the cryopump, let the system stabilize for 30 minutes before you proceed. While you are waiting, you can put the parts you used to install the cryopump back in the accessories box.

   Important: The charcoal ***must*** be cool before the system can enter high vacuum.
6. Verify that the temperature of the sample chamber is 300 K or greater.
7. Verify that the sample chamber is closed.
8. Verify that the pressure gauge has been powered up for at least 30 minutes.

   Important: To obtain accurate results, the pressure gauge must be powered up for at least 30 minutes before you use it. Although you can run the calibration before the pressure gauge is warm, the test results will be suspect.
9. You can now put the cryopump into high vacuum.
   a. Select **Instrument>>Chamber** from the dropdown tool bar at the top of the MultiVu window.
   b. When the **Chamber** dialog box opens, clock on the **HiVac** button to initiate the high-vacuum process.

2.2.10 Run the HiVac Pressure Gauge Calibration Utility

The HiVac Pressure Gague Cablibration utility enables the Cryopump option, calibrates the pressure gauge, and installs the configuration files. It also serves as a test of the operation of the cryopump.

Complete the following steps to run the HiVac Pressure Gauge Calibration utility:

1. Verify that the temperature of the sample chamber is 300 K or greater.
2. Verify that the sample chamber is closed.
3. Verify that the pressure gauge has been powered up for at least 30 minutes.

Important: To obtain accurate results, the pressure gauge must be powered up for at least 30 minutes before you use it. Although you can run the calibration before the pressure gauge is warm, the test results will be suspect.

4. Open the **Quantum Design** program group, and then select the **HiVac Pressure Gauge.exe Calibration** option. The HiVac Pressure Gauge Calibration utility starts up.
5. Click the picture of the installed gauge.

   For gauge 4083-055: Verify the correct gauge by noting the large red Q logo on the gauge, the centered LED display, and the bolt heads sticking out on top. Follow steps 6 thru 14.
6. Select the `Eyesys.cal` file.
7. Select **OK**. The **HiVac Pressure Gauge Calibration** dialog box opens and displays the **Step 1** tab, which is the first of six tabs in the dialog box. The tabs step you through the tasks you perform to run the utility.

   The **Current pressure in torr** panel at the top of the dialog box indicates the pressure inside the sample space as determined by using the opened `.cal` file for the calibration. The panel is visible in each tab.
8. Select **Purge** to purge the system. The mouse pointer appears again when the system is purged. After the system is purged, select **Next** to open the **Step 2** tab.
9. Select **Vent** to vent the sample chamber. The mouse pointer appears again when the chamber is vented. After the chamber is vented, select **Next** to open the **Step 3** tab.
10. Use a small, nonconductive tool, such as a long-handled wooden toothpick, to press the recessed CAL button that is on the side of the pressure gauge. Press the button until you feel it engage. After you press the CAL button, select **Next** to open the **Step 4** tab.
11. Use the up and down arrows to adjust the displayed pressure until the pressure is between 760 and 780 torr. Notice that a short time delay occurs after you press the up or down arrow and before you see a change in the display. Select **Save** when you have set a pressure. After you have set and saved the pressure, select **Next** to open the **Step 5** tab.
12. Select **High Vacuum** to enable the Cryopump option, and then wait until the pump is at normal operation and the sample chamber status is at HiVac. The mouse pointer appears again when the pump is at normal operation and the chamber status is at HiVac. After the Cryopump option is enabled, select **Next** to open the **Step 6** tab.
13. Press the CAL button on the pressure gauge until you feel the button engage. After you press the CAL button, select **Exit** to close the **HiVac Pressure Gauge Calibration** dialog box.
14. Select **OK**.
15. **For gauge 4083-350**: Verify the correct gauge by noting the large blue Q logo on the gauge, the right offset LED display, and the recessed bolts on top.

    This gauge has a factory calibration. It has been calibrated in Helium. No further calibration is necessary.

    If one wishes to use a different gas in the system, the gauge can be recalibrated for this gas. Or one may wish to simply recalibrate the gauge. The steps for calibration are as follows and may be done out of order.

    a. At atmospheric pressure (~760 Torr), press and hold the mode button for 3 seconds. The display will flash all leds on if successful.

    b. At purged state (must be 5-15 Torr as read on gauge), press and hold the mode button for 3 seconds. The display will flash all leds on if successful.

    c. At High Vacuum state (~1e-5 Torr), press and hold the mode button for 3 seconds. The display will flash all leds on if successful.

    In order to reset the gauge to the factory default calibration:

    a. Press and hold the mode button for more than 10 seconds. The display will flash all leds on if successful.

16. Back up the system ROM configuration to a `.cfg` file as follows: (*a*) double-click on the **PPMS 32-bit Tools** icon on the PC desktop, (*b*) run the Romcfg32 utility, (*c*) select the **Diag (all Configs including above)** check box, (*d*) select the **Read Configuration** button, (*e*) specify a file name for the configuration you are saving, and then (*f*) select **OK**.

2.3 Removing the Cryopump

Warning!

Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you install or remove the cryopump from the dewar or when you work with liquid helium, liquid nitrogen, or any other cryogen. For more information about cryogenic safety, refer to the *Physical Property Measurement System: Hardware Manual.*

Complete the following steps to remove the cryopump from the PPMS and reinstall the standard PPMS top plate assembly.

1. Set the PPMS system temperature to 320 K.
2. Locate the blank plate, the PPMS top plate assembly, and the sheet metal housing for the PPMS top plate assembly. These components should be in the cryopump accessories box.
3. Use a 5/32-inch hex Allen key to unscrew the four 10-32 screws from the cryopump manifold. Keep the screws in a safe place; you use them to reinstall the standard PPMS top plate.
4. Vent the system continuously.
5. Remove the screws in the cryopump sheet metal side panels, and then remove the side panels.
6. Remove any inserted probe or baffle set.
7. Slowly pull the entire cryopump assembly straight up and out of the cold bath. Removing the cryopump slowly helps avoid damaging it by allowing it to heat up from the top slowly, thus boiling off any nitrogen condensed inside the cryopump.

Caution!

Do not move the cryopump any angle or the tube will bend. Sometimes the o-ring may freeze as you lift the cryopump straight out of the dewar, and the tube will stick. If this occurs, do not force the pump to move as it may jolt upward, and you may hurt yourself and damage the tube. Wait approximately one minute until the pump can move freely, then continue to lift it straight out.

8. **Let the cryopump warm to room temperature.**
9. Insert the blank plate (part number 4078-092) into the dewar opening. Refer to figure 2-7.
10. Install the standard PPMS top plate assembly. Use the four screws to attach the top plate assembly to the PPMS probe.
11. Disconnect the sample chamber pumpout line from the cryopump and plug it into the standard port on the back of the PPMS probe head. You must remove the sample space plug (part number 4083-059) to do this.

NOTE

If the cryopump will be out of the sample chamber for a brief time—for example, if you are only going to perform a warm regeneration—steps 12 and 13 are unnecessary.

12. Use the Model 6000 **CONFIG** menu to tell the Model 6000 that the cryopump is removed. Do the following: (*a*) select **CONFIG** >> **Hardware** >> **High Vacuum**; (*b*) under **Type of System** option, select **None**; and then (*c*) press <Alt+Enter> to save the change.

13. Install the sheet metal housing if the cryopump will be out of the sample chamber for an extended period of time. Use the eight supplied screws to attach the sheet metal housing.

2.4 Reinstalling the Cryopump

Warning! Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you install or remove the cryopump from the dewar or when you work with liquid helium, liquid nitrogen, or any other cryogen. For more information about cryogenic safety, refer to the *Physical Property Measurement System: Hardware Manual.*

1. Perform a warm regeneration. Refer to section 2.2.7.
2. Vent the system continuously.
3. Connect the sample space pumping line to the PPMS probe head if the sample space pumping line is not already connected. Refer to section 2.2.6.
4. Remove the two Phillips-head screws attaching the blank plate to the opening to the dewar. Refer to figure 2-7. Place the screws in the accessories box for safe storage.
5. Use the plug removal tool, which is the long screw in the middle of the blank plate, to remove the blank plate from the opening to the dewar. The plug covers the opening through which the cryopump pumping tube penetrates into the dewar.
6. Slowly and carefully slide the cryopump pumping tube into the opening to the dewar. Slide the pumping tube into the dewar until you can screw down the cryopump.

Caution! Handle the cryopump carefully by holding the head with two hands. Use your finger to put a small amount of vacuum grease on the inside surface of the o-ring. It is not necessary to remove the o-ring. Carefully insert the tube straight into the dewar. Inserting it at an angle may cause the thin tube to bend, which will prevent the cryopump from working.

NOTE While you insert the cryopump, watch the amount of gas that boils off, and if necessary insert the cryopump more slowly to reduce the amount of boil-off. The more slowly you insert the cryopump, the more helium you conserve.

7. Use a 5/32-inch hex Allen key to install the four 10-32 screws that hold down the cryopump manifold. It is important to tighten these screws very well so that they compress the O-ring on the sample chamber.
8. Install the cryopump sheet metal housing.
9. Insert the baffle assembly.
10. Test the installation by installing the cap, plugging in the pressure gauge, and purging the system. Watch the static pressure to verify that the sample chamber is not leaking.

After you install the cryopump, wait several minutes before you instruct the system to enter high vacuum. *The charcoal must cool before the system can enter high vacuum.*

Remember to put all parts used to install the cryopump back in the accessories box for proper storage.

CHAPTER 3

Operation

3.1 Introduction

This chapter contains the following information:

- Section 3.2 explains how to perform basic cryopump system operations.
- Section 3.3 explains use of the **Wait** sequence command.

3.2 Cryopump Operation

Operation of the cryopump is handled like other sample-chamber gas-handling commands such as **Vent**, **Purge**, and **Pump Continuous**. To achieve high vacuum in the sample chamber, you simply select a high-vacuum command from the PPMS MultiVu software or from the front panel of the Model 6000 PPMS Controller—just as you would select other chamber commands. The chamber status description that appears on the Model 6000 front panel or in PPMS MultiVu indicates when high vacuum has been achieved. If you are using a sequence to run an experiment that requires high vacuum, you can simply use the **Wait** command, as is explained in Section 3.3. The automatic sequence of events performed by the system is described in Section 1.2. The system automatically terminates high vacuum whenever a different chamber command is issued. PPMS options, such as Heat Capacity (Model P650) or Helium-3 (Model P825), automatically initiate the high-vacuum operation when it is necessary.

When a cryopump system is being operated under normal conditions—that is, it is entering high vacuum less than 100 times per month—you will need to perform an in-dewar regeneration approximately every three months. The in-dewar regeneration procedure should require just a few minutes.

Note: You can perform an in-dewar regeneration more often than once every three months. If you do so, you will find that high-vacuum performance has been enhanced.

An out-of-dewar regeneration is sometimes required to thoroughly clean the sorption pump of air (see Section 4.3). This procedure is more complex and takes longer to perform than the in-dewar regeneration.

3.2.1 Using the Contact Baffle

The contact baffle on the sample-chamber baffle assembly (Figure 3-1) contains a charcoal holder for increased pumping speed at the lowest sample-chamber temperatures. The contact baffle also provides thermal radiation shielding for the lowest region of the sample chamber. The spring contacts ensure that the charcoal holder and bottom baffle are maintained at the same temperature as the PPMS system temperature.

The charcoal on the baffle assembly begins pumping helium gas at temperatures below about 10 K. Hence, even if the sample chamber is "sealed," the pressure in the sample chamber could become equivalent to high-vacuum conditions when temperatures are below 10 K. When temperatures are above 20 K, the charcoal has no effect on the helium in the sample chamber.

In experiments that require exchange gas at temperatures below 10 K, you can remove the charcoal holder from the end of the baffle assembly by simply unscrewing it from the threaded post. When you remove the charcoal holder (e.g., as a necessary part of calibrating calorimeters with the Heat Capacity option), use a method that prevents oils from your fingers from contaminating the charcoal.

The contact-baffle assembly is not required when using the Helium-3 system. The Helium-3 insert provides its own thermal shielding and also contains its own charcoal for these purposes.

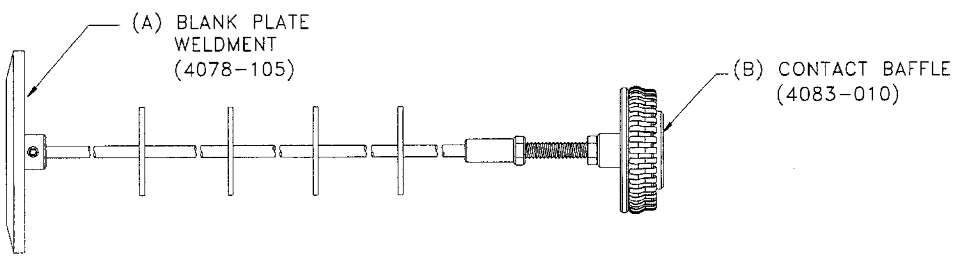


Figure 3-1. Sample-chamber baffle assembly with contact baffle

3.2.2 Initiating High Vacuum

Typically, PPMS options automatically initiate high vacuum. However, in the event you want to manually initiate high vacuum, perform the following steps:

1. Verify that the opening to the sample chamber is sealed. You should be using the contact-baffle assembly (see Figure 3-1) to seal the chamber opening. If you are using the Helium-3 system, verify that the insert is completely seated on the top flange.
2. Purge the sample chamber if the system has recently been opened to the atmosphere.
3. Enable high vacuum. In the Model 6000, the quickest way to issue a high-vacuum command is to select **STATUS** >> **Chamber** >> **6. Pump HiVac**. In MultiVu, open the **Chamber** dialog box (**Instrument** >> **Chamber**) and click on the **HiVac** button.

   Chamber commands are also located in the **Interactive Control** menu, which you open by selecting **CTRL** >> **Control Menu** >> **1. Interactive Control**. In the **Interactive Control** menu, enable high vacuum by selecting **4. Pump** >> **Use Cryo Pump**.

a. **PrePump mode.** As soon as you issue the high-vacuum command, the system enters PrePump mode and monitors the pressure. Monitoring the pressure takes a minimum of 30 seconds and might last as long as 2 minutes. The minimum monitoring time is extended as long as the vacuum can be improved. The operation of the temperature control firmware is interrupted so that full pumping force can be applied to pump on the sample chamber.

b. **HiVacEvac mode.** Next, the system enters HiVacEvac mode. In HiVacEvac mode, the flapper valve is open (see Figure 3-2) and the charcoal absorbs the gas in the chamber. The system remains in HiVacEvac mode for a minimum of 30 seconds and up to 2 minutes while it waits for the pressure to stop dropping.

c. **HiVac mode.** After the charcoal has adsorbed all the gas, the system enters HiVac, or high-vacuum, mode. When the pressure returned by the external pressure gauge has not dropped for at least 2 minutes, the Model 6000 front panel indicates that the system has entered HiVac mode. The pressure, as indicated on any of the status panels on the Model 6000 front panel, might *not* show zero.

The **Chamber** panel in the **Status–System** screen on the front panel of the Model 6000 identifies the status of the current chamber operation.

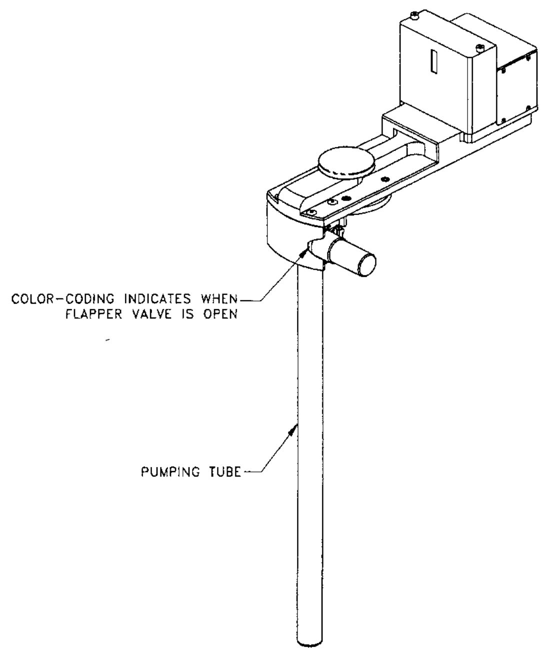


Figure 3-2. Color-coding on the cryopump motor housing indicates when the flapper valve is open and when it is closed. A red stripe is visible when the flapper valve is open and a black stripe is visible when the flapper valve is closed.

3.2.3 Ending High Vacuum

Issuing any chamber command other than a high-vacuum command takes the system out of HiVac, or high-vacuum, mode. For example, if you select **Vent Continuous** while the system is at high vacuum, the system automatically closes the flapper valve to isolate the sorption pump from the sample chamber before it vents the chamber.

The colored stripe on the motor housing should change from red to black when the sorption pump is sealed off from the sample chamber (see Figure 3-2).

3.2.4 Regenerating the Sorption Pump

Periodically, it is necessary to perform a cryopump regeneration operation to restore the pumping capacity of the charcoal sorption pump. The cryopump is regenerated by using an in-dewar procedure to remove helium gas or an out-of-dewar procedure to remove air, water, and nitrogen. The in-dewar procedure is generally required about four times a year—that is, after approximately 500 operations—and takes only a few minutes to perform. The out-of-dewar regeneration procedure might be required approximately once a year, depending on the lab environment and usage practices (see below and Section 4.3).

When it is time to perform an in-dewar cryopump regeneration (based on the number of high-vacuum cycles), the Model 6000 PPMS Controller will notify you. The in-dewar regeneration is an automated procedure that you initiate from the front panel of the Model 6000 or from a PPMS MultiVu sequence.

Use the steps below to perform an in-dewar regeneration:

1. Warm the system to 320 K.
2. Use the steps below to activate the in-dewar regeneration mode from the Model 6000 or from a MultiVu sequence:
   - **Model 6000**. Select **CTRL** >> **Control** >> **Immediate Operations** >> **14. CryoReg** >> **Regenerate with CryoPump in Dewar**.
   - **MultiVu**. Double-click on **Execute Commands**, which is in the **Advanced** subgroup in the **Sequence Commands** bar. When the **Execute Commands** dialog box opens, enter "CRYOREG 0" in the text box and click on the **OK** button to insert the command into the sequence.
3. Allow the charcoal to cool back down to helium temperatures before entering high vacuum again. The time required for the charcoal to cool depends on the amount of helium in the dewar. You should wait at least 10 minutes before entering high vacuum, but you might need to wait up to half an hour. Note that the charcoal continues to cool whether the flapper valve is open or closed.

Section 4.3 contains detailed instructions for performing an out-of-dewar regeneration. As is explained there, the process includes removing the cryopump from the PPMS probe. An out-of-dewar regeneration could become necessary if the cryopump has been accidentally exposed to air while it is in the high-vacuum mode, or if the system is routinely operated in a humid environment, in which water often condenses on the probe and baffles.

3.3 Using the "Wait" Sequence Command

If you are using the cryopump as part of a sequence that requires a high vacuum state, you can use the **Wait** sequence command to delay operations until the high vacuum state has been reached.

The **Wait** command is found in the **System** subgroup (see Figure 3-3). As with the other sequence commands, you access the **Wait** command by double-clicking on it. This action opens the **Wait** dialog box (Figure 3-4), which has separate **Condition(s)**, **Delay (secs)**, and **On Error Execute** setting subgroups. The **Condition(s)** subgroup lets you set delays according to **Temperature**, **Field**, **Position**, and **Chamber**. The **Delay (secs)** subgroup has a text box in which you can set the amount of time to delay action after the condition has been met, and the **On Error Execute** subgroup has a dropdown menu in which you can select an action to be executed when the system encounters an error.

To set up a **Wait** command to use with cryopump operations, click in the check box next to **Chamber**, enter any **Delay** time, and select any **On Error Execute** action. Then, click on the **OK** button. The command will be inserted into the sequence, as is shown in the example sequence at the top of Figure 3-4.

Important: Verify that you have clicked in the check box next to **Chamber** before you click on the **OK** button. Otherwise, the system will not consider the vacuum state when it reaches the command.

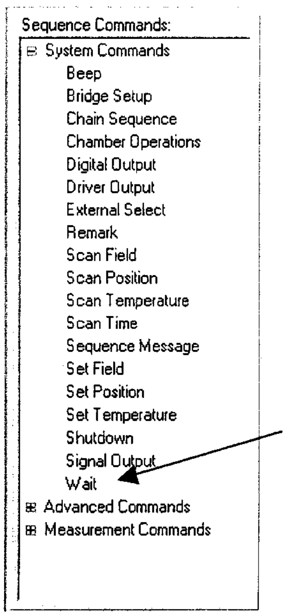


Figure 3-3. Wait sequence command

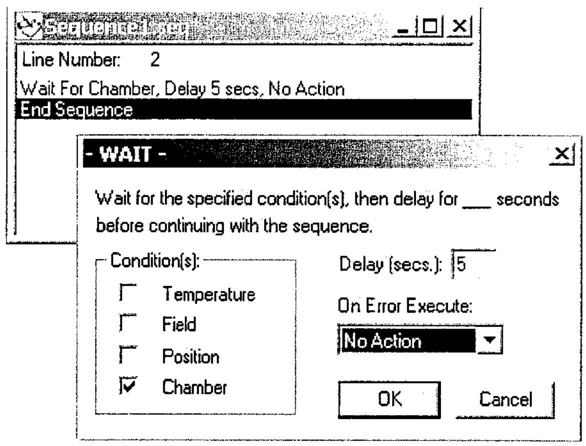


Figure 3-4. Wait dialog box and Wait (for Chamber condition) sequence command

C H A P T E R 4

Troubleshooting and Maintenance

4.1 Introduction

This chapter contains the following information:

- Section 4.2 contains troubleshooting tips.
- Section 4.3 has instructions for the out-of-dewar charcoal regeneration procedure.
- Section 4.4 shows the cryopump-wiring diagram.

4.2 Troubleshooting

This section presents suggestions for dealing with basic problems that might arise with the cryopump. If you have any questions or cannot resolve a problem, please contact Customer Service at Quantum Design.

4.2.1 Failure to Reach High Vacuum

The following problems can prevent the system from reaching high vacuum:

- The system has been exposed to the atmosphere (see Section 4.2.2).
- The flapper valve fails to open or close (see Sections 4.2.3 and 4.2.4).
- The charcoal needs to be regenerated (see Sections 4.2.4 and 4.3).
- The system is leaking (see Section 4.2.6).
- The isolation solenoid is not working.
- *EverCool systems*: The extension cap has not been attached to the pump tube.

4.2.2 Exposure to Atmosphere

If the sorption pump has been accidentally exposed to the atmosphere, it is probably saturated with frozen air and might require an out-of-dewar regeneration (Section 4.3) before it operates properly.

4.2.3 Flapper Valve Fails to Open

The color-coded motor-housing indicator indicates the position of the flapper valve (see Figure 3-2). When the flapper valve opens, the indicator should show red. If it continues to show black, or both red and black, when attempting high vacuum, investigate whether one or more of the following situations has occurred:

- The spring has failed.

  Remove the cover panel and inspect the spring.
- The cam is slipping.
- The flapper valve has frozen shut.

  If the flapper valve fails to open, an error message will be generated in PPMS MultiVu. If this error message appears but the flapper valve indicator displays the red stripe (meaning that the flapper valve is actually open), there is a problem with either the wiring or the limit switch.
- The motor has failed.

4.2.4 Flapper Valve Fails to Close

The color-coded motor-housing indicator indicates the position of the flapper valve (see Figure 3-2). When the flapper valve closes, the indicator should show black. If it continues to show red, or both red and black, when terminating high vacuum, investigate whether one or more of the following situations has occurred:

- The spring has failed.

  Remove the cover panel and inspect the spring.
- The cam is slipping.
- The flapper valve has jammed.

  If the flapper valve fails to close, an error message will be generated in PPMS MultiVu. If this error message appears but the flapper valve indicator displays the black stripe (meaning that the flapper valve is actually closed), there is a problem with either the wiring or the limit switch.
- The micro switch has failed.
- The motor has failed.

4.2.5 System Fails to Regenerate

If the system fails to achieve adequate performance after you have performed a regeneration procedure, investigate whether one or more of the following situations has occurred:

- The regeneration heater has failed.
- The charcoal has been saturated with air (see Section 4.3).
- The pressure gauge has failed.

The "Regen heater may be open" error message might appear if the cryopump was just installed or if the sorption pump was just regenerated. Under these circumstances, the message only indicates that the pressure gauge cannot read a changing pressure. In other words, the pump regeneration was successful. However, if the "Regen heater may be open" error message appears after the cryopump has been installed at least a week, the message indicates that there is a problem with the system, because the system can accumulate helium in a week

4.2.6 Leak in the System

If the system requires frequent out-of-dewar regenerations or never achieves an adequate vacuum, it might have a leak. To investigate this possibility, first verify that the O-ring on the cryopump pumpout fixture and the O-ring on the centering ring have been adequately greased with Apiezon M-grease. Next, verify that the four 10-32 × 3/8 socket-head screws attaching the pumpout fixture to the cryopump are tightened firmly.

If the procedures above do not resolve your problems, call Customer Service at Quantum Design. Leak detection is often a complex task, and our trained personnel can advise you about the best way to approach such a problem.

4.2.7 Vacuum Gauge Does Not Power Up

If the lights on the front of the vacuum gauge are not on, it indicates that the vacuum gauge has not powered up. Verify that the power supply for the vacuum gauge is properly connected (see Section 2.2.6, Step 8).

4.2.8 Cryopump Pumping Tube Fits Poorly in Dewar

In rare instances, the manufacturing tolerances of the dewar prevent the cryopump pumping tube from fitting properly in the dewar. If the installed pumping tube appears to be stressed in any way, you must adjust its location so that the pumping tube will not be bent.

Use the steps below to adjust the location of the cryopump pumping tube:

1. Loosen the four 10-32 screws located near the front of the cryopump manifold.
2. Slide the body of the cryopump forward until the pumping tube fits properly inside the dewar.
3. Re-tighten the four 10-32 screws.

4.3 Out-of-Dewar Regeneration Procedure

The only regular maintenance you will perform on the Cryopump High-Vacuum option is charcoal regeneration. The in-dewar regeneration procedure (Section 3.2.4) releases adsorbed helium from the sorption pump. To remove other gases, you must perform an out-of-dewar regeneration, which involves removing the entire cryopump assembly from the dewar and evacuating the cryopump pumping tube at room temperature.

This section presents the steps for performing an out-of-dewar charcoal regeneration. Before you perform the out-of-dewar regeneration, perform the in-dewar regeneration (Section 3.2.4). You will need to perform an out-of-dewar regeneration only if the in-dewar procedure fails to restore adequate pumping capability to the sorption pump.

Note that you can reduce how often out-of-dewar regenerations are required by basic usage practices, such as closing the sample chamber off from the atmosphere as soon as you have inserted or removed probes and pucks. Also, verify that probe inserts (e.g., the Helium-3 insert) are warm and dry before you insert them into the sample chamber, and always purge the sample chamber after you insert a puck or probe and before you initiate high vacuum. These practices all restrict the amount of moisture to which the sample chamber is exposed.

Instructions for the out-of-dewar regeneration are given in Sections 4.3.1 through 4.3.3.

WARNING!

Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you install or remove the cryopump from the dewar or when you work with liquid helium, liquid nitrogen, or any other cryogen. For more information about cryogenic safety, refer to the *Physical Property Measurement System: Hardware Manual.*

4.3.1 Remove the Cryopump from the Dewar

1. Set the PPMS system temperature to 320 K.
2. Use a 5/32-inch hex Allen key to unscrew the four 10-32 screws from the cryopump manifold. Keep the screws in a safe place; you use them to reinstall the standard PPMS top plate.
3. Vent the system continuously.
4. Remove the screws in the cryopump sheet metal side panels, and then remove the side panels.
5. Remove any probe or baffle set.
6. Slowly pull the entire cryopump assembly straight up and out of the cold bath.

   When you remove the cryopump slowly, you help prevent damage to it by allowing it to heat up slowly from the top. This method boils off any nitrogen that has condensed inside it.

CAUTION!

Do not insert or remove the cryopump at an angle or the tube will bend. Sometimes the O-ring freezes as you lift the cryopump straight out of the dewar, and the tube will stick. If this occurs, do not force the pump to move because it might jolt upward, injuring you and damaging the tube. Wait approximately one minute until the pump can move freely, then continue to carefully lift it straight out.

7. Insert the blank plate (part number 4078-092) into the dewar opening (refer to Figure 2-7).

   If the cryopump will remain out of the dewar for an extended length of time, you should place the standard PPMS top plate on top of the probe. The standard top-plate assembly (part number 4078-112) will help prevent gases from leaking into the PPMS annulus.

4.3.2 Perform the Out-of-Dewar Regeneration

1. Verify that the cryopump has warmed to room temperature.
2. Use the four 10-32 × 3/8 socket-head screws to attach the cryopump pumpout fixture (part number 4083-208), with the O-ring facing upward, to the bottom side of the sample chamber opening on the cryopump (see Figure 2-6). Tighten the screws until they are just finger tight.
3. Use the blanking plate (part number HPNW40C) and associated centering ring (part number HPNW40B) to cover the top of the sample-chamber opening on the cryopump (see Figure 2-6).
4. Use the Model 6000 CTRL menu or a MultiVu sequence command to initiate the out-of-dewar regeneration.
   - Model 6000: Select **CTRL** >> **3. Immediate Operations** >> **14. CryoReg** >> **Regenerate with CryoPump in Room**. The flapper valve opens and the system is pumped out. Then the flapper valve closes and the cryopump system is regenerated. This process takes at least 30 seconds. The out-of-dewar regeneration does not use the regeneration heater. You can follow the status of the regeneration by selecting **CTRL** >> **1. Interactive Control** >> **4. Pump**.
   - MultiVu: Insert the out-of-dewar regeneration command into a sequence, then run the sequence while the cryopump is out of the dewar.

     To insert the out-of-dewar regeneration command, double-click on **Execute Commands**, which is in the **Advanced** subgroup in the **Sequence Commands** bar. When the **Execute Commands** dialog box opens, enter "CRYOREG 1" in the text box and click on the **OK** button to insert the command into the sequence.
5. When regeneration is complete, the message "Vented" will appear in all menus identifying the status of the sample chamber.
6. Remove the top blanking plate (part number HPNW40C).
7. Remove the four 10-32 × 3/8 socket-head screws attaching the pumpout fixture to the cryopump. Then remove the pumpout fixture.
8. You can bolt the regeneration pumpout fixture to the PPMS top plate for storage. This storage method protects the surface of the pumpout fixture and the O-ring seal. Note that you only need to insert the screws into the top plate, you do not need to torque them down.

4.3.3 Re-Install the Cryopump

1. Vent the system continuously.
2. Remove the two Phillips-head screws that attach the blank plate (part number 4078-092) to the dewar opening (refer to Figure 2-7). You can store the screws in the accessories box.
3. Use the plug-removal tool, which is the long screw in the middle of the blank plate, to remove the blank plate from the opening to the dewar. The plug covers the opening through which the cryopump pumping tube penetrates into the dewar.
4. Slowly and carefully slide the cryopump pumping tube into the opening to the dewar, continuing until you can screw down the cryopump.

CAUTION!

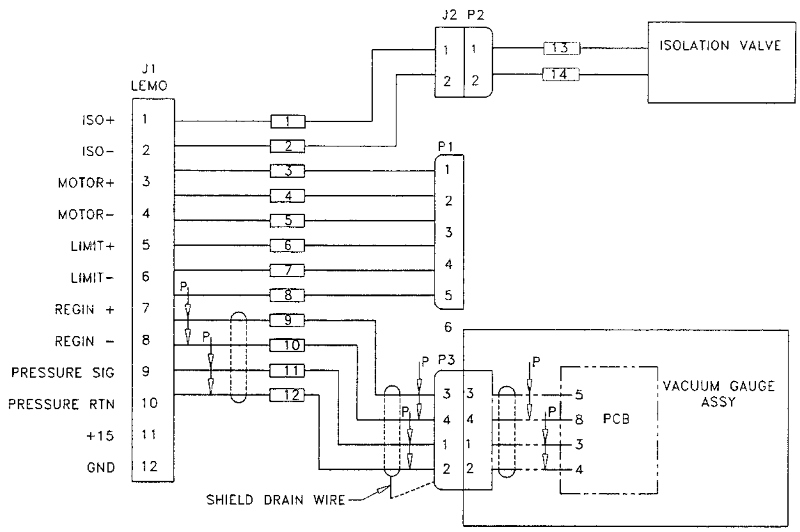
Handle the cryopump carefully by holding the head with two hands. Use your finger to put a small mount of vacuum grease on the inside surface of the O-ring. It is not necessary to remove the O-ring. Carefully insert the tube straight into the dewar. Inserting it at an angle can cause the thin tube to bend, which will prevent the cryopump from working.

5. Use a 5/32-inch hex Allen key to install the four 10-32 screws that hold down the cryopump manifold. It is important to tighten these screws firmly so that they compress the O-ring on the sample chamber.
6. Install the right- and left-side covers that protect the wires of the sample chamber (Figures 1-4 and 2-1, part numbers 4083-205 and 4083-206).
7. Insert the baffle assembly.
8. Test the installation by installing the cap, plugging in the pressure gauge, and purging the system. Watch the static pressure to verify that the sample chamber is not leaking.
9. After you install the cryopump, wait several minutes before you instruct the system to enter high vacuum.

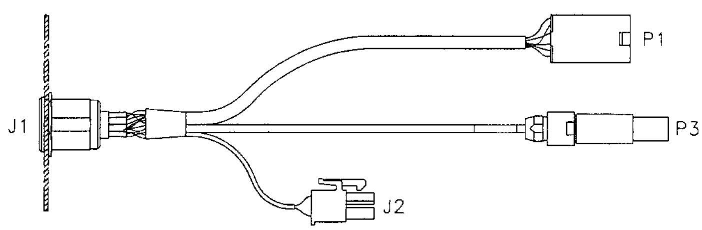
   Important: The charcoal ***must cool*** before the system can enter high vacuum.
10. Return the parts you used to install the cryopump back to the accessories box.

4.4 Wiring Diagram

Figures 4-1A and 4-1B show the pinouts for the green, color-coded Lemo connector on the cryopump cable. (Figure 2-5 illustrates the cryopump cable.)



A. Wiring diagram for green Lemo connector on cryopump cable



B. Internal cryopump cables connected to green Lemo connector on cryopump cable

Figure 4-1. Cryopump wiring diagram

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C O N T E N T S

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P R E F A C E

Contents and Conventions

P.1 Introduction

This preface contains the following information:

- Section P.2 discusses the overall scope of the manual.
- Section P.3 briefly summarizes the contents of the manual.
- Section P.4 illustrates and describes conventions that appear in the manual.

P.2 Scope of the Manual

This manual contains the information that you will need to use the Physical Property Measurement System (PPMS), including materials on its basic functionality and the hardware that is unique to it. This manual does not cover the PPMS MultiVu software, which is the Windows-based application that runs the PPMS. For detailed information about PPMS MultiVu, refer to the *Physical Property Measurement System: PPMS MultiVu Application User's Manual.*

The PPMS has a variety of measurement options as well as alternate set ups, so some of the manual materials might not be relevant to your equipment. For example, this manual explains how to use nitrogen-jacketed PPMS dewars. If your PPMS uses a standard dewar (i.e., one without a nitrogen jacket), you can ignore instructions that concern only liquid nitrogen. Also, this manual includes material about systems that have a magnet. If your system does not include a magnet, you can ignore those sections. All other PPMS functions are identical for systems with or without magnets.

P.3 Contents of the Manual

- Chapter 1 introduces the PPMS, including safety considerations and system setup, and explains how to contact Quantum Design.
- Chapter 2 describes and illustrates the main PPMS hardware components.
- Chapter 3 describes how the PPMS operates and gives an example of a measurement.

- Chapter 4 explains how to use and customize the PPMS and describes routine maintenance procedures such as refilling a cold dewar with helium.
- Appendix A describes and illustrates the PPMS electrical ports.
- Appendix B explains how to transfer helium and nitrogen to fill warm (empty) standard dewars and nitrogen-jacketed dewars.
- Appendix C provides maintenance instructions for the vacuum-pump assembly.

P.4 Conventions in the Manual

File menu	Bold text identifies the names of menus, dialogs, options, buttons, and panels used in the PPMS MultiVu software.
File >> **Open**	The >> symbol indicates that you select multiple, nested software options.
STATUS	Bold text and all capital letters distinguish the names of keys located on the front panel of the Model 6000 PPMS Controller.
`.dat`	The Courier font indicates file and directory names and computer code.
<Enter>	Angle brackets distinguish the names of keys located on the PC keyboard.
<Alt+Enter>	A plus sign connecting the names of two or more keys indicates keys that you press simultaneously.
Important	Text is set off in this manner to signal essential information that is directly related to the completion of a task.
Note	Text is set off in this manner to signal supplementary information about the current task; the information may primarily apply in special circumstances.

CAUTION!
Text is set off in this manner to signal conditions that could result in loss of information or damage to equipment.

WARNING!
Text is set off in this manner to signal conditions that could result in bodily harm, loss of life, or irreparable damage to equipment.

WARNING!
Text is set off in this manner to signal electrical hazards that could result in bodily harm or loss of life.

C H A P T E R 1

Introduction and System Setup

1.1 Introduction

This chapter contains the following information:

- Section 1.2 presents an overview of the function of the PPMS.
- Section 1.3 presents an overview of the PPMS hardware.
- Section 1.4 covers important safety guidelines.
- Section 1.5 describes environmental factors to consider in setting up the system.
- Section 1.6 explains how to contact Quantum Design's service centers.

1.2 Overview of the PPMS

The Physical Property Measurement System (PPMS) provides a flexible, automated workstation that can perform a variety of experiments requiring precise thermal control. You can use the PPMS to execute magnetic, electro-transport, or thermo-electric measurements, or you can modify the system in order to perform your own laboratory experiment. The unique open architecture of the PPMS allows you to fully configure the basic PPMS platform or to use the PPMS with different PPMS measurement options, such as the AC Measurement System option, Heat Capacity option, or Ultra-Low Field option. All PPMS options, like the PPMS platform, are fully automated.

Control of the PPMS sample environment includes magnetic fields up to ±16 T, depending on the magnet purchased, and a 1.9–400 K temperature range. Temperature is reported with a typical accuracy of ±0.5%. Temperature can be varied with full sweep capability and slew rates from 0.01 K/min up to 12 K/min. Temperature stability is ≤ 0.2% for temperatures ≤ 10 K and ≤ 0.02% for temperatures > 10 K.

Please familiarize yourself with the information in this manual, which is designed to help you operate and maintain the basic PPMS platform. It is important that you understand the basic PPMS platform before you perform PPMS experiments or use PPMS options.

For information about PPMS MultiVu, which is the Windows-based software application that controls operation of the PPMS and its options, refer to the *Physical Property Measurement System: PPMS MultiVu Application User's Manual.*

1.3 Overview of System Hardware

Figure 1-1 illustrates a base PPMS and the approximate dimensions of each component. Note that the actual dimensions and layout of your PPMS will reflect the system that you purchase (e.g., options, type of dewar) and your laboratory. Dimensions of the electronics cabinet and the various dewars are listed in Table 1-2.

The base system includes the following hardware components, which are described in Chapter 2.

- dewar
- probe
- top-plate assembly
- probe-lifting assembly
- electronics cabinet
- Model 6000 PPMS Controller
- vacuum pump
- pumping lines
- connection cables
- power cords

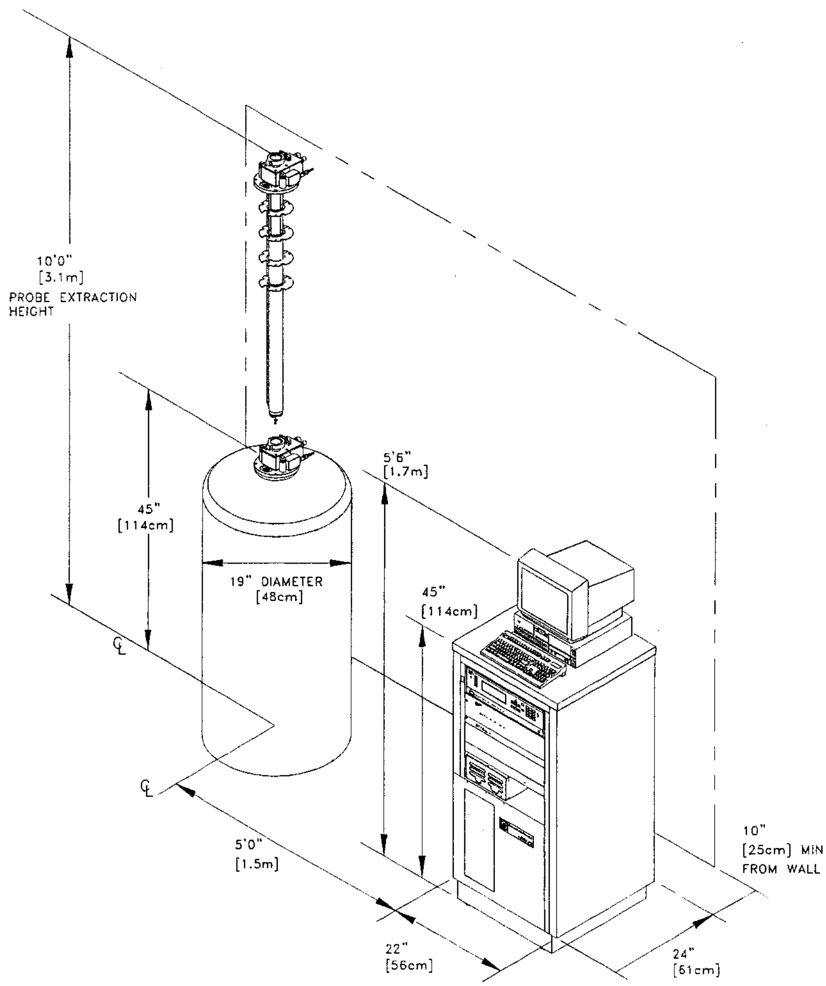

Figure 1-1. Components of the base PPMS and approximate dimensions (measurements are rounded[1])

[1] The inch to cm equivalences are approximate, because both measures were rounded after inches had been converted to centimeters.

Most systems also include a personal computer, a sample puck kit, and a helium-transfer kit. You can order other options to expand the capabilities of the base system, including a magnet and the Model 6700 Magnet Controller. The PPMS can be equipped with a 1-T, 7-T, 9-T, 14-T, or 16-T longitudinal magnet or a 7-T transverse magnet.

With the exception of 14-T and 16-T longitudinal systems and 7-T transverse systems, PPMS units can operate with one of three different types of dewars: the standard, nitrogen-jacketed, or high-capacity nitrogen-jacketed dewar. Two nitrogen fill ports located on top of the nitrogen-jacketed dewar distinguish it from the standard (non-nitrogen-jacketed) dewar. Figure 1-2 illustrates the nitrogen fill ports, and Figures 2-1–2-3 illustrate these three dewars. A liquid-nitrogen transfer adapter is included with all nitrogen-jacketed dewars.

The probe is the component that is inserted into the dewar. If the system has a longitudinal magnet, the magnet is attached to the probe, as illustrated in Figure 2-4. Any system with a magnet also includes the Model 6700 Magnet Controller.

Please save the original packing crates for your system so that you can ship components back to Quantum Design for installation of an option, upgrading, or repair.

1.4 Safety Precautions

WARNING!

The PPMS superconducting magnets produce extremely strong *three-dimensional* magnetic fields that can be dangerous and the PPMS uses cryogenic liquids for temperature control. Critical PPMS-related safety precautions include those for using superconducting magnets, for using cryogenic materials (liquids and gases), and for using electrical equipment, as is reviewed below.

Above all, Quantum Design and its staff ask that you use standard safe laboratory procedures.

- Use common sense.
- Pay attention to the system's state and your surroundings.
- If the behavior of the system appears unusual, something might be wrong with it. If so, take appropriate action.
- Supervise inexperienced users and train them in general electrical safety procedures.

The PPMS has safety features to prevent accidents from causing injury or serious equipment damage. *If you use the equipment in a manner that is not specified by Quantum Design, the protection afforded by the equipment could be impaired.*

1.4.1 Cryogens

WARNING!

Always wear protective clothing and ensure that the room has good ventilation when you work with cryogenic materials such as liquid helium and liquid nitrogen. This will protect you against cryogenic material hazards: (1) they can expand explosively when exposed to room temperature; (2) they can cause serious burns.

- Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium, liquid nitrogen, or other cryogens. Avoid loose clothing or loose fitting gloves that could collect cryogenic liquids next to the skin. The extreme cold of liquid and gaseous cryogens can cause serious burns and has the potential to cause loss of limbs. Surfaces that have been exposed to these cryogens are extremely cold and should not be allowed to contact skin.
- Work with cryogenic materials in well-ventilated areas only. In the event a helium container ruptures or there is a helium spill, vent the room immediately and evacuate all personnel. In a poorly ventilated area, helium can displace the air, leading to asphyxiation. Because helium rises, well-vented rooms with high ceilings are generally safest.

WARNING!

Do not remove, disable, or otherwise tamper with the dewar rupture disk or the pressure-relief valves. Any type of modification can lead to dangerous operating conditions.

When liquid helium or nitrogen boils and expands in a sealed container such as the PPMS dewar, it can cause large pressure buildups. Explosions can occur if this pressure is not relieved. The PPMS dewar and probe contain pressure-relief valves and rupture disks to allow gaseous cryogens to escape before dangerous pressures are reached. Figure 1-2 illustrates these safety features.

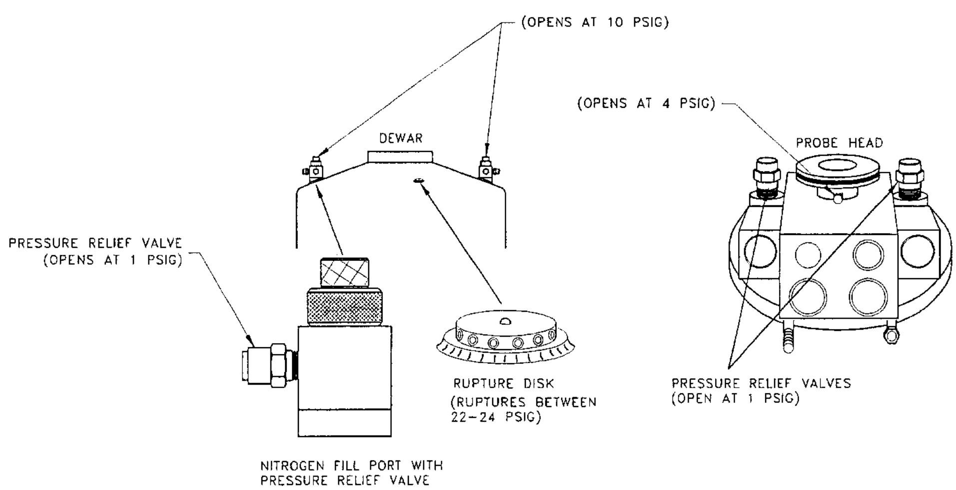

Figure 1-2. Pressure-relief valves and rupture disk on PPMS dewar and probe head

WARNING!

If a dewar ruptures or cryogenic materials spill, vent the room immediately and evacuate all personnel.

Only perform cryogen transfers when you are in a well-ventilated room. Cryogens expand to hundreds of times their liquid volume when they boil, which occurs well below room temperature. A relatively small volume of liquid nitrogen or helium can displace all the air in a room during a spill. Nitrogen and helium are colorless and odorless, and the only symptoms of insufficient oxygen are dizziness and unconsciousness, followed by death.

1.4.2 Magnets

WARNING!

All magnet-safety precautions must take into account the strong ***three-dimensional*** fields produced by the superconducting magnets.

- People wearing a pacemaker or other electrical medical device must stay at least 16.5 ft. (5 m)[2] from the PPMS dewar.
- Ferromagnetic objects must be kept at least 16.5 ft. (5 m) from the PPMS dewar.
- Magnetic fields must be at zero (0) before you disconnect the controllers from the probe head.
- Helium levels must be at least 60% to use a magnet to full field.

- ***Never disconnect a charged magnet*** from the Model 6700 Magnet Controller, and ***never disconnect any other system connections while a magnet is charged.*** The superconducting PPMS magnets can trap magnetic flux, so it would be possible to leave a charged magnet that is completely disconnected from the rest of the system. Under such circumstances, you have no means to discharge the magnet directly.

  Several different cables have connections for magnet control. In the event that you must disconnect the probe from the magnet controllers, verify that the magnet has been driven to zero field before you disconnect any cables, with the exception of the sample-chamber connection. The sample chamber connection—that is, the cable from the gray Lemo connector that is on the PPMS probe head—is the only cable that you can safely disconnect while the magnet is charged. You must leave all other connections intact.

- The safety guidelines given here are generalized to a 9-T longitudinal magnet. Verify that any person wearing a pacemaker or other electrical or mechanical medical device stays at least 16.5 ft. (5 m) from the PPMS dewar. This distance applies to people located in adjacent rooms and on floors above and below the equipment, because the magnets produce *three-dimensional* fields. The magnetic fields produced by the PPMS can be dangerous or fatal to

[2] At the current time (August 2004), 5 m should be a large enough distance to protect wearers of metallic implants or medical devices from most magnetic fields produced by Quantum Design magnets. However, the safe distance from newer magnets (in development) could be greater. Hence, personnel who work with and around the superconducting magnets should review thoroughly documentation for new equipment.

anyone who is wearing a pacemaker or other electrical medical device. This information should be posted in the laboratory where the PPMS is operated and adjacent areas so that people wearing such devices are aware of the presence of large magnetic fields.

Important: The automated control system can turn on the magnet while the system is unattended. Furthermore, the ***three-dimensional*** magnetic field of the PPMS will penetrate nearby walls, the ceiling, and the floor. Therefore, your safety considerations should include such adjacent spaces. Also, note that transverse magnets produce substantially stronger fields around the dewar than longitudinal magnets do.

- The superconducting magnets supplied with PPMS units all produce strong fields that are not completely confined to the system unless it has some type of magnetic shielding. For example, PPMS superconducting magnets can disturb computer monitors, affect electron microscopes, erase credit cards, attract ferromagnetic tools, and so on. Table 1-1 summarizes some of these effects.
- Quantum Design recommends that you measure the magnetic field around the PPMS and draw a line showing where the measured field drops below 5 G. It is your responsibility to determine the location of this line, because it varies from system to system. This line is typically about 3–10 ft. (1–3 m) from the edge of the dewar. Do not bring heavy ferromagnetic objects, such as gas cylinders and large tools, within this region when the magnet is charged. Gas cylinders in the laboratory should be secured to the walls and only informed personnel should be allowed to use large tools in the presence of the PPMS. It is possible to cause injury to personnel and damage to PPMS equipment by allowing heavy objects to be attracted to the PPMS.
- Keep the helium level ***above*** the superconducting magnet. There is high potential for damage, such as an uncontrolled magnet quench, when the superconducting magnet is not completely covered by helium. See Sections 3.5 and 4.2.4 for more information.

1.4.3 Electricity

WARNING!

The Model 6000 PPMS Controller, Model 6700 Magnet Controller, personal computer, and vacuum pump are all powered by standard 120 VAC or 240 VAC power lines. These voltages are potentially lethal, so you should exercise appropriate care before opening any of the electronics units, including turning off the equipment and disconnecting it from its power source.

- Turn off and unplug all electronic equipment before removing any of its covers.
- Keep electrical cords in good working condition, and replace frayed and damaged cords.
- Keep liquids away from the workstations.

Safe operation of the PPMS requires the appropriate electrical power input. The input power requirements for the PPMS are the following:

- 50–60 Hz, 100–120 VAC at 15 A
- 50–60 Hz, 200–240 VAC at 10 A

1.5 Environmental Considerations and PPMS Setup

You must consider a number of environmental constraints when you install the PPMS in a laboratory, including the effects of magnetic fields generated by the superconducting magnet; the physical dimensions of the equipment; vertical clearance above the dewar; and the local altitude and humidity.

The PPMS is intended for indoor use at altitudes less than about 6000 ft. (1829 m). If you will be operating the system at altitudes above our specifications, please discuss it with your Quantum Design representative. The PPMS should be operated in an ambient temperature between 5 °C and 40 °C, with a maximum relative humidity of 80% at 40 °C.

Important: The electrical safety features of the PPMS might be impaired if it is operated outside these environmental considerations.

1.5.1 Magnetic-Field Considerations

Before you install the PPMS, consider how the *three-dimensional* field generated by the superconducting magnet will affect nearby people and objects. For example, measuring out from a 9-T longitudinal magnet at full field, we obtained the surrounding radial distances at which various field strengths occur. These results are shown in Table 1-1 according to their effects on people and objects, including those located above and below the magnet. This list is not comprehensive, so you should consider *all* the equipment in your laboratory that might be affected by magnetic fields. Also, remember that a PPMS with a stronger magnet (e.g., 14 T or 16 T) will produce effects at significantly smaller distances than those listed.

Table 1-1. Possible effects of the PPMS magnet, based on a system with a 9-T longitudinal magnet

ITEM	EFFECT	FIELD REQUIRED (Oe)	APPROXIMATE RADIAL[a] DISTANCE FROM THE DEWAR
Electron microscope	Disturbance	1	85.0 in. (216 cm)
Color and monochrome computer monitors (CRT type, unshielded)	Disturbance	1–5	50.0–59.8 in. (127–152 cm)
Credit cards, bank cards, etc.	Erasure	10	40.2 in. (102 cm)
Watches and micromechanical devices	Disturbance	10	40.2 in. (102 cm)
Pacemaker (lowest known field)	**Disturbance**	**17**	**33.1 in. (84 cm)**
Magnetic tapes	Erasure	20	31.1 in. (79 cm)
Transformers and amplifiers	Saturation	50	22.8 in. (58 cm)
Floppy disks	Erasure	350	11.8 in. (30 cm)

[a] The magnetic fields are three-dimensional, so their effects will extend above and below the magnet as well as around it.

1.5.2 Physical Dimensions

When you are deciding where you will locate the PPMS, consider the constraints below as well as the dewar and cabinet dimensions, which are listed in Table 1-2. Note that these measurements are approximate.

- Empty space is needed around the PPMS to allow regular transfers of helium and nitrogen and for a transfer vessel (usually a large portable dewar), which must be brought near the PPMS dewar.
- Vertical clearance of about 6 ft. (1.8 m)[3] is needed above the dewar so that you can easily insert and extract the probe. These dimensions are suitable for inserting and removing the probe for all configurations[4] of the PPMS dewar, including the VSM and systems that have a 14-T magnet (which requires a crane).
- Vertical clearance of about 3.3 ft. (1 m) is needed above the dewar for the sample-insertion tool and the helium-transfer line.

Table 1-2. Approximate physical dimensions of the PPMS dewars and the electronics cabinet

HARDWARE	PHYSICAL DIMENSIONS
Standard dewar (no nitrogen jacket)	45 in. high × 19 in. diameter (114 cm[a] high × 48 cm diameter)
Nitrogen-jacketed dewar	46 in. high × 21 in. diameter (116 cm high × 53 cm diameter)
High-capacity (nitrogen-jacketed) dewar	46 in. high × 28 in. diameter (116 cm high × 71 cm diameter)
EverCool dewar (w/o cold head)	45 in. high × 22 in. diameter (114 cm high × 55 cm diameter)
Electronics cabinet	22 in. wide × 24 in. deep × 45 in. high (56 cm wide × 61 cm deep × 114 cm high)

[a] The inch to cm equivalences are approximate, because both measures were rounded after inches had been converted to centimeters.

1.5.3 Local Altitude and Humidity

The altitude and humidity of the laboratory can affect the performance of the PPMS.

The PPMS is designed to operate at altitudes below about 6000 ft. (1829 m). You can operate the PPMS at altitudes of 6000 ft. (1829 m) and above, but it is not an optimal environment. To control the sample temperature in the PPMS at temperatures that are below the boiling point of helium, the pressure difference between the inside and outside of the dewar must be monitored. If you are at a high altitude where atmospheric pressure drops significantly below 760 torr (1 atm), you might notice some problems with temperature control or some sluggishness during low-temperature operation.

[3] A room with a ceiling about 10 ft. (3 m) high should provide enough vertical clearance to insert and remove the probe, depending on your setup.
[4] These dimensions are correct as of August, 2004.

The PPMS is best suited for dry environments and it should be operated with the humidity less than 90%. Ice naturally forms when water in the air condenses and then freezes on cold surfaces, and serious system problems can be caused when even the smallest piece of ice forms inside the PPMS. As humidity increases, it is easier for water to enter the system. Eventually this will cause temperature-control problems. The PPMS does not have an airlock chamber, so the sample chamber should be warmed to room temperature and vented continuously with a clean, dry gas whenever the chamber is opened to the atmosphere. The system is designed so that you can warm and vent the sample chamber by pushing a few buttons.

1.6 Contacting Quantum Design

If you have questions or problems related to your QD equipment, please contact your local QD service representative at one of the offices listed below. When you call, please be able to give the representative a full description of the problem, including the circumstances involved and the recent history of your system.

United States

Quantum Design World Headquarters
6325 Lusk Boulevard
San Diego, CA 92121

Tel: 1-858-481-4400
1-800-289-6996
Fax: 1-858-481-7410

Email: service@qdusa.com
Web: http://www.qdusa.com

Service for Canada, Mexico, the U.S., and other countries not listed below

Europe

L.O.T.—Gmbh & Co KG
Im Tiefen See 58
D-64293 Darmstadt, Germany

Tel: 49-6151-880631
Fax: 49-6151-896667

Email: qd.euroservice@lot-oriel.de
Web: http://www.lot-oriel.com

Service for Austria, Belgium, Crete, Croatia, Czech Republic, Denmark, England, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and Yugoslavia

Japan

Quantum Design Japan
Sanpo Ikebukuro Building Annex
4-32-8 Ikebukuro
Toshima-ku, Tokyo
171-0014, Japan

Tel: 81-3-5954-8570
Fax: 81-3-5954-6570

Email: qdjapan@tkb.att.ne.jp
Web: http://www.qd-japan.com

Service for Japan

Korea

Quantum Design Korea
Kyungbin Building, Fourth Floor
517-18 Dogok-dong, Kangnam-gu
Seoul, 135-270, Korea

Tel: 82-2-2057-2710
Fax: 82-2-2057-2712

Web: http://www.qdkorea.com

Service for Korea

People's Republic of China

Oxford Instruments Beijing Office
Room 714, Office Tower 3
Henderson Center
No. 18 Jianguomennei Ave
Dongcheng District
Beijing 100005
P.R. China

Tel: 8610-6518-8160/8161/8162
Fax: 8610-6518-8155

Email: lambert@oxford-instruments.com.cn
Web: http://www.oxford-instruments.com.cn

Service for People's Republic of China

Taiwan

Omega Scientific Taiwan Ltd.
5F-1, No. 415, Sec. 4
Hsin Yi Road
Taipei, Taiwan R.O.C.

Tel: 886-2-8780-5228
Fax: 886-2-8780-5225

Email: lonson.lin@omega-cana.com.tw

Service for Taiwan, Hong Kong, Singapore

C H A P T E R 2

Hardware

2.1 Introduction

This chapter contains the following information:

- Section 2.2 describes the dewar, including its functions and the three main types.
- Section 2.3 describes the probe and its main components.
- Section 2.4 describes the top-plate assembly.
- Section 2.5 describes the probe-lifting assembly.
- Section 2.6 describes the Model 6000 PPMS Controller.
- Section 2.7 describes the optional Model 6700 Magnet Controller.
- Section 2.8 describes the electronics cabinet.
- Section 2.9 describes the vacuum pump.
- Section 2.10 describes the sample puck and the puck tools.

2.2 Dewar

The dewar contains the liquid-helium bath in which the probe is immersed. Primarily constructed of aluminum, the outer layer of the dewar has reflective superinsulation to help minimize helium consumption. The outer layer is evacuated through a valve on the top of the dewar (Figures 2-1, 2-2, and 2-3)—this evacuation valve ***must not*** be modified or altered.[1] The dewar regions that are evacuated contain activated charcoal on cold surfaces to aid cryopumping.

Most PPMS units can operate with one of three different types of dewars: the standard dewar (Figure 2-1), the nitrogen-jacketed dewar (Figure 2-2), or the high-capacity nitrogen-jacketed dewar (Figure 2-3). The exceptions include EverCool units and systems that have a 14-T or 16-T longitudinal magnet or a 7-T transverse magnet. Instructions for filling warm (or empty) dewars with nitrogen and helium are given in Appendix B, and instructions for refilling cold dewars with nitrogen and helium are given in Sections 4.7.2.

Note: Due to physical constraints, EverCool systems and systems with a 14-T or 16-T longitudinal magnet or a 7-T transverse magnet have special dewars that are not discussed in this manual. For more information about EverCool dewars, refer to the *PPMS EverCool Dewar Option User's Manual.* Contact Customer Service at Quantum Design if you have questions about the other dewars.

[1] If you have any questions about this issue, please contact Customer Service at Quantum Design.

2.2.1.1 STANDARD DEWAR

Figure 2-1 illustrates a top view and a cross-section of a standard dewar. The standard dewar contains a set of heat shields around the neck of the helium container and does not have a nitrogen jacket. Otherwise, it is similar to but slightly smaller than the nitrogen-jacketed dewar.

Standard dewars have a 30 L liquid-helium capacity.

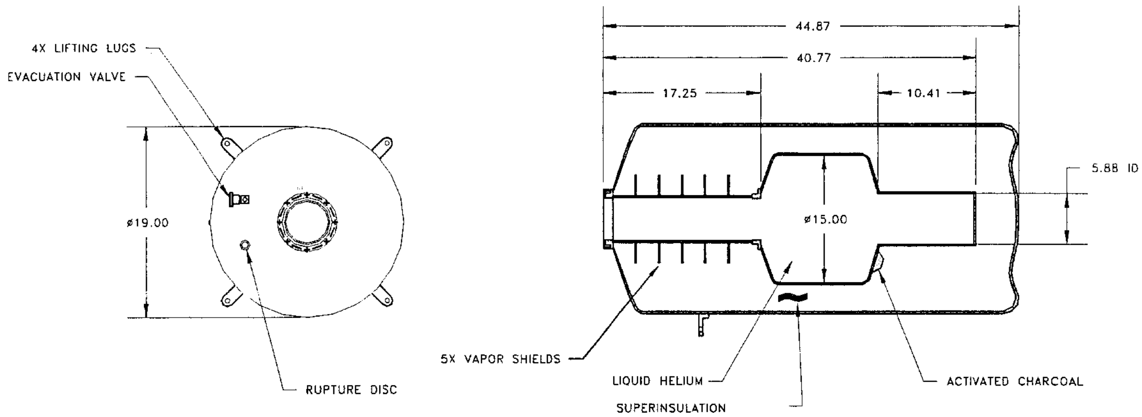

Figure 2-1. Top view and cross-section of a standard dewar, illustrating construction of dewars without a nitrogen jacket (dimensions are in inches)

2.2.1.2 NITROGEN-JACKETED DEWAR

Nitrogen-jacketed dewars (Figure 2-2) consume significantly less liquid helium than dewars without nitrogen jackets. Two liquid-nitrogen-fill ports give the top of the nitrogen-jacketed dewar a distinctive appearance.

The operating efficiency of nitrogen-jacketed dewars is partly due to a layer of liquid nitrogen sandwiched between the superinsulation and the liquid helium, which further insulates the helium bath, as does the vacuum in the region between the liquid helium and the liquid nitrogen.

A liquid-nitrogen transfer adapter is included with all nitrogen-jacketed dewars. The transfer adapter (Figure 2-2) is a short, L-shaped tube that fits on the end of most standard liquid-nitrogen transfer lines and facilitates the liquid-nitrogen fill procedure.

The standard nitrogen-jacketed dewar has a 30 L liquid-helium capacity and a 40 L liquid-nitrogen capacity.

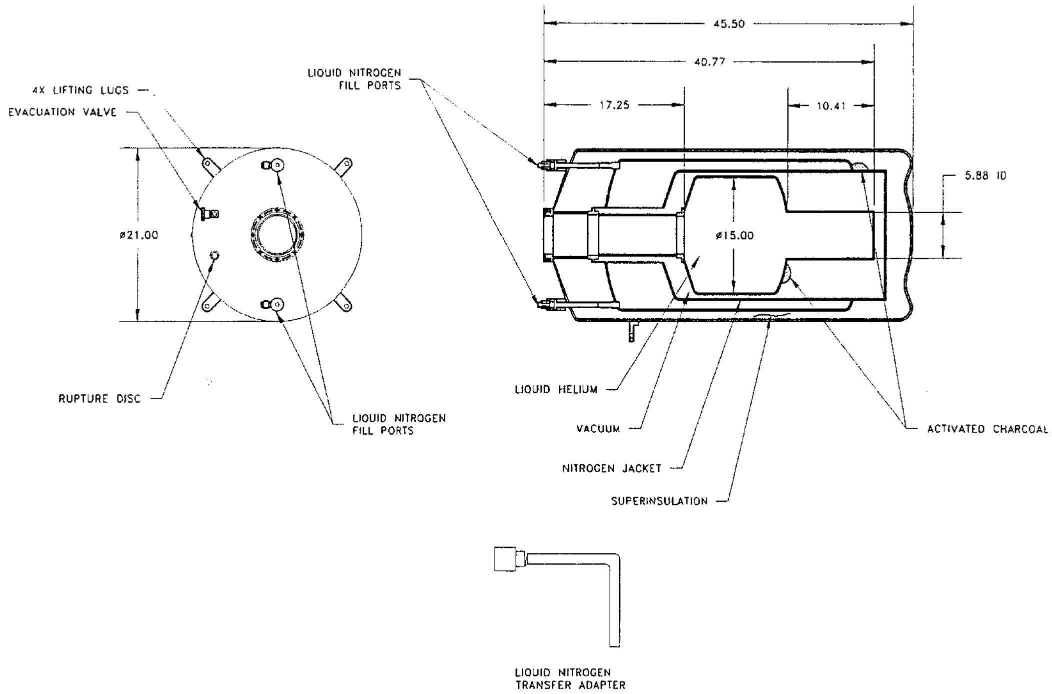

Figure 2-2. Top view and cross-section of a nitrogen-jacketed dewar and a side view of a liquid nitrogen transfer adapter (dimensions are in inches)

2.2.1.3 HIGH-CAPACITY NITROGEN-JACKETED DEWAR

High-capacity nitrogen-jacketed dewars are used solely with systems that have a 7-T or 9-T longitudinal magnet. Figure 2-3 illustrates a top view and a cross-section of a high-capacity nitrogen-jacketed dewar, which has a 68 L liquid-helium capacity and a 48 L liquid-nitrogen capacity.

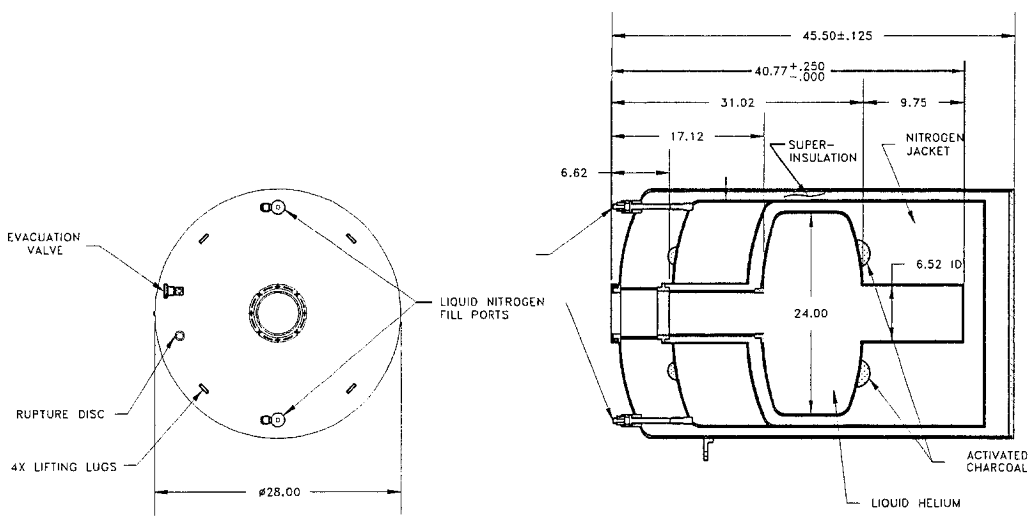

Figure 2-3. Top view and cross-section of a high-capacity nitrogen-jacketed dewar (dimensions are in inches)

2.3 Probe

The probe (Figure 2-4) is immersed in the liquid-helium bath inside the dewar. A sophisticated device with delicate components, the probe incorporates the basic temperature-control hardware, the superconducting magnet, the helium-level meter, the gas lines, the sample puck connectors, and various electrical connections. You can prevent damage to the probe by following the probe-handling instructions in Section 4.2.1.

The probe is composed of several concentric stainless steel tubes and other important elements. Its outer layer isolates the sample chamber from the liquid-helium bath. Two concentric tubes, separated by a sealed, evacuated region, prevent heat exchange between the sample chamber and the helium bath. The vacuum space between the outer and inner vacuum tubes contains reflective superinsulation to minimize radiative power loss into the helium bath. An aluminum heat shield in the vacuum region directs heat to the neck of the dewar, where there is no liquid helium. A metal bellows at the bottom of the probe prevents it from being damaged by differential thermal expansion between the outer vacuum tube and the heat shield. A cap at the bottom of the probe protects the bellows. The protective cap is not sealed, and liquid helium flows freely into it.

Major components of the probe are the sample chamber, impedance assembly, optional magnet, baffled rods, and probe head, which are discussed in the following sections.

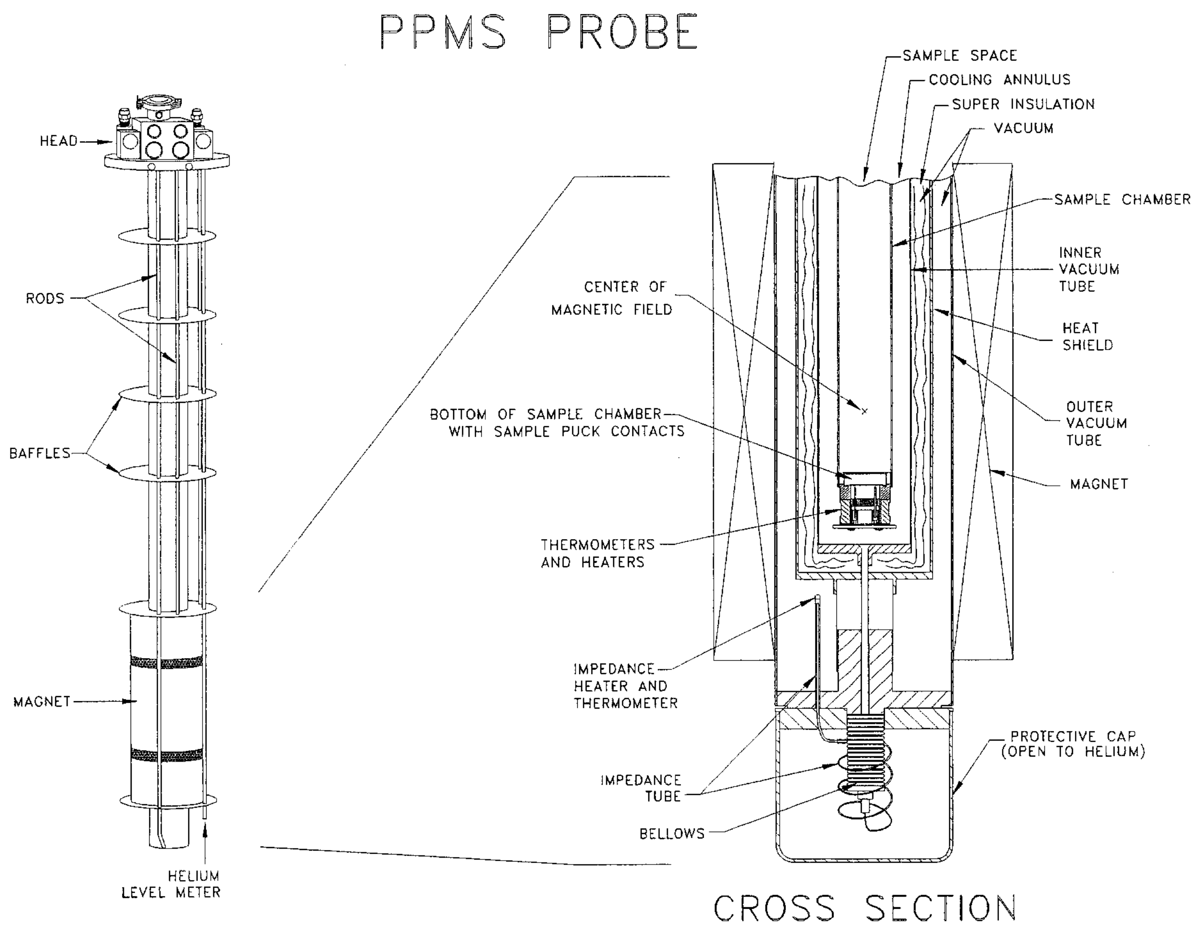

Figure 2-4. Major components of the PPMS probe

2.3.1 Sample Chamber

The sample chamber is inside the two vacuum tubes. The lower 3.9 in. (10 cm) of the sample chamber is constructed of copper in order to provide a region of uniform temperature. The very base of the sample chamber contains a 12-pin connector that contacts the bottom of an installed sample puck. Two thermometers and a heater are immediately below the sample puck connector. Their proximity to the copper sample puck and mating connector helps them maintain close thermal contact with the puck and sample during experiments. The wiring for the sample puck connections, heaters, and thermometers runs up the outside of the sample chamber to the probe head. The pins from the sample puck connector are wired to the pins on the gray-ringed Lemo connector on the probe head. Appendix A has a list of pinouts for the sample puck, sample puck connector, and gray Lemo connector.

The region between the sample chamber and the inner vacuum tube is referred to as the cooling annulus. Helium is pulled through the impedance tube into the cooling annulus so that it can warm and cool the sample chamber evenly.

2.3.2 Impedance Assembly

The impedance assembly enables and disables the flow of helium into the cooling annulus from the dewar. The assembly consists of a narrow tube (the impedance), a heater that warms the impedance, and a thermometer that indicates when the impedance is warm. When the impedance is warm, a bubble forms inside the tube, blocking the flow of liquid helium. Then when the impedance heater is off, the liquid helium cools the impedance tube and flows into the cooling annulus, where it either vaporizes or fills the annulus, depending on the pressure inside the annulus. The cap at the bottom of the probe protects the impedance tube.

Newer probes (those manufactured since January 1998) are enabled for the Continuous Low-Temperature Control (CLTC) option—they have a carefully tuned second impedance in parallel with the primary impedance. Owners of earlier model probes can purchase the CLTC option by contacting Quantum Design. See Sections 3.3 and 4.3 for more information on temperature-control modes.

2.3.3 Baffled Rods

The rods that run the length of the probe contain electrical connections to the magnet and impedance assembly. One of the rods contains the helium-level meter. Several baffles provide support for the rods. The rods are delicate and cannot support the full weight of the probe.

2.3.4 Probe Head

The top part of the probe that protrudes out of the dewar is referred to as the "probe head." The probe head contains the two helium-fill ports and all the connection ports for attaching gas, vacuum, and electrical lines from the Model 6000 PPMS Controller. Most of the ports and connections are on the back of the probe head. Figures 2-4 and A-3 illustrate the probe head, and Appendix A discusses the ports and connections.

The probe head includes the access port into the sample chamber. A blank flange covers the access port unless certain PPMS options have been installed.

2.3.5 Optional Magnet

The PPMS can be purchased with a 1-T, 7-T, 9-T, 14-T, or 16-T longitudinal magnet or a 7-T transverse magnet. The magnet is a superconducting solenoid composed of a niobium–titanium alloy embedded in copper. It is on the outside of the probe, so it is always immersed in liquid helium.

The magnet coil constitutes a closed superconducting circuit. The persistence switch is a small heater on the magnet wire that drives a section of the magnet non-superconducting. The persistence switch allows the Model 6700 Magnet Controller to be switched into the magnet circuit so that the magnetic field can be changed. When the heater is turned off, the entire magnet can superconduct, which eliminates the need for a current source during constant field operation. This state is referred to as the **Persistent** mode of the magnet. Section 3.5 discusses magnetic-field control in more detail.

For 1-T, 7-T, 9-T, 14-T, and 16-T longitudinal magnets, the magnetic field is centered 2.1 in. (5.4 cm) above the surface of an installed sample puck, but the field uniformity varies. The 7-T transverse magnets are shipped with the center of the field 1.6 in. (4.0 cm) above the surface of an installed puck.

2.4 Top-Plate Assembly

The top-plate assembly (Figure 2-5) consists of the components that seal the sample chamber: the top plate; a centering ring, O-ring, and hinge clamp; the top-plate baffle assembly; and a threaded adapter.

The top plate is a KF blank flange that closes the sample-chamber access port. A centering ring with an O-ring around its diameter fits between the blank flange and the access port in order to seal the sample chamber. A hinge clamp holds the blank flange on top of the access port.

The top-plate baffle assembly is a set of baffles on a light G-10 rod that is attached to the bottom of the blank flange. The baffles confine thermal gradients to specific regions of the sample chamber, aiding thermal control so that the system can achieve temperatures as low as 1.9 K. A small threaded adapter at the end of the baffle rod allows you to attach other components to the rod. Note that some PPMS options seal the sample chamber differently and do not use the components shown in Figure 2-5.

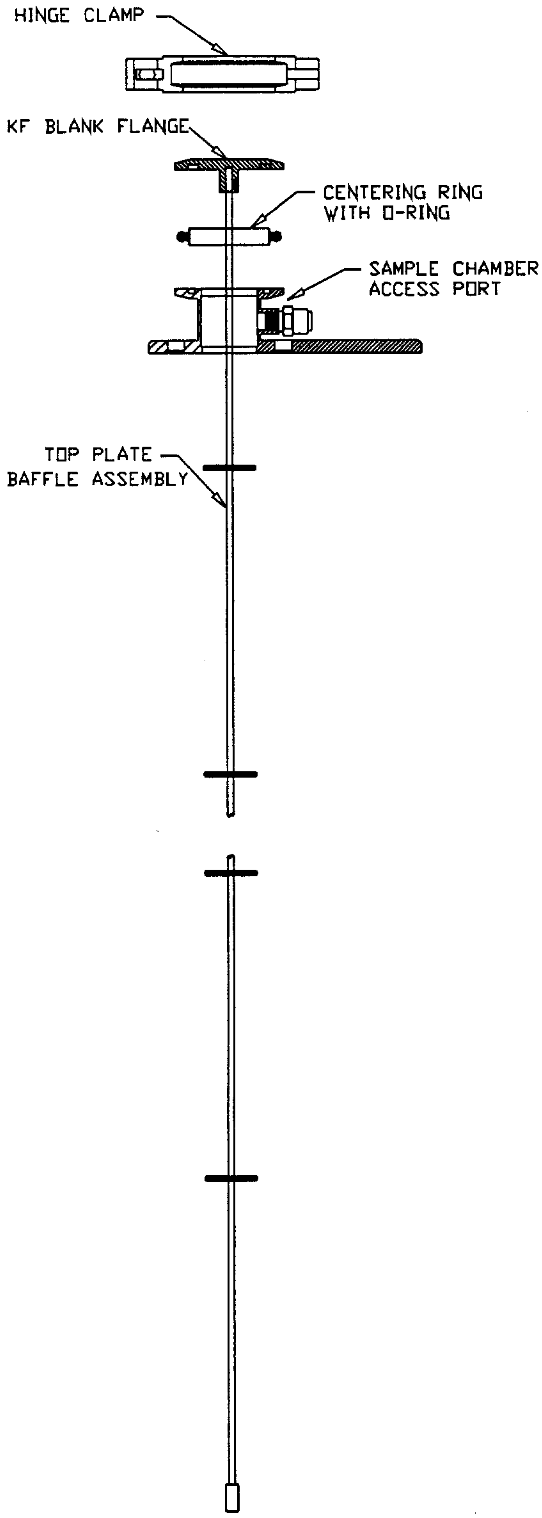

Figure 2-5. Cross-section of top-plate assembly

2.5 Probe-Lifting Assembly

The probe-lifting assembly (Figure 2-6) is used to install and remove the probe. The assembly consists of a U-bolt, a locking mechanism, and a plate. The plate fits just underneath the sample-chamber access port, which is located on the probe head (see Figures 2-4 and 2-5).

You typically will use the probe-lifting assembly in conjunction with a hoist. You can tie or pass a rope through both the U-bolt and a fixture in the ceiling so that you can slowly raise and lower the probe. When the probe-lifting assembly is not being used, remove it from the probe. Section 4.7.4 explains how to use the probe-lifting assembly.

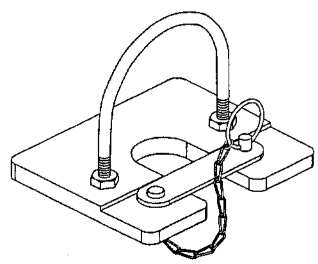

Figure 2-6. Probe-lifting assembly

2.6 Model 6000 PPMS Controller

The Model 6000 PPMS Controller (Figure 2-7) is an integrated user interface that houses the electronics and the gas-control valves for the PPMS. The Model 6000 contains the CPU board, motherboard, and system bridgeboard. The CPU board is the system processor, the motherboard controls system integration, and the system bridgeboard supplies temperature readings. Gas valves and gas lines inside the Model 6000 are used to control temperature.

Refer to Sections 2.6.1.1 and 2.6.1.2 and Appendix A for more information on the Model 6000. Refer to the *Physical Property Measurement System Firmware Manual* and the *Physical Property Measurement System Commands Manual* for practical information about using the Model 6000.

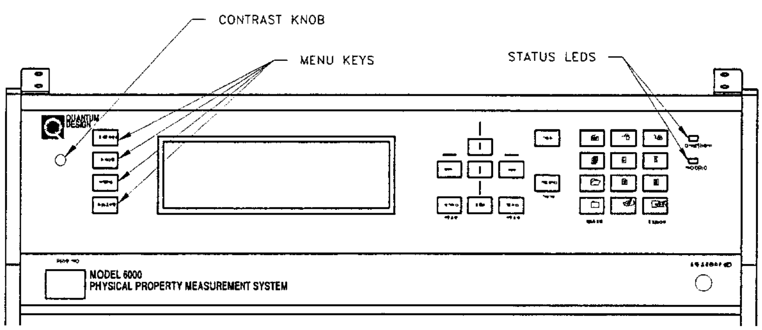

Figure 2-7. Front panel of Model 6000 PPMS Controller

2.6.1.1 MODEL 6000 FRONT PANEL

Figure 2-7 illustrates the front panel of the Model 6000, which has a power button, a display screen, a contrast knob, a number pad, and a signal output (BNC connector), as well as menu keys, arrow keys, and two status LEDs.

The status LEDs light up during remote control of the system and when an error is logged into the data file.

The signal output comes from an internal digital-to-analog converter. The signal output can be linked to any one of about 30 system parameters, including temperature, field, position, excitation current, and resistance. The output has a –10 V to +10 V range, and values for the linked parameter must be specified for both 0 V and +10 V. This analog output is linked in parallel to the "A1" analog output port on the Model 6000 rear panel.

2.6.1.2 MODEL 6000 REAR PANEL

The rear panel of the Model 6000 has ports for all system connections, including necessary PPMS connections, connections to optional Quantum Design hardware, and auxiliary connections that accommodate interfacing with other devices. Appendix A discusses these ports in more detail.

2.7 Optional Model 6700 Magnet Controller

CAUTION!

Do not alter or remove the connection from the Model 6700 to the "P7–Magnet" port on the Model 6000. Altering or removing this connection could destroy the 24 V power supply in the Model 6000 and/or Model 6700 and void the manufacture's warranty.

If you ever have a magnet-related question or encounter a problem when you are using a magnet, contact Customer Service at Quantum Design.

The Model 6700 Magnet Controller (Figure 2-8) is the controller and source of current for the optional magnet. It is a bipolar power supply that allows smoother ramping through zero (0) field than traditional one-sided power supplies. As is discussed in Section 3.5, the Model 6700 uses four different approach modes to control charging and discharging of the magnet.

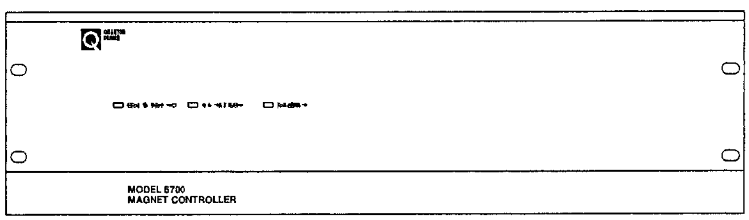

Figure 2-8. Front panel of the Model 6700 Magnet Controller

2.7.1.1 MODEL 6700 MAGNET CONTROLLER FRONT PANEL

There are three LEDs on the front panel of the Model 6700: the "Logic Power" LED, which is lit when the Model 6000 is powered on, and the "DC Enable" and "On-Line" LEDs, which are lit whenever the system is deliberately charging or discharging the magnet.

2.7.1.2 MODEL 6700 MAGNET CONTROLLER REAR PANEL

The rear panel of the Model 6700 has a power switch that (indirectly) turns off the current to the magnet. *Never* turn off the power to the Model 6700 while the magnet is ramping.

CAUTION!

Never turn off the power to the Model 6700 while the magnet is ramping.

2.8 Electronics Cabinet

The electronics cabinet (Figure 2-9) holds the Model 6000 and Model 6700, the vacuum pump, and a power strip. It also has room for the additional hardware and electronics needed with some PPMS options. Refer to Section 1.4.3 for electrical specifications for the cabinet.

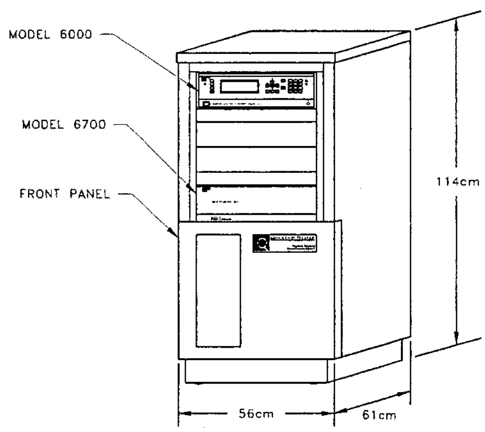

Figure 2-9. PPMS electronics cabinet

2.9 Vacuum Pump

A direct-drive pump operates continuously to control pressure in the sample chamber and to aid thermal control. Valves in the Model 6000 regulate the vacuum and the gas-flow rates. Figure 2-10 shows one of the models of pumps used in the PPMS.

The pump is installed in the bottom of the electronics cabinet. It should have an oil-mist filter attached to its exhaust line and a foreline trap on its input to protect the system from contamination. The oil-mist filter is located on an inside wall of the electronics cabinet.

The vacuum pump must be maintained to ensure optimal performance of your PPMS. Pump operation and maintenance are covered in Section 4.7.3 and Appendix C.

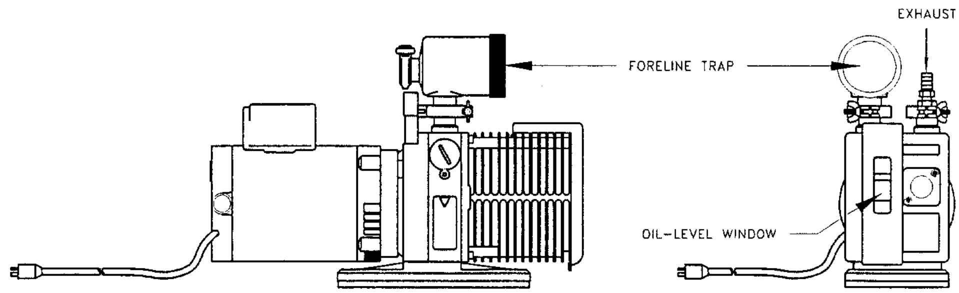

Figure 2-10. An oil-mist direct-drive pump used to control pressure and temperature in the PPMS

2.10 Sample Puck and Assorted Tools

The sample puck (Figure 2-11) is a unique modular component that gives the PPMS great flexibility. The puck holds the sample for many experiments that use the base PPMS platform and that do not require motion of the sample. Some options, such as the AC Measurement System (ACMS) option and the horizontal rotator options, do not use the sample puck.

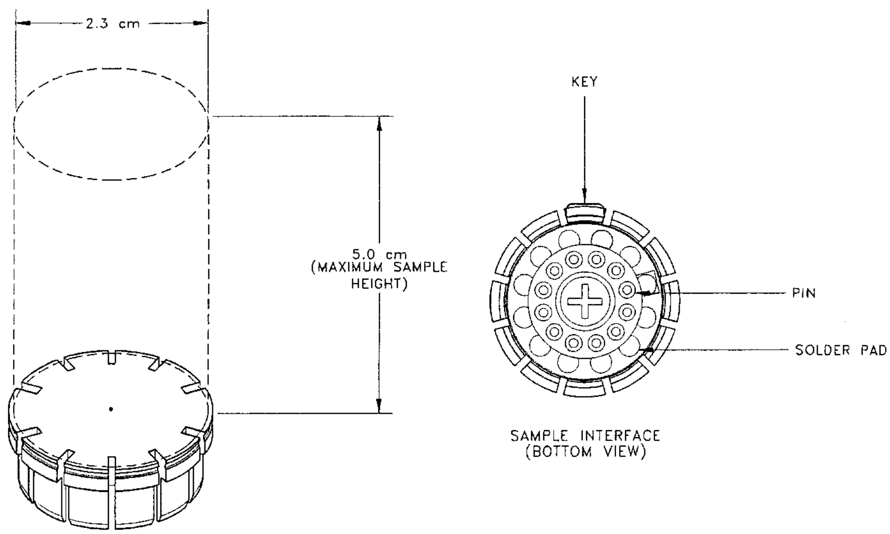

Figure 2-11. Top and bottom views of a sample puck

The puck is a 0.91 in. (2.3 cm) diameter disk that is constructed of oxygen-free high-conductivity copper that maintains high thermal uniformity. It has been gold-plated to prevent oxidation. The system thermometers and heaters are located directly beneath the installed puck, so temperature control is intimately related to the temperature of the sample. Options that use other sample-mounting techniques often have an additional thermometer located near the sample.

The base of the puck contains 12 solder pads through which electrical leads establish contact with the sample (you supply these leads). These solder pads are hard-wired to a set of 12 pins on the base of the puck. When you install the puck, the 12 pins connect to the sample-puck connectors located on the bottom of the sample chamber and then ultimately to the pins of the gray-ringed Lemo connector on the probe head. The puck is keyed to ensure that the electrical connectors align properly.

The last solder pad (counting clockwise) is square instead of round. You will use this solder pad as a reference point to help you wire sample leads to the proper solder pads. Refer to Section 4.4 for sample-mounting instructions.

Each PPMS option includes several pucks, so you can mount different samples on different pucks. You also can configure each puck for a different type of experiment.

2.10.1 Puck-Insertion Tool

The puck-insertion tool[2] is a long rod used for installing the puck in the sample space. The lever of the puck-insertion tool is engaged when it is lying flat across the handle, as is shown in Figure 2-12. When the lever is engaged, the tool grips the puck by a groove in its outer rim.

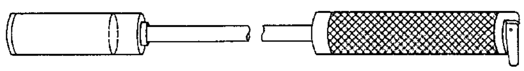

Figure 2-12. Sample insertion tool with lever in engaged position

The puck-insertion procedure is described in Section 4.5. The procedure is easy and requires only a few seconds after you have warmed the sample chamber to room temperature.

2.10.2 Puck-Adjustment Tool

The puck-adjustment tool (Figure 2-13) is used to adjust the tension in the fingers of the puck so that the fingers maintain solid thermal contact with the 12-pin connector located at the bottom of the sample chamber.

The puck-adjustment tool consists of two metal cylinders. In Figure 2-13, Cylinder 1 is the finger spreader. Cylinder 2 is the finger contractor and the test cutout. The finger spreader and the finger contractor adjust the tension of the chuck fingers. The test cutout, which has the same dimensions as the cutout in the heater block, tests how well the chuck fingers will contact the heater block.

[2] The puck-insertion tool is also called the puck-extraction tool or sample-insertion tool, depending on context.

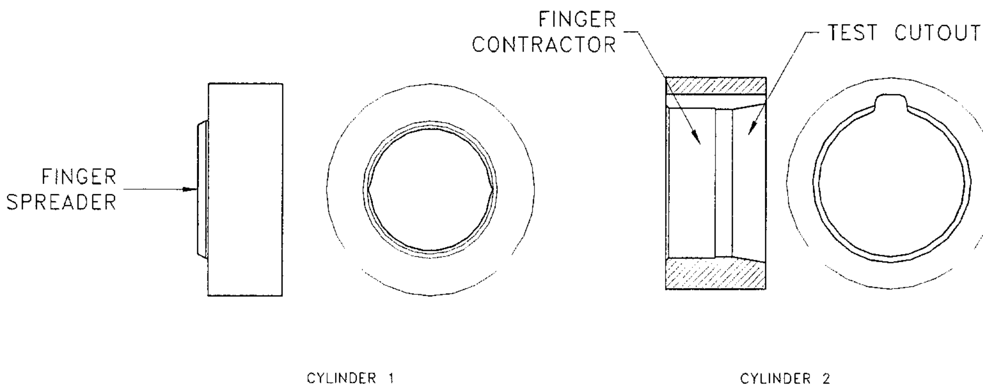

Figure 2-13. Puck-adjustment tool

You will use the puck-adjustment tool after you have inserted the sample puck into the sample chamber approximately 10 times or whenever the puck fits loosely into the bottom of the chamber. Instructions for using the puck-adjustment tool are given in Section 4.7.1.

2.10.3 Puck-Wiring Test Station

The puck-wiring test station[3] (Figure 2-14) is used to verify the contact between a sample and puck. The test station contains three sets of contacts, all wired in series: a Lemo connector identical to the sample-chamber connector on the probe head, a puck connector, and 12 banana jacks. PPMS measurement options (e.g., Heat Capacity) come with templates that allow you to label the banana plug functions when the standard cabling is being used for an option.

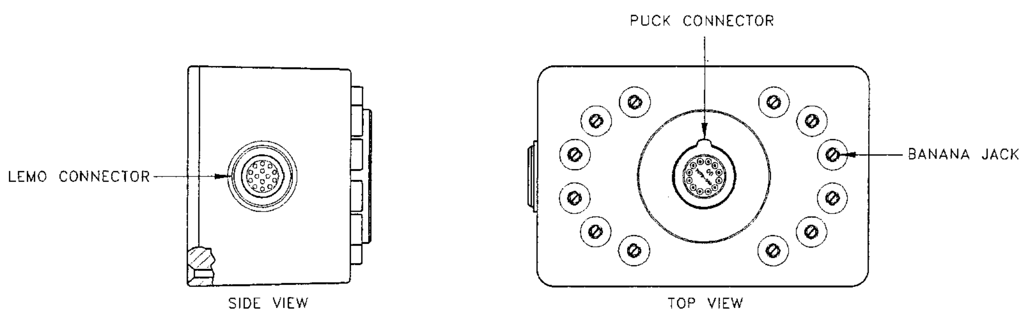

Figure 2-14. Puck-wiring test station

[3]The puck-wiring test station is also referred to as the P150 sample-wiring test station.

C H A P T E R 3

Theory of Operation

3.1 Introduction

This chapter contains the following information:

- Section 3.2 illustrates the main PPMS subsystems and their interactions.
- Section 3.3 describes temperature control and operational regimes.
- Section 3.4 describes atmospheric control and gas-line configuration.
- Section 3.5 describes magnetic-field control.
- Section 3.6 describes the helium-level meter and monitoring helium levels.
- Section 3.7 describes features of the Model 6000 that can be customized.
- Section 3.8 presents an example of a measurement.
- Section 3.9 describes variables to consider during a measurement.

3.2 PPMS System Block Diagram

Figure 3-1 illustrates how the temperature control, gas-flow control, magnetic-field control, and helium-level metering subsystems are incorporated in the PPMS.

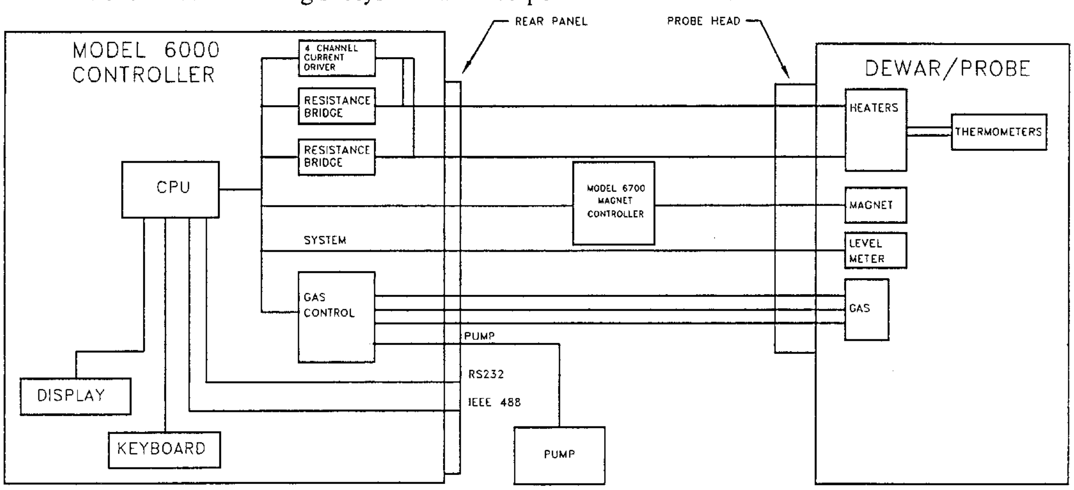

Figure 3-1. PPMS block diagram

3.3 Temperature Control

Figure 3-2 shows cross sections of the PPMS probe, including the components that control temperature. The outer layer of the probe is an evacuated region filled with reflective superinsulation. This layer is between the liquid-helium bath and cooling annulus, where it minimizes thermal exchange between the sample chamber and the 4.2 K liquid-helium bath. It contains an aluminum heat shield that directs heat to the neck of the probe rather than into the helium bath, where it would increase the rate of helium consumption. Without this evacuated region, temperature control would be difficult or impossible and helium consumption would be significantly higher.

The cooling annulus is the active region of temperature control. The continuously pumping vacuum pump draws helium from the dewar through the impedance tube and into the cooling annulus. The helium vapor flows through the annulus at rates that are controlled by a flow-control valve in the Model 6000 PPMS Controller.

The sample chamber is also usually kept at a pressure of a few torr with helium gas so that the walls of the sample space can maintain thermal contact with the sample. The sample chamber has a top-plate baffle assembly that helps isolate the sample space at the bottom of the chamber from the heat radiated by room-temperature components at the top. This baffle assembly is required for the sample space to reach the lowest attainable temperatures.

Sample temperature is monitored by a platinum resistance thermometer and a negative temperature coefficient (NTC) thermometer that are mounted directly beneath the electrical connectors for the sample puck. The platinum thermometer reads temperatures ranging between approximately 80 K and 400 K; the NTC thermometer reads temperatures ranging between approximately 1.9 and 100 K. A weighted average of the two thermometer readings is used in the crossover region between 80 K and 100 K. Another NTC thermometer, which is not shown in Figure 3-2, is mounted just above the sample space to monitor the temperature gradients in the chamber.

3.3.1 Temperature-Control Modes

The PPMS offers three unique operational regimes for controlling temperature in the sample space—one for high temperatures and two for low temperatures. The high-temperature regime is used for temperatures above the liquid-helium boiling point (4.2 K at 1 atm), which is the so-called "crossover temperature." The low-temperature regimes, Continuous Low-Temperature Control (CLTC) and pot-fill mode, are used to regulate temperatures below the crossover temperature. Each low-temperature regime can be used to lower the sample-space temperature to about 1.9 K, but their characteristics and advantages differ, as shown in Table 3-1.

Since January 1998, PPMS systems have included the high-temperature regime and both low-temperature regimes, with CLTC shipped as the default mode. Before that time, the PPMS included only the high-temperature regime and pot-fill mode, but owners of such systems can add the CLTC option as a purchased upgrade.

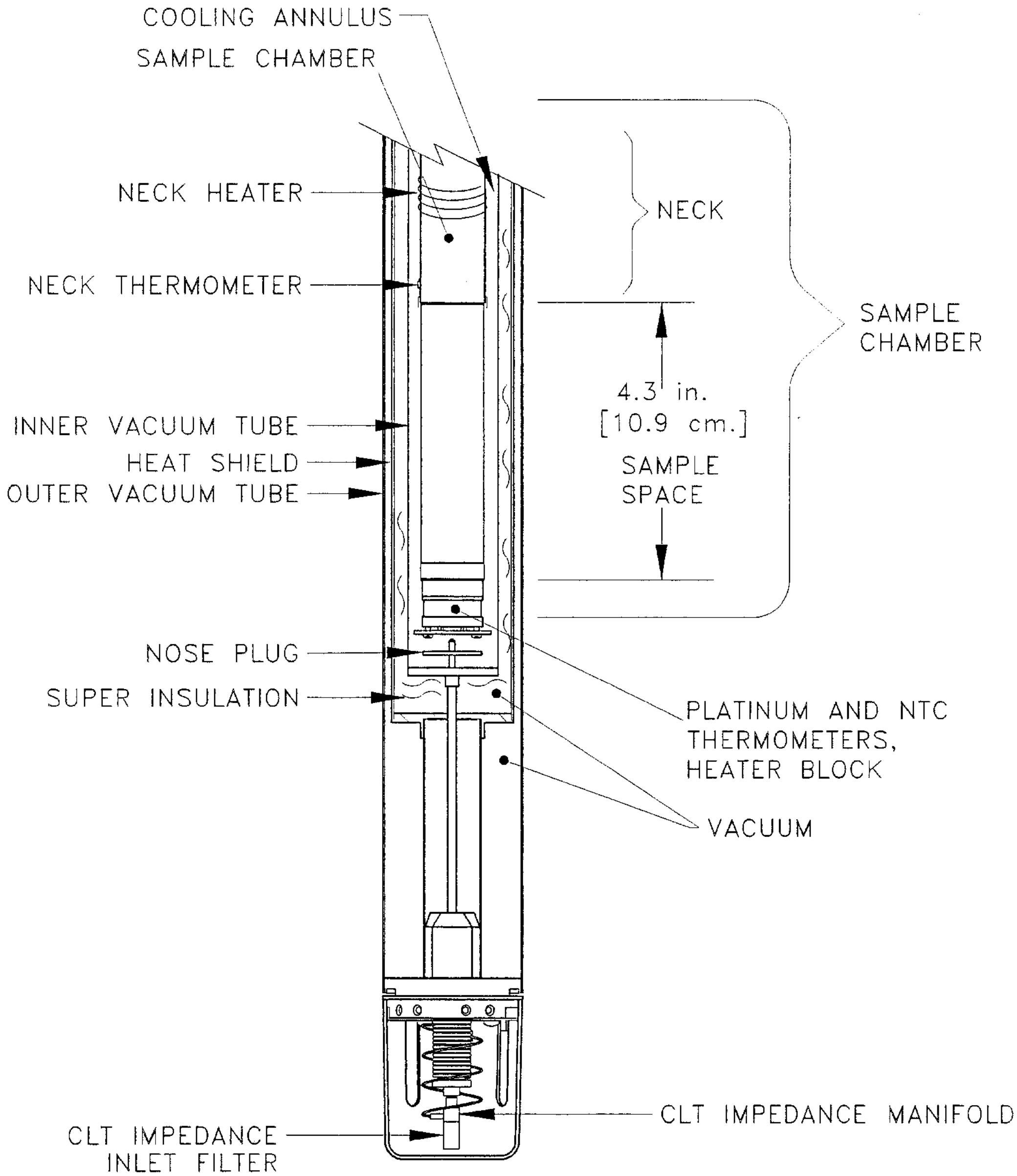

Figure 3-2. Cross-sections of the PPMS probe and its temperature-control components

3.3.1.1 HIGH-TEMPERATURE CONTROL

At temperatures above about 4.2 K, the system cools the sample space by drawing cold helium vapor, at a variable rate, through the impedance tube into the cooling annulus and across the outside of the sample chamber. Even when the sample space is not being cooled, the system maintains a helium flow of about 100 cc/min through the cooling annulus.

A block heater is mounted at the base of the sample chamber (see Figure 3-2), where it heats the sample to the desired temperature and warms the vapor in the cooling annulus, thus uniformly warming the entire sample space. Thermal gradients in the sample space are further minimized by a neck heater, which is wrapped around the sample chamber and located just above the sample space and near the neck thermometer.

The flow-control valve and the block and neck heaters use the sample temperature and neck temperature as feedback to obtain rapid thermal control. Maximum warming and cooling rates are around 6 K/min.

3.3.1.2 CONTINUOUS LOW-TEMPERATURE CONTROL

The system uses the Continuous Low-Temperature Control (CLTC) option to regulate temperatures below about 4.2 K by drawing cold helium gas through the carefully tuned CLTC flow impedance that restricts the gas flow. Flow through the primary impedance is completely turned off and the helium gas is drawn from the CLTC impedance through the annulus to cool the sample space. The system heaters warm the gas and the sample space directly.

CLTC mode includes a precooling phase that begins when the temperature in the sample space is about 11 K. The precooling minimizes thermal gradients in the sample chamber so that the unit can indefinitely maintain temperatures below 4.2 K and ensures that the temperature of the chamber smoothly transitions through 4.2 K. The precooling method uses aggressive feedback on multiple parameters. This might cause a temporary loss of temperature control, reflecting processes that prevent liquid helium from collecting in the annulus while the neck is cooled. However, the duration of each precooling process is heavily dependent on the thermal history of the system.[1]

3.3.1.3 POT-FILL MODE TEMPERATURE CONTROL

In pot-fill mode, the system initiates a pot fill at about 4.2 K when it fills the cooling annulus with a controlled amount of liquid helium and manipulates the boiling point of the helium. The liquid helium is drawn through the primary impedance tube, with the impedance heater off. The fill procedure is regulated by the pressure difference between the cooling annulus and the dewar. When the annulus is almost full, which takes about 45 minutes, the impedance heater is turned on, warming the impedance tube until the helium pressure inside the tube prevents liquid helium from entering either end. This state is commonly called "on the pot."

The system can use pot-fill mode to maintain temperatures of about 1.9 K for hours.[2] The liquid-helium bath around the sample space provides a uniform, stable thermal environment. However, it can be difficult to maintain a temperature very close to the boiling point of the liquid helium because the control mechanisms in the high-temperature and pot-fill modes are so different.

When the system is "on the pot," it controls temperature increases and decreases by opening and closing the flow-control valve in the Model 6000 and by using the heaters. For cooling, the

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[1] For example, a rapid change from room temperature to 2 K will cause wild temperature oscillations for some time, while a slow change might require little-to-no precooling.

[2] The length of time is impossible to estimate because it depends on the equipment and the experimental situation, but the minimum will probably be 3–4 hours.

system opens the flow-control valve, which decreases the pressure above the liquid helium, thereby lowering the boiling point of the helium. The temperature of the liquid helium in the annulus drops accordingly. For warming, the system closes the valve slightly, allowing the pressure in the annulus to increase, and subsequently raising the boiling point of the helium. The heaters are used for short time periods to accelerate the warming process.

In the event you reset the temperature from below 4.2 K to above 4.2 K, it will take about 45 minutes to empty the cooling annulus. During this time, the system cannot control temperature in the sample space.

3.3.1.4 SELECTING THE LOW-TEMPERATURE CONTROL MODE

CLTC is the default mode of low-temperature control in the PPMS, but you can use the mode that best meets your experimental needs. Table 3-1 summarizes the general characteristics and advantages of each mode. Low-temperature control modes are changed by using the MultiVu software application or the Mon 6000 utility, as explained in Chapter 4, "System Operation." For more information on MultiVu and the Mon 6000 utility, see the *Physical Property Measurement MultiVu Application User's Manual* and the *Physical Property Measurement System Firmware Manual*, respectively.

Note: Because the two control modes are so different, sometimes you can use pot-fill mode to cool the chamber when CLTC mode is not bringing temperatures below 4.2 K. Rather than stopping the experiment to investigate the cooling problem, you can switch to pot-fill mode and attempt to bring the unit to your target temperature. If the unit cools successfully when you use pot fill, you might be able to complete the experiment before you fix the cooling problem.[3]

Table 3-1. Characteristics of low-temperature control modes

CONTROL METHOD	CHARACTERISTICS	ADVANTAGES	DISADVANTAGES
CTLC	• Begins a precooling phase at about 10 K • Reaches low temperatures without collecting liquid helium around the sample space	• Transitions through 4.2 K helium boiling point smoothly • Attains stable temperatures at (and near) 4.2 K helium boiling point • Increases temperature quickly and smoothly	• Control of temperature might be temporarily lost at beginning of precooling phase, depending on thermal history • Control of temperature is relatively less stable than with pot-fill mode
Pot-fill mode	• Takes over temperature control at about 4.2 K • Fills cooling annulus with liquid helium and manipulates boiling point of helium	• Maintains extremely uniform thermal environment for the sample space • Maintains a very quiet thermal environment for the sample space • Provides best absolute temperature accuracy and stability below 4.2 K helium boiling point	• Loses temperature control when transitioning through 4.2 K helium boiling point • Control of temperature at (and near) 4.2 K helium boiling point is relatively less stable than with CTLC mode

[3] CLTC cooling problems are most often from frozen contaminants blocking one of the impedance tubes. To clear the tube, you must remove the entire PPMS probe from the liquid helium dewar.

3.3.2 Temperature-Approach Modes

You can set the PPMS to approach a temperature set point with the **Fast Settle** mode or the **No-Overshoot** mode. **Fast Settle** mode changes the temperature very rapidly, but it can undesirably affect samples that show temperature hysteresis behavior. In **Fast Settle** mode, the temperature-control hardware first overshoots or under-shoots the temperature set point in order to help overcome thermal gradients in the sample chamber, then the hardware backtracks to the set point. In **No-Overshoot** mode, the PPMS approaches the temperature set point slowly, from only one direction, so it does not overshoot or undershoot the set point. Thermal equilibrium takes considerably longer to achieve in **No-Overshoot** mode.

3.4 Atmospheric Control

The PPMS vacuum and gas lines accommodate thermal control and atmospheric control of the sample chamber. Figure 3-3 illustrates the vacuum and gas lines.

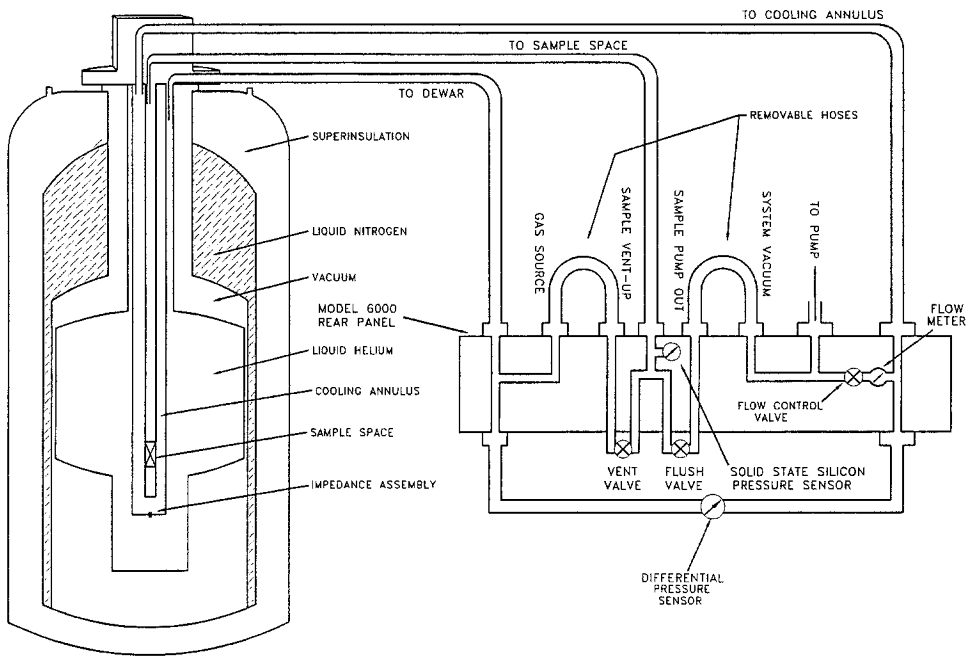


Figure 3-3. Gas and vacuum control in the PPMS

The flow-control valve and the differential pressure sensor are part of the PPMS temperature-control system. The flow-control valve, which is between the pump and cooling annulus, adjusts the rate at which helium vapor is drawn across the sample chamber. The differential pressure sensor, which is between the annulus and dewar, monitors the pressure difference between the annulus and dewar in order to facilitate filling the annulus with helium for low-temperature operation.

All other system plumbing is used for atmospheric control. Under normal operation, the flush valve opens the sample chamber to the pump. The vent valve allows helium gas into the sample chamber during venting and purging procedures. A purging procedure vents the sample chamber with clean gas and pumps it out through the flush valve, and then repeats the same process two more times. When the chamber is sealed, both the vent valve and flush valve are closed. The vent and flush valves are never open at the same time. The system's solid-state silicon pressure sensor is located on the sample space line within the Model 6000, between the vent valve and flush valve, as shown in Figure 3-3.

Gas-Line Configuration

The standard PPMS configuration does not provide a high or ultra-high vacuum environment. It keeps the sample chamber at a few torr with gaseous helium vapor supplied by the dewar. However, the gas lines can be configured in several different ways. For example, you can substitute some other clean gas for the helium that vents the sample chamber and provides the several torr of pressure that maintains thermal uniformity within the sample space. The alternate gas source should be connected to the "Sample Vent-Up" port that is on the rear of the Model 6000. When you use an alternate gas source, you should blank off the "Gas Source" port, which provides helium from the dewar, so that the differential pressure sensor will still work. Additional plumbing and gauges can also be inserted between the pump and flush valve.

If a high or ultra-high vacuum is required in the sample space, you can insert an alternate type of vacuum pump into the system near the probe head, where larger throughputs can be achieved. The efficiency of sample-space temperature control can be adversely affected by changing the pressure of gas within the sample chamber. However, rather than thermal control through heat exchange, some experiments require an adiabatic environment (e.g., heat capacity). Quantum Design offers a High-Vacuum option for the PPMS for precisely such requirements.

3.5 Magnetic-Field Control

WARNING!

The helium level must be ***above*** the superconducting magnet (a helium level of about 60%) to take the magnet to full field. There is high potential for damage, such as an uncontrolled magnet quench, when the superconducting magnet is not completely covered by helium. See Sections 1.4.2 and 4.2.4 for more information.

Figure 3-4 illustrates how the current through the magnet coil is changed to charge or discharge the magnet. The essential process is as follows:

1. The Model 6700 Magnet Controller matches the current in the magnet.
2. A small portion of the superconducting magnet wire (the persistence switch) is heated by another resistive wire.
3. The heated persistence switch becomes non-superconducting, which switches the magnet controller into the previously closed superconducting circuit.
4. The magnet controller drives the magnet to the current that is necessary for the new field.

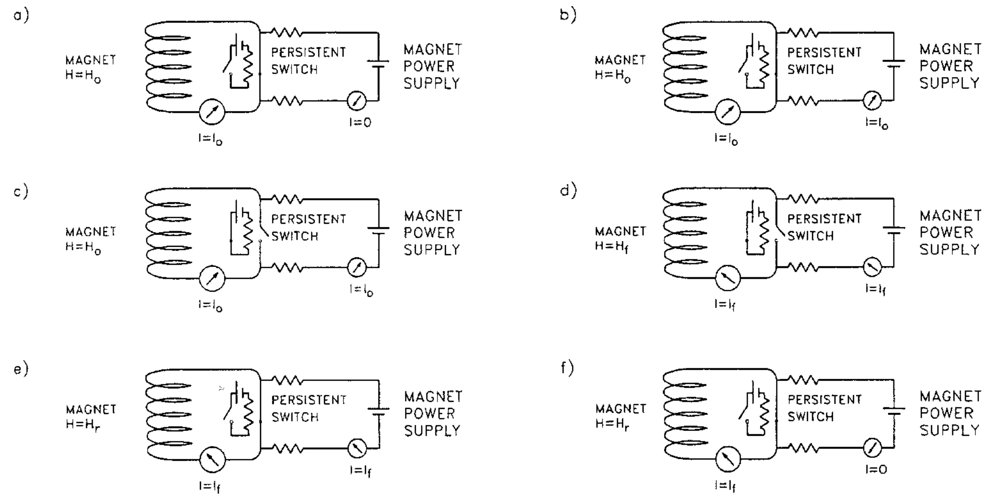


Figure 3-4. Changing the field in the magnet: To change the field in the magnet from H_0 (a) to H_f (f), the magnet power supply first matches the magnet current (b). Then the persistent switch heater is turned on (c), switching the power supply into the circuit. The current is driven to the new value (d) and the persistent switch heater is turned off (e).

The persistence switch heater is generally turned off after the field set point is reached, allowing the entire magnet to superconduct again. The magnet is in **Persistent** mode when the persistence switch is superconducting. In **Persistent** mode, the current in the magnet does not dissipate, so the power supply current can be turned off. The magnet can also be operated in **Driven** mode, which retains the current source in the magnet circuit in order to drive the current. Field changes can be made more quickly in **Driven** mode, but the resulting field is much noisier.

3.5.1 Control Mechanisms

For each PPMS, the field in the sample space is a known function of the current in the magnet. Systems are individually calibrated to their own field-to-current ratio. To ensure that the proper field exists in the magnet during magnet charging and discharging, the current from the power supply is passed through one of two calibrated resistors in the Model 6700 before the persistence switch heater is turned off. The two resistors are for high-power and low-power operation, and the appropriate resistor is used for each current. The voltage drop across the resistor is directly proportional to the current in the magnet and thus proportional to the field within the sample space. The field is calculated from this potential drop and if the field is not within a certain range of the field set point, the magnet current is adjusted accordingly until the field is within the acceptable range. For 7-T and 9-T longitudinal magnets, the field must be within about 1.5 Oe of the set point for set points above about 9500 Oe. For set points below 9500 Oe, the field must be within about 0.15 Oe of the set point before the persistence switch heater is turned off. For 14-T magnets, the field must be within about 3 Oe of the set point for set points above about 15,000 Oe, and the field must be within about .3 Oe of the set point for set points below 15,000 Oe before the persistence switch heater is turned off. The field that is reported is calculated from the drop across the resistor. The temperature coefficient of the calibration resistors in the Model 6700 is nominally 30 ppm/°C, so variations in the temperature of the instrument might have very small effects on the reported field. Notice that the field reported by the PPMS is only that due to the current through the magnet circuit—the reported field value does not account for any background sources or remnant field in the magnet.

After the persistence switch heater is turned off, magnetic field relaxation, or flux creep, can still occur. To minimize this effect, the PPMS offers a specific magnet-charging technique called **Oscillate** mode, which is described in Section 3.5.

3.5.2 Magnetic-Field Approach Modes

The PPMS uses **Oscillate** mode, **No-Overshoot** mode, or **Linear** mode to approach a field set point.

In **Oscillate** mode, the magnet controller allows the magnet to overshoot or undershoot the field set point by about 30%, if possible, and then narrows in on the set point in an oscillatory fashion, under-shooting or overshooting the set point by 30% on each iteration. **Oscillate** mode can undesirably affect samples that show field hysteresis behavior. **Oscillate** mode is best used to help eliminate field relaxation. When charging to zero field, the **Oscillate** mode should be used to keep the remnant field in the magnet as small as possible.

In **No-Overshoot** mode, the magnet is charged to 70% of the difference between the field set point and the present field, and then the magnet slowly approaches the set point, from only one direction, in continuous 70% increments until the magnet is close enough to the set point to drive directly to it without overshooting it. The charging direction is never reversed when **No-Overshoot** mode is used, but field relaxation can occur. That is, after the magnet enters **Persistent** mode, the actual field in the magnet can change slightly from the reported field. You should use **No-Overshoot** mode with field-hysteretic samples.

Linear mode is the quickest charging mode. **Linear** mode fine-tunes the field after an initial attempt at charging the magnet directly to the field set point. Both field overshooting and field relaxation are possible in **Linear** mode.

Important: When you set measurement parameters, do not confuse the **No-Overshoot** temperature-approach mode with the **No-Overshoot** magnet-charging approach mode.

3.6 Helium-Level Metering

The helium-level meter is inside one of the rods running the length of the probe. The meter is thus outside the sample chamber and vacuum tubes. The helium-level meter is a long superconducting wire configured for a four-wire resistance measurement. Because the portion of superconductor that is not immersed in liquid helium is resistive, the resistance of the wire is directly proportional to the amount of liquid helium required to fill the tank. The value that the PPMS reports is a percentage of full. For example, 100% indicates the dewar is full, 75% indicates the dewar is three-quarters full, and so on. The helium-level meter does not extend all the way to the bottom of the dewar, so 0% does not mean the dewar is dry, only that the meter is completely exposed. When the helium-level meter is completely exposed, the impedance tube intake of the probe is not immersed in liquid helium, and temperature control will be lost or inhibited.

Heat is generated by the metering process, so the helium-level meter is usually not on continuously, but the helium level is automatically checked on an hourly basis. You should monitor the helium continuously only during helium transfers. For more information about continuous monitoring, refer to the "Helium Level" section in the *Physical Property Measurement System Commands Manual*.

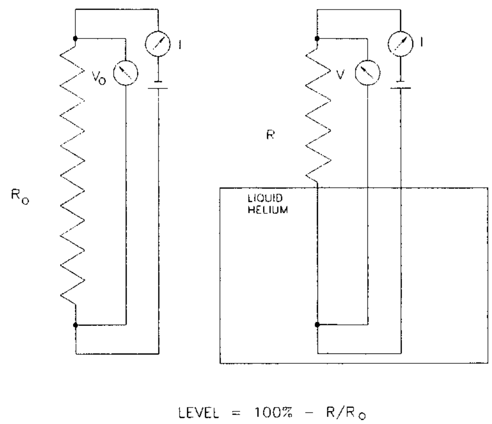


Figure 3-5. Schematic of helium-level meter

3.7 Model 6000 Flexibility

The electrical inputs and outputs on the Model 6000 allow the PPMS to accommodate a wide range of experiments and to be configured to fit many different needs. For example, you can monitor the channels of the user bridge from the Model 6000 analog outputs or front panel or from the personal computer. Appendix A lists all Model 6000 inputs and outputs and explains the uses and capabilities of each port so that you can customize the system.

The voltages of the four Model 6000 analog outputs can be linked to 30 different sources with desired gain settings. These analog outputs allow use of an oscilloscope, chart recorder, or similar instrument. The "Link BNC to Parameter" section in the *Physical Property Measurement System Commands Manual* explains how you configure the analog outputs.

The Model 6000 provides three −24 V auxiliary drives (relays); a low-current, 15 V power source; two different types of digital TTL level inputs; two −10 V to +10 V analog inputs the Model 6000 can digitize; and three optically isolated 5 V external select lines (TTL-level outputs). Model 6000 units that have a user bridge board also have access to two current drivers that provide up to 1 A or 20 W of power—whichever limit is reached first. You can configure each input and output.

The Model 6000 also provides two communication ports (IEEE-488 and RS-232); a motor output that includes connections for a 0/−24 V actuator, index, and limit switch; and a configurable pressure gauge input. Besides electrically configuring the system as necessary, you can also configure the gas and vacuum lines as required, adding gas sources, gauges and pumps (see Section 3.4). The complexity of the system allows several different ways to set up the same experiment.

The automated sequence feature of the PPMS lets you automate the entire measurement process. Any function the Model 6000 can perform, including controlling all PPMS hardware and recording measurement values, can be accessed within a sequence file that runs automatically, so you can perform an experiment without being present. Try exploring this feature. The "Sequence Files" section in the *Physical Property Measurement System Commands Manual* discusses measurement automation in detail. The *Physical Property Measurement System: PPMS MultiVu Application User's Manual* discusses how to use PPMS MultiVu sequence files and sequence commands.

If the Model 6000 does not have the specifications necessary for your experiment, you can still measure a sample in the PPMS by using your own instruments. Appendix A lists the pinouts for the sample puck, probe head Lemo connectors, and Model 6000 "D" connector so that you can make the necessary electrical connections. You can attach a current source and voltmeter to the sample to perform four-wire resistivity measurements. By attaching the sample leads to the sample in a slightly different configuration, you can make Hall coefficient measurements. You can use other instruments to measure other sample characteristics. You can even interface GPIB-capable instruments with the Model 6000 and a PC in order to facilitate automated data collection from *other* instruments. With some planning, you can set up the PPMS to automatically perform all types of different experiments. If you have questions about how to customize the PPMS to fit your specific application, contact a Quantum Design representative. Quantum Design offers a variety of options designed specifically to help meet the needs of your experiments.

3.8 Example Measurement

The PPMS can be configured for four-terminal resistance, Hall effect, magneto-resistance, critical current, critical field, critical temperature, DC magnetization, AC susceptibility, heat capacity, and thermal conductivity measurements—to name some of its more common uses. Quantum Design is continually developing PPMS options that standardize frequently made measurements, making them easier to perform and more accurate. You use each option in conjunction with the PPMS in a different manner.

One of the most common measurements made with the PPMS is resistivity. Quantum Design offers more than one resistivity option for the PPMS. This section describes a resistance measurement to illustrate how you can use the PPMS.

To perform four-terminal resistance measurements, you mount a sample on a puck and attach four leads to the sample. An example is shown in Figure 3-6; you can use other geometrical arrangements of the leads.

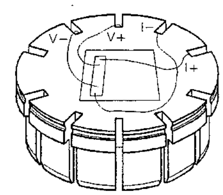


Figure 3-6. Leads attached for four-terminal resistance measurement

Solder each lead to an appropriate solder pad on the base of the puck. This allows the hardware to make electrical contact with the sample. In the Model P400 Resistivity option, the hardware that makes electrical contact with the sample is the user bridge board in the Model 6000, and the solder pads you use are #3, #4, #5, and #6 (see Appendix A). To perform simultaneous measurements on another sample, the other sample would be mounted to the same puck and its leads would be soldered to pads #7, #8, #9, and #10. Take care that you electrically isolate each sample and each sample lead. The puck is conductive, so the leads must be insulated and samples must be mounted with an electric, but not thermal, insulator underneath them. Most PPMS options also allow you to use special pucks that have labeled solder pads prewired to the surface of the puck for easier sample mounting. Some options, such as the ACMS option or the Horizontal or Vertical Rotator option, use different sample holders.

You will insert the puck into the sample chamber by using the procedures explained in Section 4.5. During the measurement the hardware will pass a current through the sample via two leads, using the other two leads to measure the electric potential drop across the sample. Because the input impedance of the voltmeter is very high, both the current and the potential drop can be known to a high degree of accuracy. Ohm's law gives the resistance. The user bridge board operates in several different modes to accommodate a variety of requirements and still allow a high degree of measurement sensitivity. The resistance that the bridge board measures is reported in the **Status–Bridge** screen on the front panel of the Model 6000.

To perform different types of measurements, different hardware is used, but the basic premise of the system remains the same. The sample sits within the thermally, magnetically controlled environment of the sample space while electrical wiring to the base of the chamber allows connection to current sources, voltmeters, ammeters, and the like. The Model 6000 frequently contains all such necessary equipment.

You can manipulate various measurement parameters, including the measured resistance, applied current, sample temperature, applied magnetic field, time, select line status, and so on. These values can be placed into a data buffer in the Model 6000, linked to one of the Model 6000 analog outputs, or uploaded into a data file on a personal computer. The PPMS software can graph the data file as the data is recorded. You can export data files to another format in order to use them with data manipulation applications, such as spreadsheets or professional graphing programs. If you are using the PPMS as a temperature and field control platform, you can measure sample resistance as a function of temperature and magnetic field. Entire resistance curves can be plotted and the critical temperature can be determined for superconducting samples.

For the example given above, you could set the PPMS to measure the sample resistance at 20 different temperatures and then increase the applied magnetic field by 0.25 T and repeat the resistance measurements at all 20 temperatures. This type of measurement can be facilitated by using sequences.

When you use a sequence file, the PPMS becomes fully automated. It can automatically perform temperature changes, field changes, applied current changes, and resistance measurements. It can automatically control all PPMS hardware and thus place the system in **Shutdown** mode when the experiment is complete. The Model 6000 can control numerous other operations. Refer to the *Physical Property Measurement System Commands Manual* and the *Physical Property Measurement System: PPMS MultiVu Application User's Manual* for further information regarding sequence commands. The main point of illustration here is that the above resistance experiment can be performed entirely automatically. You can automate other experiments in a similar manner.

3.9 Experimental Considerations

Although the PPMS is extremely flexible, you must consider certain limitations when you design an experiment. One of the first constraints to consider is the size of the sample. The diameter of the sample puck is 2.3 cm, with a set of notches around its perimeter in which the electrical leads seat. The maximum sample height is 5.0 cm. While the superconducting PPMS magnets have a high field homogeneity, the uniformity of the field over the sample is greater for small samples. Similarly, although the PPMS provides very precise temperature control, the effect of thermal gradients on the sample is less for small samples. Recall that temperature control in the PPMS is usually based on the temperature of the sample puck. Settling times, before the sample is at the same temperature as the puck, also could be longer for large samples

The PPMS is ideally suited for measurements of bulk solid samples and thin film samples. Powdered, aqueous, and liquid samples can be accommodated with a variety of techniques, but you should use caution with such techniques, because the PPMS is very difficult to clean in the event such a sample is lost within it. The use of sealed sample holders requires additional caution, because they tend to burst when the sample chamber is evacuated. Before introducing a sealed sample holder into the PPMS, you should verify that it will not break when it is subjected to an external pressure of only a few torr, as it will be inside the PPMS sample chamber.

When you mount a sample, it is important to secure it with a method that will withstand the experimental extremes. Be sure to determine the thermal, magnetic, and conductive properties of the bonding media before using it in an important experiment. The temperature range of the PPMS is 1.9–400 K. The magnetic field available depends on the magnet that is purchased with the system. Other properties of the bonding media and of any electrical leads could also be important. For example, with thin film samples, the leads and bonding media must not chemically react with the sample.

The sample puck is conductive, so when you use it as a mounting technique, verify that the electrical leads are isolated and individually insulated. When using the sample puck you also need to consider how the sample might interact with it—often, samples must not be in electrical contact with the puck. Note that thermal contact with the puck is still desired in the latter cases. You can use a substance such as sapphire to electrically isolate resistive samples from the puck and still allow good thermal contact. A thin layer of Kapton tape serves as a less expensive substitute. For experiments that use other sample holders, you should consider the relevant properties of the sample holder. For example, for DC magnetization measurements, you can use a clear plastic drinking straw as a sample holder because the straw fits within the sample chamber, is easy to use with option hardware, is not conductive, and has very low magnetic susceptibility.

CHAPTER 4

System Operation

4.1 Introduction

This chapter contains the following information:

- Section 4.2 presents general guidelines for using the PPMS.
- Section 4.3 describes how to change the low-temperature control mode (pot fill or CLTC).
- Section 4.4 discusses sample-mounting procedures.
- Section 4.5 explains how to install a puck into the sample chamber and how to remove it.
- Section 4.6 describes some of the ways the PPMS can be customized.
- Section 4.7 describes routine maintenance procedures such as refilling a cold dewar and checking the oil in the vacuum pump.

4.2 General Guidelines

The PPMS is a precision laboratory instrument that is designed to be robust and adaptable. However, it is complex, and some parts are fragile. This section provides guidelines for the appropriate use and maintenance of the system and its critical components. You can help prevent damage to the system and ensure that it provides optimal measurements by reviewing this material and following the guidelines.

4.2.1 Handling the Probe

WARNING!

Always remove the probe from the dewar very slowly—raise it about one inch per minute. The probe could explode violently if you rapidly pull it from the dewar when there is a leak in the vacuum space.

Handle the probe with care; it is an intricate, delicate, and expensive piece of equipment. Always use the plate just below the probe head (Figure 2-4) to support the probe. The long tubes that run between the probe head and the magnet end of the probe are part of the equipment—they are *not* structural supports, they *cannot* support the full weight of the probe, and they are easily damaged. Always provide support at both the magnet end and the probe head when you lay the probe in a horizontal position.

It is important to work slowly and carefully when you lower a probe into (or lift a probe out of) a full or partially full dewar. To facilitate this process, Quantum Design includes a probe-lifting assembly with the system (see Section 4.7.4). By gradually lowering the probe into the dewar, you decrease the unnecessary helium boil-off caused by a warm probe. It also can avoid serious damage to the equipment that could occur if a part of the probe froze or boiled because of unexpected circumstances, such as a leak. In addition, you can watch for unusual behavior, such as condensation or gas escaping from relief valves, when you slowly move a probe in and out of liquid helium.

Keep the original packing crate and padding for the probe so that you can use it in the event you ship the probe back to Quantum Design for modification, option installation, or repair.

4.2.2 Powering the System Off and On

Generally, the power to the PPMS hardware should be left on—including the power to the Model 6000, Model 6700, and vacuum pump—to maintain system safeguards, as explained in Section 4.2.2.1. In the event you must turn off the power to the system or any component, use the sequence in Section 4.2.2.2. Turn on the system or component as soon as possible, using the sequence in Section 4.2.2.3.

Important: *Before you turn off the power to the Model 6000, verify that the system is in* ***Shutdown*** *mode with the magnet in* ***Persistent*** *mode and the* ***Field*** *at zero (0) Oe. Also, leave the magnet leads and blue Lemo attached to the system.*

If there is an ***unplanned*** power outage, we recommend that you turn off the power to all components and the main system breaker, in that sequence, then pull the power plug from the wall. Leave the magnet leads and blue Lemo attached to the system. When the power returns, turn on the system by using the sequence in Section 4.2.2.3.

You do not need to turn off the system if it will be idle, but you can conserve helium by putting it in **Shutdown** (standby) mode (Section 4.2.3).

Important: Shutdown mode *does not* turn off the system, it reduces the use of helium while allowing the Model 6000 to monitor the status of the system.

4.2.2.1 POWER LOSS

During a power loss or when you power off the system, leave the magnet leads connected—the leads will allow any current in the magnet to safely drain away. Also, leave the blue Lemo connected to the system.

Important: ***Do not*** disconnect the blue Lemo or the magnet leads while the power is off.

When the power to the Model 6000 is cycled off and back on, the Model 6000 retains certain parameters, including all information stored in the sequence file and data buffer, the field in the magnet, and most of the user-configuration parameters. To support the nonvolatile RAM, the Model 6000 has a lithium battery that lasts about 10 years.

When there is a power loss, the software will automatically place the PPMS in **Shutdown** (standby) mode, but the PPMS will lose the settings for any measurements (e.g., temperature, field) that are in process at the time of the outage. Further, the system will stop sending output to any motor. Other types of information that will not be retained or restored include commands that are being executed when the power is lost as well as any direct output from the Model 6000, such as analog outputs, which return to 0 V. If a power outage occurs when you are using a sequence to perform measurements, the sequence will stop running. When the power comes back on, you will need to reset the measurement parameters and restart the measurement.

When the power to one or more components is turned off, the system cannot effectively monitor its own status. For example, the Model 6000 assumes that all other components are present and functioning, even if a component has been powered off. If you turn off the power to the Model 6000 for several hours while the flow-control valve is open, the pump will stay on, filling the cooling annulus with liquid helium. As a result, the system will require an unusually long time to warm to above 4.2 K when you turn on the Model 6000. We recommend that you use the sequence below to turn off the PPMS, and that you always place the PPMS in **Shutdown** mode before you turn it off—these procedures will help bring the system to a stable, helium-conserving state.

4.2.2.2 POWER OFF SEQUENCE

1. If the magnetic field is not in **Persistent** mode and at zero (0) Oe, reset it according to the sequence below:
   a. Select **Instrument** >> **Field** (Figure 4-1).
   b. In the **Field** dialog box, set the **Mode** to **Persistent** and the **Set Point** to zero (0) Oe.
   c. Click on the **Set** button.
   d. Leave the dialog box open so that you can monitor the field until it is within 1000 Oe of zero (do not continue until the field is within 1000 Oe of zero).
   e. In the **Field** dialog box, click on the **Close** button.

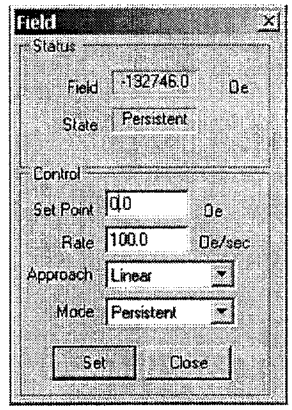


Figure 4-1. PPMS Field dialog

2. Bring the system to a stable state by putting it in **Shutdown** mode:
   - To use the Model 6000, select **CTRL** >> **Interactive Control** >> **8. Shutdown Mode.**
   - To use MultiVu, select **Instrument** >> **Shutdown** from the dropdown menus at the top of the MultiVu window.
3. Deactivate any active option (**Utilities** >> **Activate Option**).
4. Exit the MultiVu program and turn off the power to the computer.
5. Disconnect the annulus line (the large pumping line) at the probe head. Open the annulus connection enough to stop the flow, but leave it seated in the connector.
6. Turn off the power to the individual PPMS components, including the vacuum pump.
7. Turn off the main breaker on the back of the PPMS cabinet.
8. Unplug the PPMS plug from the power source.

4.2.2.3 POWER ON SEQUENCE

1. Plug in the PPMS power cord.
2. Turn on the main breaker on the back of the PPMS cabinet.
3. Turn on the power to the computer.
4. Turn on the power to the individual PPMS components, including the vacuum pump.
5. Start MultiVu.
6. Set the temperature to 5 K (**Instrument** >> **Temperature**). When you set the temperature to 5 K, the equipment automatically opens the valves and starts pumping out the lines.
7. Wait five minutes for the system to stabilize.
8. Reconnect the annulus line at the probe head.
9. Set a new temperature.
10. Activate an option.

4.2.3 Shutdown Mode

Shutdown (also known as standby) mode *does not* turn off the system, but it does help conserve helium resources while allowing the Model 6000 to monitor the status of the system. Place the PPMS in **Shutdown** mode whenever it will be idle and you want to conserve helium.

When the temperature-control hardware is in **Shutdown** mode, the software adjusts the flow-control valve to maintain approximately 100 cc/min. of flow through the cooling annulus, turns off the system heaters, and lowers the power to the impedance heater. Note that with these adjustments, the PPMS does not remain at a steady temperature.

Important: The magnet must be in **Persistent** mode and the **Field** must be at zero (0) Oe *before* you place the system in **Shutdown** mode (see Step 1 in Section 4.2.2.2).

When you initiate the **Shutdown** mode, the software automatically places temperature control in standby mode and seals the sample chamber. These settings will be displayed in the front panel of the Model 6000 and in the **Status** bar at the bottom of the MultiVu window.

- To put the system in **Shutdown** mode using the Model 6000, select **CTRL** >> **Interactive Control** >> **8. Shutdown Mode**.
- To put the system in **Shutdown** mode using MultiVu, select **Instrument** >> **Shutdown** from the dropdown menus at the top of the MultiVu window.

To end **Shutdown** mode, set a new temperature (in MultiVu, select **Instrument** >> **Temperature**).

4.2.4 Monitoring the Helium Level

The helium level in the dewar must be regularly monitored, especially if you are using magnets—***the helium level must be above about 60%*** to charge magnets to high fields. If you do not have or are not using a magnet, you can let the helium level drop to approximately 30% before refilling the dewar, as explained below. Section 4.7.2.2 has instructions for refilling a cold PPMS dewar with liquid helium.

In many cases, you can safely transfer helium into the PPMS dewar while a sequence is running. ***Do not*** add helium to the dewar if you are ramping the magnet or if the temperature is below 5 K.

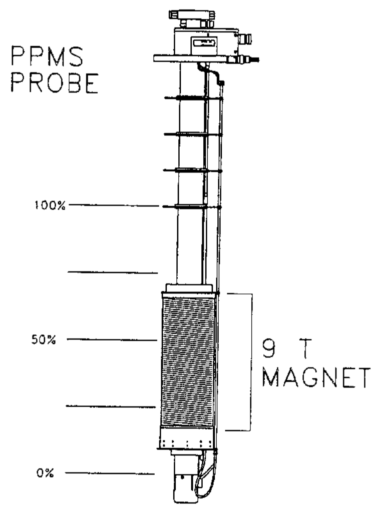


Figure 4-2. Helium levels relative to probe and 9-T magnet

4.2.4.1 HELIUM LEVELS: USING A MAGNET

The PPMS is not like a car—although you can drive a car until the fuel gauge reads nearly empty, the PPMS could be seriously damaged if you operate the magnet when it is not immersed in liquid helium: When a charged superconducting magnet is not completely immersed in liquid helium, there could be an uncontrolled magnet quench, warming the magnet so that it loses its superconducting properties and gives off large amounts of energy in the form of resistive heat.

Figure 4-2 shows approximate helium levels relative to a 9-T PPMS magnet (the exact location of the top of the magnet varies from magnet to magnet). ***To ensure that the magnet remains immersed, you should perform a helium transfer whenever the helium-level meter reads below about 60%.*** As explained in the next section, the helium level does not change at a consistent rate. In the event you plan to let the helium level drop below 60%, verify that the magnet does not have a persistent field.

WARNING!

Keep the helium level ***above*** the superconducting magnet (a helium level of 60%). There is high potential for damage, such as an uncontrolled magnet quench, when the superconducting magnet is not completely covered by helium. See Sections 1.4.2 and 3.5 for further information.

4.2.4.2 HELIUM LEVELS: NOT USING A MAGNET

When you are not using a magnet during measurements, we recommend that you begin carefully monitoring the helium level when it reaches 30%. Maintaining the helium level at 30% or above will help prevent serious temperature-control problems (see below). Although typical static helium boil-off rates are usually less than 5–7 liters per day, the actual rate of PPMS helium consumption varies, depending on ambient conditions and how the system is being used. For example, when the helium level reaches 30%, it begins decreasing faster than when it is above 30%—the shape of the dewar interior and the nature of the helium-level meter mean that the absolute boil-off rate does not translate into a constant percentage drop in the helium-level meter. Levels appear to drop faster when the dewar is full or almost empty because the helium container is narrower at the top and bottom.

Carefully consider helium-consumption rates before you start a long experiment, especially when the PPMS will be running an unsupervised automated sequence. If you are not using a magnet during measurements, you can maintain temperature control with helium levels as low as 12%. Below about 12%, the helium bath no longer covers the impedance tube and the system quickly loses the ability to control temperature. Further, contaminants can enter the impedance and create a blockage, which will cause additional problems. Because changes are so unpredictable by the time the helium level reaches 12%, it is difficult to accurately monitor low helium levels. For these reasons, we recommend maintaining the helium level around 30% at all times, except for prolonged idle periods.

4.2.5 Monitoring the Nitrogen Level

The nitrogen in nitrogen-jacketed dewars serves a less crucial purpose than the helium, so it could boil away almost completely without any repercussions other than more rapid consumption of helium. However, to keep the helium well insulated, you should fill nitrogen jackets about twice a week. Section 4.7.2.1 explains how to transfer liquid nitrogen into a cold PPMS dewar.

To determine if nitrogen remains in the jacket, look for ice on one of the pressure-relief valves. You can check the nitrogen level by dipping a clean, frosted, metal rod into the jacket through one of the nitrogen fill ports. To frost the rod, dip it in liquid nitrogen, then expose it to room-temperature air.

4.3 Setting the Low-Temperature Control Mode

The Quantum Design PPMS offers two unique modes for controlling low temperatures in the sample chamber: Continuous Low-Temperature Control (CLTC) and pot-fill (these modes are explained in Chapter 3). Since January 1998, the PPMS has included both modes, with CLTC shipped as the default. Earlier model PPMS systems included only the pot-fill mode, but owners of such systems can purchase the CLTC option.

If your PPMS has the capability for both low-temperature control modes, you can change from CLTC to pot-fill mode (or vice versa) by using the MultiVu **Utilities** dropdown menu or the Mon6000 utility, which is often located in `C:\QDPPMS\Tools`. Here we include instructions for using both utilities. To determine if you have the CLTC option, follow the MultiVu instructions in Section 4.3.1.1 through Step 3.

4.3.1 MultiVu

As explained below, you will first verify the low-temperature control mode that is currently active, then you will issue the command to switch to the other mode.

4.3.1.1 VERIFY OPTION AND CONTROL MODE

In MultiVu, you will use the **Send GPIB Commands** dialog to verify the mode that is being used.

1. Select **Utilities** >> **Send GPIB Commands** from the MultiVu dropdown menus (Figure 4-3).

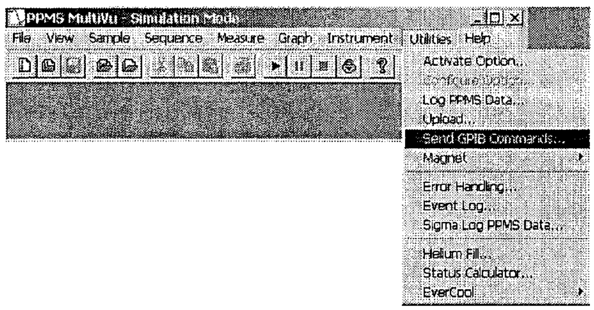


Figure 4-3. Opening the Send GPIB Command utility in MultiVu

2. The **Send GPIB Commands** dialog will open, as shown in Figure 4-4.

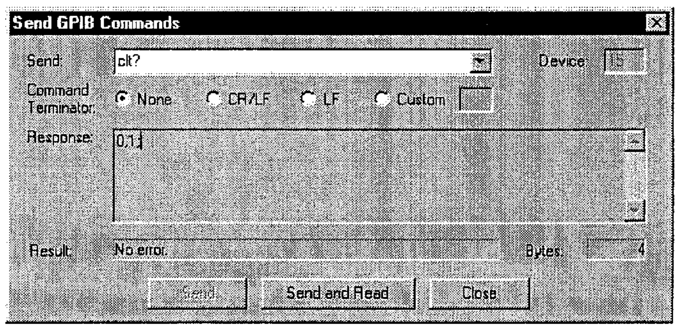


Figure 4-4. Using the Send GPIB Command dialog to verify control mode

In the **Send GPIB Commands** dialog, note the **Send**: text box at the top of the dialog, the **Response**: area in the middle of the dialog, and the **Send and Read** button at the bottom of the dialog. You will use these sections to verify the temperature-control mode.

3. In the text box next to **Send:** type the following: `clt?` (just as is shown in Figure 4-4). Then, click on the **Send and Read** button. In the **Response:** area, the utility will report two numbers (e.g., "**0,1**" as shown in Figure 4-4).

   The first number indicates the active temperature-control mode and the second indicates if the CLTC option has been installed. For example, the first number in Figure 4-4 is "**0,**" indicating that the system is using pot-fill mode, and the second number is "**1,**" indicating that the CLTC option has been installed. A "**0,0**" report would indicate that pot-mode is being used but there is no CLTC option, and a "**1,1**" report would indicate that low temperatures are being controlled by the CLTC option. The status codes are summarized in Table 4-1.

Table 4-1. Status codes for temperature-control modes

STATUS CODE	TEMPERATURE-CONTROL MODE	CLTC INSTALLED
0,0	Pot fill	No
0,1	Pot fill	Yes
1,1	CLTC	Yes

4.3.1.2 CHANGE LOW-TEMPERATURE CONTROL MODE

To use MultiVu to change the low-temperature control mode, you will issue a command to shut down the PPMS, along with a number specific to the control mode that you want to be activated. The shutdown commands are summarized in Table 4-2.

The example below uses the commands that activate CLTC.

1. In the **Send:** text box type the following:

   `shutdown 2`

   (just as is shown in Figure 4-5).

2. Click on the **Send and Read** button.

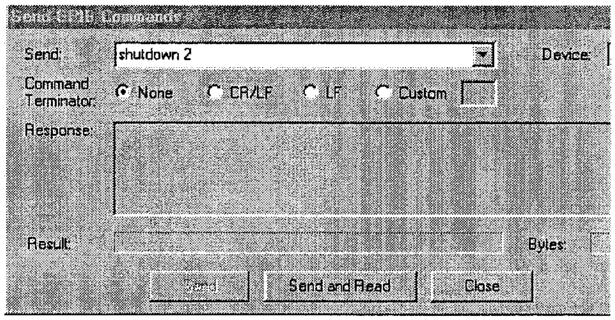


Figure 4-5. Switching from pot-fill mode to CLTC

3. To verify which temperature mode the system has activated, type `clt?` and click on the **Send and Read** button again (Figure 4-6).

4. If the system has switched to CLTC, the **Response** area should now display "**1,1**" (Figure 4-6).

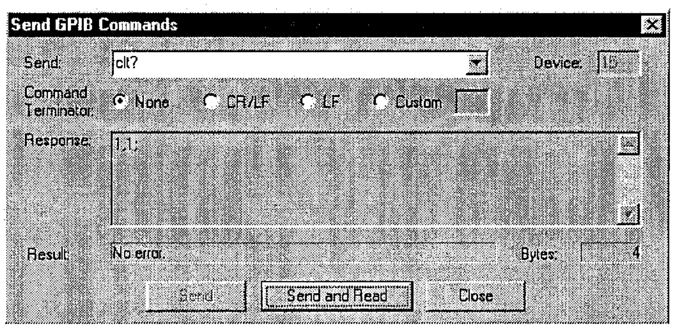


Figure 4-6. Verifying that CLTC is the low-temperature control mode

Table 4-2. Commands to shut down the PPMS and set the temperature-control modes

COMMAND	ACTION
shutdown 0	Shut down the PPMS but do not change the temperature-control mode.
shutdown 1	Shut down the PPMS and set the temperature-control mode to pot fill.
shutdown 2	Shut down the PPMS and set the temperature-control mode to CLTC.

4.3.2 Mon6000

The **Mon6000** dialog is set up somewhat differently than the **Send GPIB Commands** dialog in MultiVu, but you will use the same commands that you use with MultiVu (Table 4-1) to verify or change the low-temperature control mode. Note that you need to press the **<Enter>** key after you enter each command into the **Mon6000** dialog.

1. Open the **Mon6000** dialog:
   a. Locate the `Tools` subdirectory of the `QDPPMS` directory (the `QDPPMS` directory might be on your `C:` drive).
   b. Locate the file named `Mon6000.exe` and double click on it to open it.
2. When the Mon6000 dialog opens (Figure 4-7), you will see separate text-entry panels titled "**Command To Send**" and "**Response Received.**"

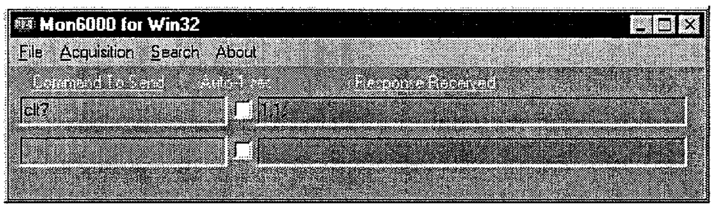


Figure 4-7. Checking the low-temperature control mode using the Mon6000 dialog

3. Enter your temperature-mode verification command (i.e., `clt?`) into the **Command To Send** panel and press the **<Enter>** key.

   As shown in Figure 4-7, the **Response Received** panel will then display the active low-temperature regime. You can see that the CLTC option is installed and it is being used, because the **Response Received** panel displays "**1,1**" just as it would in MultiVu.
4. To shut down the PPMS and activate pot-fill mode, enter the shutdown command (`shutdown 1`), as is shown in Figure 4-8, and press the **<Enter>** key.

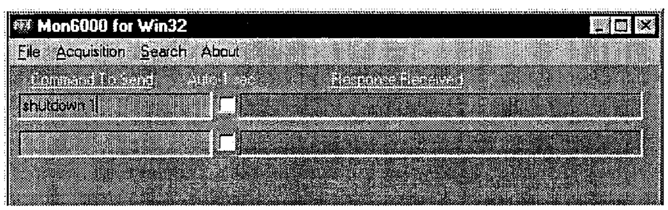


Figure 4-8. Switching low-temperature control modes using the Mon6000 dialog

5. You can verify that you have changed to pot-fill mode by typing "`clt?`" again in the **Command to Send** panel.

   The **Response Received** panel should display "**0,1**" if the system has changed to pot-fill mode successfully.

6. To activate CLTC, type `shutdown 2` in the **Command to Send** panel.

4.4 Sample Mounting

Several broad considerations affect the sample-mounting technique you will use, no matter what type of sample holder you choose, including a sample puck and a plastic straw. These considerations are the temperature range of the experiment and the electrical and magnetic properties of the elements in the mounting arrangement.

4.4.1 Guidelines for Mounting Samples

The sample-mounting method that you use must withstand the temperature range of the experiment. Not all glues and tapes stick well at low temperatures. Furthermore, differential thermal expansion between elements of your arrangement could prevent it from functioning as you intended.

The sample puck is conductive, so electrical leads will be shorted together if they contact the puck anywhere other than at the solder pads. Often, samples must be electrically isolated from the puck so that the only electrical path is through the sample. Other sample holders, such as the PPMS rotators, are made from dielectric material and do not short the signals when a sample contacts them directly. If the PPMS will be used as a magnetometer, knowing the magnetic moment of the sample holder is also important. To determine its effect on the sample measurement, measure the magnetic moment of the sample holder without a sample.

In general, samples must be securely mounted to the sample holder so that their position will remain constant (or known, in some cases). Secure mounting also is important to help prevent losing samples inside the sample chamber—it usually requires great effort to retrieve lost samples and to clean the chamber.

4.4.2 Mounting a Sample on a Sample Puck

There are many methods to secure a sample to a puck. Leads are frequently soldered or welded to samples, but the type of wires used and the method of contact vary by application. In addition, tapes, conductive epoxies, greases, glues, and paints can be used. Conductive pads can be coated onto semiconducting, thin film samples. Each method can have an array of thermal, electrical, magnetic, and reactive properties.

If you will be using a puck as the sample holder, first consult Appendix A or the appropriate option manual to determine the proper solder pads to use for electrical contact. Also, plan the geometrical arrangement of the leads.

It will be easier to solder leads to the solder pads if you remove the connector PC board from the bottom of the puck. To do so, remove the screw from the bottom of the puck. The base of the puck is slotted so that the two components fit together properly when reattached.

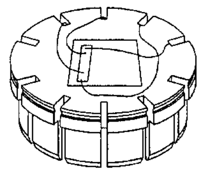


Figure 4-9. Sample mounted on puck

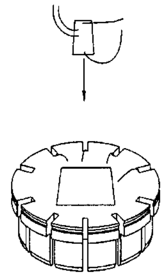


Figure 4-10. Intermediate sample leads

Verify that the leads all pass through the notches on the edge of the puck, as shown in Figure 4-9. Note that if the leads extend past the outer rim of the puck, it will be easy to damage them with the puck-insertion tool during puck insertion. Also, you should use insulated electrical leads because the puck is conductive.

In some cases it can prove useful to create an intermediate set of leads that contact the solder pads but stop short of the sample, as illustrated in Figure 4-10. You can then treat the sample and another set of leads—for example, in an oven or coating chamber—while isolating the puck from the treatment. When you have completed preparation of the sample and leads, you can secure them to the puck and attach the sample leads to the intermediate leads.

To prevent electrical signals from being shorted, you must separate the sample and the conductive puck by a substance that has high resistivity compared to the sample. In many cases, this substance can be a piece of tape. Take the phase characteristics of the insulating material into consideration, because the material will not perform correctly if it conducts or superconducts in the temperature range for your experiment. The thermal conductivity of an insulator also might be important, depending on the nature of the experiment.

It is often important that the sample and puck are in good thermal contact, which ensures that the temperature of the system thermometer accurately represents the temperature of the sample. If the sample is in poor thermal contact with the puck, heat conduction will occur through the leads and through helium gas, which is significantly slower than through the puck.

The surface of the puck can be machined to the desired geometric characteristics. To do this, you first remove the screw from the bottom of the puck and take off the connector PC board so that it will not be damaged during machine work. Work carefully so that you do not alter the edge of the puck, where the key and the groove for the puck-insertion tool are located. Also, you can remove the connector PC board from the bottom of the puck before you perform other puck treatments, such as heat treatment.

If you want to verify proper electrical connection of the sample before you insert the puck into the sample chamber, you can use a digital voltmeter or similar instrument after you have mounted the sample. Using Figure 4-11 as an example, gently contact the gold-plated receptacles on the bottom of the puck with the meter probes.

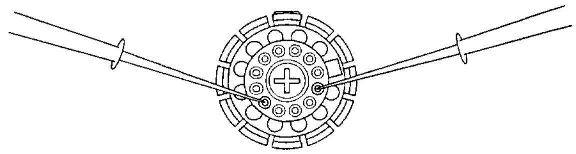


Figure 4-11. Checking for proper electrical connection of the sample

You can use this technique to check for undesired shorts, poor connections, and so on, or you can insert the puck into a P150 sample-wiring test station[1] and use the numbered banana jacks for the same purpose. Notice that the puck plugs into a plastic ring in the test station, so any shorts to ground can only be measured by directly contacting the puck itself. However, when the puck is plugged into the sample chamber, it contacts metal and is truly grounded. To ensure the validity of your data, verify that there are no shorts to the surface of the puck.

4.5 Sample Puck Installation and Removal

4.5.1 Installing a Sample Puck

After you have mounted the sample on the puck and soldered the leads to the appropriate solder pads, you can insert the puck into the sample chamber by using the instructions below.

1. Disengage the puck-insertion (puck-extraction) tool[2] by flipping up the black switch located on top of the tool or by fully depressing the switch, as shown in Figure 4-12.

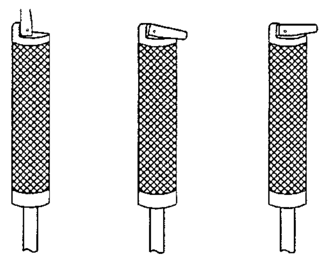


Figure 4-12. Handle of puck-insertion (puck-extraction) tool, disengaged and engaged

2. Insert the puck, with the sample facing upward, into the hollow cylinder at the bottom of the puck-insertion tool. The sample will be inside the cylinder and the connectors and solder pads will be outside the cylinder (see Figure 4-13).
3. Rotate the puck to verify that it is properly seated inside the hollow cylinder of the puck-insertion tool. The puck should rotate smoothly.

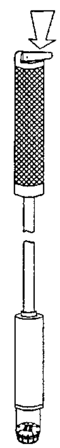


Figure 4-13. Inserting the puck into the cylinder of puck-insertion tool

[1] The P150 sample-wiring test station is also referred to as the puck-wiring test station.
[2] The name of this tool varies by context—it might be called the puck-insertion tool, the puck-extraction tool, or the sample-holder tool.

4. Engage the puck-insertion tool by flipping down the black switch located on top of the tool or by releasing the switch, if it is fully depressed, so that the switch lies flat across the handle (see Figure 4-13). The tool should now be gripping the outer rim of the puck.
5. Verify that the puck remains properly seated in the hollow cylinder of the puck-insertion tool. The puck must be level and it must not rotate—otherwise it could come loose in the sample chamber or bend the pins at the bottom of the sample chamber. If the puck lodges in the sample chamber, you might have to disassemble the probe to remove it.

CAUTION!

The puck-insertion tool (and puck) will be inserted into the sample chamber. Verify that the puck is level within the cylinder of the puck-insertion tool and firmly attached to the tool so that it cannot fall into the sample chamber. Also, hold the tool so that the bottom is level when you insert it into the sample chamber. If the puck lodges in the sample chamber, you might have to disassemble the probe to remove it.

6. Verify that the temperature of the sample chamber is at or above 298 K. The temperature *must* be at least 298 K when the chamber is opened to the atmosphere to prevent cryopumping air into the chamber. If the temperature of the chamber is below 298 K, set it to 298 K and wait until it reaches room temperature.

   You can set the temperature by using the **CTRL >> 3. Immediate Operations >> 1. Temp** menu in the Model 6000, by using the shortcut in the MultiVu **Status** bar, or by using MultiVu.

CAUTION!

Always bring the sample chamber to room temperature before you open it to the atmosphere. This will prevent condensation and cryopumping of air constituents inside the chamber, which can cause probe malfunctions such as blocked valves and loss of temperature control.

7. Verify that the field in the magnet is less than 1 tesla. If the field is greater than that, set the field to less than 1 tesla and wait for the magnet to reach the set point (select **Instrument >> Field** to open the MultiVu **Field** dialog box).

CAUTION!

Do not place the puck-insertion tool (or any other object) into the sample chamber when there are high fields in the magnet, as the force on the insertion tool could overwhelm you and cause you to damage the equipment.

8. Vent the sample chamber with clean, dry gas. Venting helps keep the sample chamber free of contaminants from the air.

   To vent the chamber, you can use the Model 6000 menu (**CTRL >> 1. Interactive Control >> 5. Vent Continuous**), or you can use the PPMS MultiVu application software (**Instrument >> Chamber >> Vent Cont.**).

9. Open the hinge clamp and remove the KF blank flange from the sample-chamber access port (see Figure 2-5). If the blank flange is difficult to move because the internal pressure is low, *do not force it.* Allow the pressure within the chamber to match the external pressure before you open the sample chamber to atmosphere.
10. Remove the O-ring from the sample-chamber access port.
11. Gently lower the puck-insertion tool into the sample chamber with the puck-end first. Stop when the sample puck touches the puck connectors at the bottom of the chamber. *Do not* force the puck down farther after it touches the connectors.
12. Slowly rotate the puck-insertion tool until the key on the puck drops into the indexing notch. When the puck drops into the notch, you will feel it lock into position.
13. Gently push down on the puck-insertion tool in order to engage the puck interface and to make solid electrical contact between the interface and the puck.
14. Disengage the puck-insertion tool and then raise the tool several centimeters. Be alert for resistance when you raise the insertion tool. Resistance can indicate that the puck has caught in the tool as you began lifting it out, so you will need to remove the puck and again try to insert it.
15. Remove the puck-insertion tool from the sample chamber.
16. Place the O-ring over the sample-chamber access port and place the KF blank flange on it.
17. Place the flange clamp in position around the top of the sample-chamber access port and then latch the clamp.
18. Purge and seal the sample chamber. To purge and seal the chamber, you can use the Model 6000 menu (**CTRL >> 1. Interactive Control >> 2. Purge and Seal**) or MultiVu (**Instrument >> Chamber >> Purge/Seal**).

The system is now prepared for you to conduct experiments. To determine your next steps, refer to the appropriate option manual. After you have performed a measurement and verified the operations of the instrument, you might find it useful to write a sequence that automates the measurement, as explained in the *Physical Property Measurement System Commands Manual* and the *Physical Property Measurement System: PPMS MultiVu Application User's Manual.*

4.5.2 Removing a Sample Puck

The procedures for removing the puck from the sample chamber are essentially the reverse of the installation procedure.

1. Verify that the sample chamber is at or above 298 K. The temperature must be at least 298 K to prevent cryopumping of air into the chamber. If the temperature is below 298 K, set it to 298 K and wait for the chamber to reach room temperature.

CAUTION!

Always bring the sample chamber to room temperature before you open it to the atmosphere. This will prevent condensation and cryopumping of air constituents inside the chamber, which can cause probe malfunctions such as blocked valves and loss of temperature control.

2. Verify that the field in the magnet is less than 1 tesla. If the field is greater than that, set it to less than 1 tesla and wait for the magnet to reach the set point.

CAUTION!

Do not place the puck-extraction/insertion tool[3] (or any other object) into the sample chamber when high fields are in the magnet, as the force on the extraction tool could overwhelm you and cause you to damage the equipment.

3. Vent the sample chamber with clean, dry gas to help keep the sample chamber free of contaminants in the air.

   To vent the chamber, you can use the Model 6000 menu (**CTRL >> 1. Interactive Control >> 5. Vent Continuous**) or you can use the PPMS software (**Instrument >> Chamber >> Vent Cont.**).
4. Open the hinge clamp and remove the KF blank flange from the sample-chamber access port (see Figure 2-5). If the blank flange is difficult to move due to low internal pressure, do not force it. Allow the pressure within the chamber to match the external pressure before you open the sample chamber to atmosphere.
5. Remove the O-ring from the sample-chamber access port.
6. Disengage the puck-insertion tool by flipping up the black switch located on top of the tool or by fully depressing the switch (see Figure 4-12).
7. Gently lower the puck-insertion tool, cylinder-end first, into the sample chamber until the tool touches the bottom of the chamber.
8. Engage the puck-insertion tool by flipping down the black switch located on top of the tool or by releasing the switch, if it is fully depressed, so that the switch lies flat across the tool's handle (see Figure 4-12).
9. Gently raise the insertion tool out of the sample chamber. You should feel some initial resistance as you pull the puck out of its seat.
10. Verify that the sample puck is in the insertion tool. If it is not, return to Step 6. If it is, disengage the lever and let the puck fall safely into your hand. *Do not drop the puck.*

Now you can insert another puck, install a PPMS option into the sample chamber, or close the sample chamber.

4.5.3 Closing an Empty Sample Chamber

Use the procedures below to close the sample chamber when it does not have a sample installed.

1. Place the O-ring and KF blank flange over the sample-chamber access port (see Figure 2-5).
2. Place the flange clamp in position around the top of the sample-chamber access port.
3. Latch the clamp.
4. Purge and seal the sample chamber by using the Model 6000 menu (**CTRL >> 1. Interactive Control >> 2. Purge and Seal**) or MultiVu (**Instrument >> Chamber >> Purge/Seal**).

[3] See Footnote 1.

4.6 System Customization

The PPMS is designed to be flexible and meet a variety of needs, so it accommodates customization. Before you begin any modifications, please read all applicable portions of the manual so that you understand how the components function and how your alterations could affect the system. Contact Quantum Design if you have questions about altering the system. Some common issues are addressed below.

4.6.1 Making Alternate Connections to the Sample Leads

If the Model 6000 does not provide the function you need, you can make electrical contact to the sample from other instruments by connecting an adapter to the gray Lemo connector cable. The pinouts are mapped for this purpose in Appendix A.

CAUTION!

Always use an adapter to access the leads in the gray Lemo connector cable (the cable that connects the probe head to the Model 6000). Use of an adapter ensures that you will be able to use the cable with other applications.

Figure 4-14 illustrates how to use an adapter to make connections at the "D" connector end of the gray Lemo cable. You can confine the wiring for this adapter to a box. We highly recommend using a breakout box, which provides an easily configured, reusable method of changing sample connections. It will keep the process flexible and isolate each wire in the gray Lemo cable, allowing contact to each wire individually. Such a box would have a female 25-pin "D" connector (DB-25) and input and output connections to the leads as necessary: for example, 12 banana plug connectors, 6 BNC connectors, other "D" connectors, or a bread board.

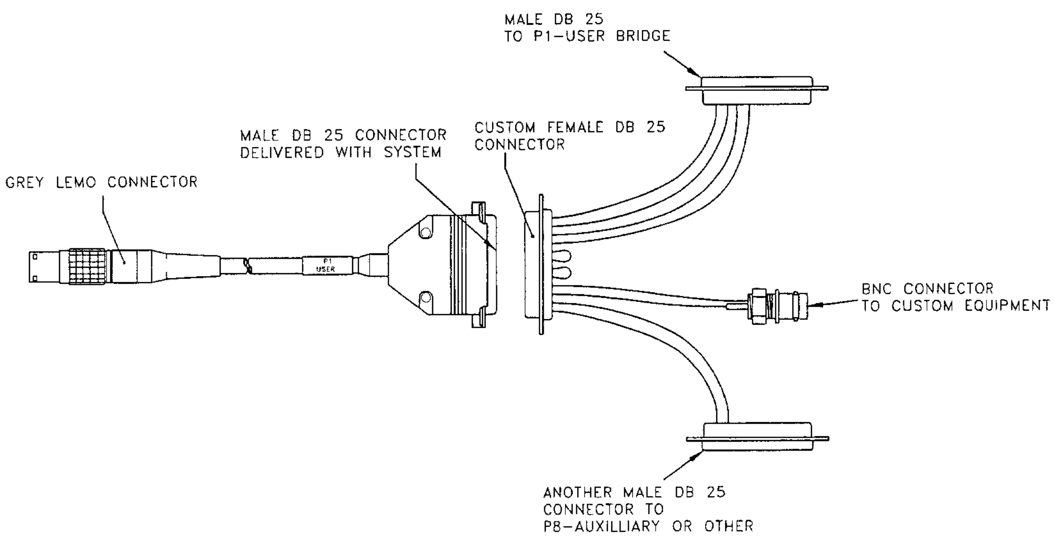


Figure 4-14. Custom adapter for making connections to the sample leads

4.6.2 Using Other Electronic Devices

The Model 6000 is designed to facilitate use with many other electronic instruments. It has an input for an external pressure gauge and an output to an external motor. Its four analog output BNC connectors monitor a variety of system signals. The "P8–Auxiliary" port contains two signal inputs to an analog-to-digital converter in order to digitize and record external signals. The "P1–User Bridge" port provides access to two current drivers, and the "P8–Auxiliary" port contains +15 V and −15 V low-power current sources. Several digital inputs and outputs are in various locations on the Model 6000. See Appendix A for detailed information about these capabilities.

You also can use the Model 6000 front panel to monitor additional equipment that uses the Model 6000 digital input and output lines. The state of each digital input and output is displayed in the **Digital:** status line at the bottom of the **Status–System Cont.** screen. The status codes are summarized in Table 4-3.

Table 4-3. Status codes for the Model 6000 digital inputs and outputs

STATUS CODE	LINE AND STATE	TYPE OF LINE	LOCATION
HL	Hold Line Active (Low)	Busy Input	P–11 External
UR	User Line Active (Low)	Busy Input	P–11 External
A1	Auxiliary Drive #1 Active (–24 V)	Auxiliary Output	P–8 Auxiliary
A2	Auxiliary Drive #2 Active (–24 V)	Auxiliary Output	P–8 Auxiliary
LM	Limit Switch Active (+5 V)	Motor Input	P–10 Motor
NX	Index Switch Active (+5 V)	Motor Input	P–10 Motor
S1	Select Line #1 Active	Select Output	P–11 External
S2	Select Line #2 Active	Select Output	P–11 External
S3	Select Line #3 Active	Select Output	P–11 External
AC	Actuator Activated (–24 V)	Actuator	P–10 Motor

Appendix A contains the information that is necessary for correctly interfacing other electronic devices with the PPMS. For example, some pressure gauges can be permanently damaged if they are connected improperly. Always verify that any electrical connections to the PPMS are solid and properly grounded.

4.6.3 Modifying the Gas and Vacuum System

If you plan to modify the gas and vacuum lines in the PPMS, first read Chapters 2 and 3 (Sections 3.3 and 3.4). Be especially careful that you understand how the PPMS functions, because your alterations can easily affect temperature control. When you make your changes, verify that any new plumbing connections are solid and have good seals.

4.7 Routine Maintenance Procedures

This section describes routine maintenance procedures that you should perform regularly. Less frequently performed procedures are discussed in Appendix B or Appendix C.

Regular maintenance procedures include adjusting the puck; transferring nitrogen and helium into a cold dewar, which you typically perform several times a week; basic servicing of the vacuum-pump assembly, which you should perform throughout the year; and O-ring inspections, which you should perform whenever you see an O-ring in the PPMS.

The less frequently performed procedures include transferring liquid nitrogen and helium into a warm dewar (Appendix B) and performing major pump-assembly services (Appendix C). Appendix C also contains a maintenance schedule and a form for tracking equipment service.

4.7.1 Puck Adjustment

You will need to adjust the sample puck whenever it fits loosely into the bottom of the chamber or after you have inserted it into the sample chamber approximately 10 times. Figure 4-15 displays the components of the puck-adjustment tool, and the steps below explain how to use it.

1. Place the puck on the finger spreader (see Figure 4-15).

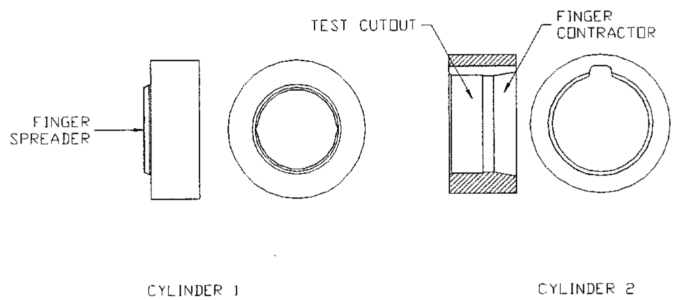


Figure 4-15. Puck-adjustment tool

2. Remove the puck from the finger spreader.
3. Place the puck inside the finger contractor.
4. Press straight down on the puck and continue pressing until the puck is pressed completely into the finger contractor. When the entire chuck is in the contractor, the contractor evenly applies force to the outside of the fingers, pushing them inward. The contractor pushes the fingers—regardless of external wear or variations on the puck—so that they obtain their optimal location.
5. Remove the puck from the finger contractor.
6. Place the puck inside the test cutout. Verify that the puck fits easily but snugly in the test cutout.

4.7.2 Refilling a Cold Dewar

> **WARNING!**
>
> - Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid nitrogen or any other cryogen. Review Section 1.4.1, "Cryogens," before you transfer liquid nitrogen.
> - Always use a well-ventilated room to perform this procedure.

4.7.2.1 TRANSFERRING LIQUID NITROGEN

If there is any liquid helium in the PPMS dewar, you can use the procedures below to transfer liquid nitrogen into the nitrogen-jacketed dewar. However, if the dewar contains no liquid helium, you must use the "warm" dewar-fill procedures in Appendix B. The warm dewar-fill procedures are designed to prevent blockages in the impedance tube.

To facilitate the liquid-nitrogen transfer, we recommend that you review the process before you begin. If you are unfamiliar with these transfers, ask for help from someone who is familiar with the supply vessel.

1. At the PPMS dewar, prepare for the liquid-nitrogen transfer:
   a. Remove the brass fittings from one of the two liquid-nitrogen fill ports by turning the larger fitting counter-clockwise until it comes off the dewar. This prevents the O-ring from freezing.
   b. Open the other nitrogen fill port by turning the larger brass fitting counter-clockwise to loosen it and then removing the small insert plug when it is loose (see Figure 4-16).

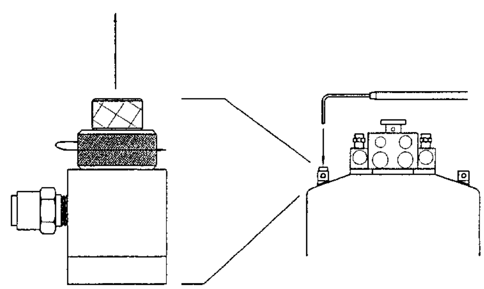


Figure 4-16. Preparing for a liquid nitrogen transfer

2. Screw the liquid-nitrogen transfer adapter onto the end of the nitrogen supply line. The liquid-nitrogen transfer adapter is included with the dewar but the supply line is not.
3. At the PPMS dewar, insert the small end of the liquid-nitrogen transfer adapter into the open liquid-nitrogen fill port and turn the brass fitting clockwise to secure the adapter in place (Figure 4-16).

4. At the liquid-nitrogen supply dewar, slowly turn the liquid supply valve until it is about 50% open. Exhaust should begin coming out of the second nitrogen fill port on the PPMS dewar. Do not open the liquid supply valve more than 50%—a fully opened valve can produce violent spillovers of exhaust that are extremely hazardous and difficult to avoid.

WARNING!

Always open the liquid supply valve slowly, and only open it about 50%. Although the transfer is fast when the valve is completely open, such transfers are extremely hazardous.

5. At the PPMS dewar, visually monitor the exhaust from the second nitrogen fill port during the entire fill process. While you are monitoring the exhaust, put on your protective gear. This gear is necessary to prevent serious burns from the extremely cold fitting, supply line, and transfer adapter.

   Do not leave the PPMS unattended during this step and always stand at least 0.5 m (1.5 ft.) from the exhaust plume.

6. At the liquid-nitrogen supply dewar, close the liquid supply valve when the exhaust turns to liquid, indicating that the jacket is full. The fill time will depend on the amount that was in the jacket when you started and how fast you perform the transfer. For example, jackets that are refilled twice a week take about 15 minutes to refill.

7. At the PPMS dewar, perform in sequence the steps below:

   a. Remove the liquid-nitrogen transfer adapter: turn the brass fitting counter-clockwise and lift the transfer adapter out of the dewar.

      In the event that the fitting and adapter are frozen together, you can use a warm air blower to accelerate the thawing process. Otherwise, you must wait until the parts thaw enough to be separated.

   b. Close both nitrogen fill ports: re-install the brass fittings and turn the large brass fittings clockwise.

CAUTION!

Always re-install the fill-port fittings and/or O-rings onto the nitrogen fill ports after you have transferred liquid nitrogen into the dewar. These fittings prevent dangerous ice blockages in the fill ports.

4.7.2.2 TRANSFERRING LIQUID HELIUM

WARNING!

- Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium or any other cryogen. Review Section 1.4.1, "Cryogens," before you transfer liquid helium.
- Always use a well-ventilated room to perform this procedure.
- Immediately vent the room by opening windows and doors if there is an excessive helium release.

If there is any amount of liquid helium in the PPMS dewar, use the procedures described here to transfer helium into the dewar. If there is no liquid helium in the dewar, you must use one of the warm dewar fill procedures in Appendix B to prevent blockages in the impedance tube.

To facilitate the liquid-helium transfer, we recommend that you review the process before you begin. If you are unfamiliar with these transfers, ask for help from someone who is familiar with the supply vessel.

1. Bring the helium-supply dewar close to the PPMS dewar.
2. Verify that the proper adapters and extensions are installed on the helium transfer line (see Figure 4-17).

   Important: The extensions perform an essential function: The input extension ensures that liquid can always enter the transfer line, even as the level of liquid in the storage dewar changes. A short extension is used on the output line to help reduce boil-off from the transfer. It is less cumbersome than the long one used for transfers into a warm dewar (see Appendix B).

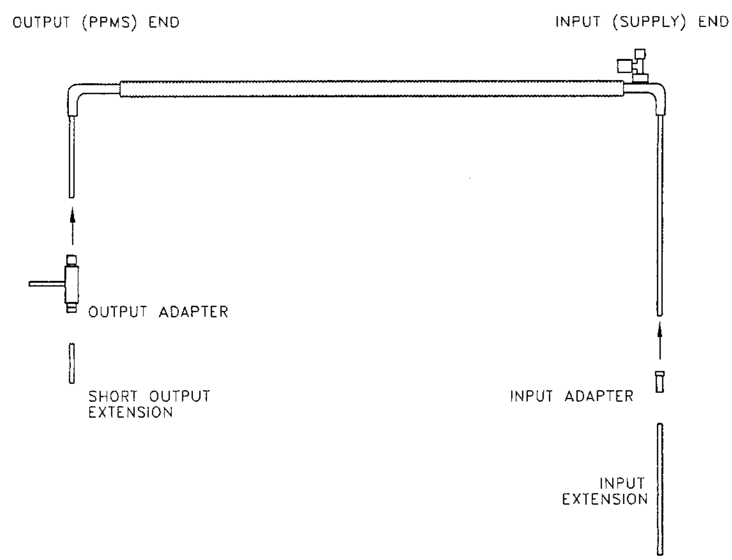


Figure 4-17. Helium-transfer line arrangement with the short output extension used for helium transfers into a cold dewar

3. At the liquid-helium supply dewar, perform in sequence the steps below, using Figure 4-18 for reference:
   a. Vent the pressure from the supply dewar by slightly opening the gas-phase valve.
   b. After the pressure has been reduced, close the gas-phase valve.
   c. Open the liquid access port. *This port is open only during the transfer.*
   d. Close the primary relief valve on the supply dewar. *This valve remains closed only during the transfer procedures.*

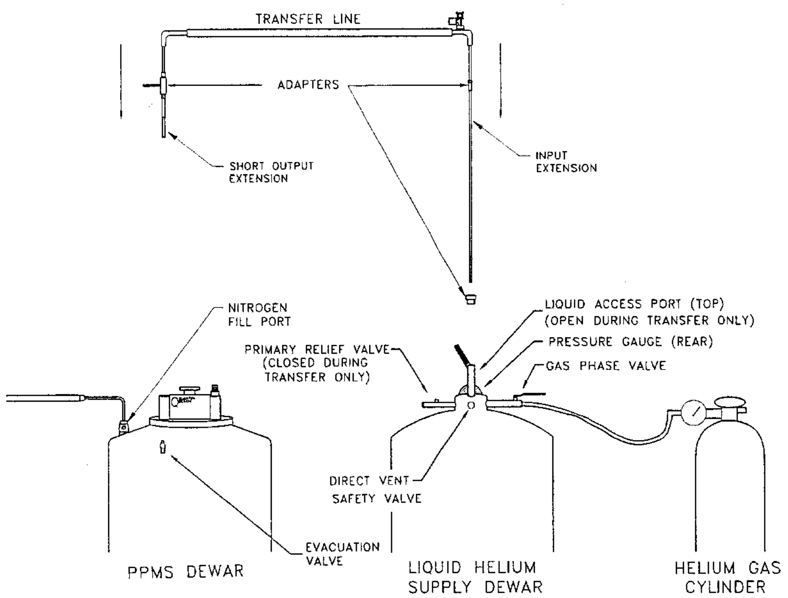


Figure 4-18. Arrangement for refilling a cold, nitrogen-jacketed dewar with liquid helium. Note the short output extension on the transfer line.

4. Using rubber or plastic tubing, connect a helium-gas cylinder to the gas-phase port on the liquid-helium supply dewar, as shown in Figure 4-18.
5. At the PPMS dewar, open one of the two helium fill ports on the probe head by pulling the entire fixture straight up (see Figure 4-19).
6. Slowly lower the input end of the transfer line into the supply dewar. Tighten the adapters that seal the transfer line to the liquid access port. Continue lowering the input end until an exhaust plume appears at the output end.
7. Insert the adapter at the output end of the transfer line into the PPMS dewar through the helium-fill port (refer back to Figure 4-18). Push the transfer line completely into the dewar.

   Gas will begin flowing from the output adapter. *Point the output-adapter-exhaust-tube away from the evacuation valve and the rest of the dewar top.* The exhaust will be so cold it can freeze and damage parts, such as O-rings and sealed valves.

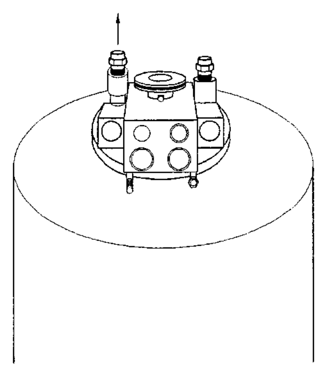


Figure 4-19. Opening a helium-fill port on the head of a PPMS probe (standard dewar shown)

C A U T I O N !

Point the output-adapter-exhaust-tube ***away*** from all hardware on the dewar and probe head. The extremely cold exhaust can damage parts, especially O-rings and sealed valves.

8. Verify that each adapter on the transfer line is properly seated so that it seals the transfer line.
9. At the liquid-helium supply dewar, open the gas-phase valve.
10. At the helium-gas cylinder, open the regulator to start transferring helium into the PPMS dewar
11. Monitor the helium transfer with the **Liquid Helium Fill Status** dialog (in MultiVu select **Utilities** >> **Helium Fill**) or the Model 6000 (select **CTRL** >> **1. Interactive Control** >> **0. Fill Dewar**).
12. When the helium level reads 85–100%, close the regulator at the helium-gas cylinder.
13. At the liquid-helium supply dewar, reset the valves:
    a. Close the gas-phase valve.
    b. Open the primary relief valve.
14. Remove the transfer line and adapters from the liquid-helium supply dewar and the PPMS dewar.
15. At the PPMS dewar, close the helium-fill port on the probe head by reinserting the relief valve.
16. At the liquid-helium supply dewar, close the liquid access port (see Figure 4-18).
17. The liquid helium transfer is now complete. The helium-level meter will turn itself off when you exit the **Fill Dewar** screen or if the fill time exceeds 30 minutes.

4.7.3 Servicing the Vacuum-Pump Assembly

To help ensure that your equipment is in working condition when you want to perform measurements, it is essential that you regularly maintain the PPMS vacuum-pump assembly. A rotary-vane pump, which is located inside the electronics cabinet (Figure 4-20), uses oil to help pull the vacuum. Oil mist is naturally expelled from the pump exhaust and collected by an oil-mist
filter installed on the inside wall of the electronics cabinet. Air to the pump is filtered through the foreline trap.

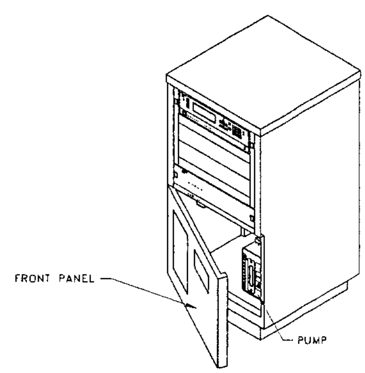


Figure 4-20. Electronics cabinet and rotary-vane pump

Maintenance Schedule

The pump-oil level, oil-mist filter, and foreline trap require regular maintenance using the procedures in Sections 4.7.3.1 and 4.7.3.2.

- At least once a month, check the oil level in the pump and and oil-mist filter and add oil as appropriate.
- At least once a week, check the amount of oil that has collected around the oil-mist filter and empty as necessary. Check the oil levels more frequently if the pump is heavily used.

- Once a year, the pump and the oil-mist filter cartridge need a complete service, as explained in Appendix C.
- Twice a year, use the instructions in Appendix C to clean the foreline trap, which acts as the inlet filter for the pump. Appendix C also contains a maintenance record so that you can track when service was last performed.

> **CAUTION!**
>
> Check the level of oil in the oil-mist filter at least once a week. If the filter becomes too full, oil can back up into the gas lines and plug the system.

Pump Versions

Since 1997, all PPMS units have used CE-compliant Edwards or Varian pumps; before that time, the PPMS was equipped with an Alcatel pump (see Figure 4-21).

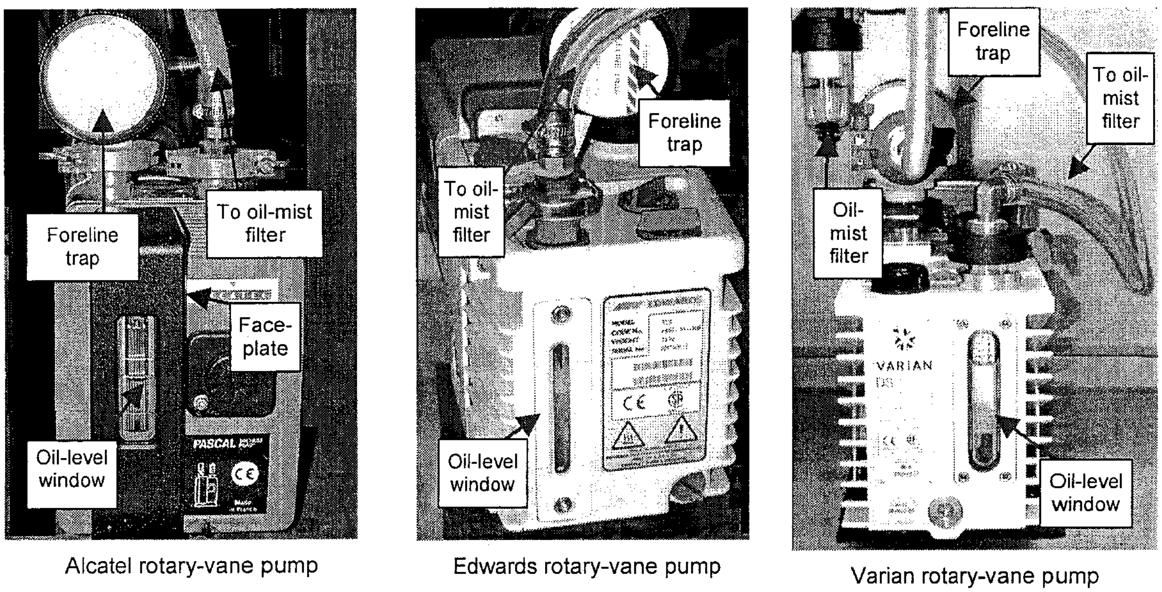


Figure 4-21. Vacuum (rotary vane) pumps used with the PPMS

Table 4-4 lists the characteristics of each pump and Sections 4.7.3.1–4.7.3.2 explain how to check the oil level in the pump and oil-mist containers. Appendix C contains the instructions for changing the oil and oil-mist filter cartridge and for servicing the foreline trap. For detailed information about your pump, refer to the separate vacuum-pump manual that comes with the system.

Table 4-4. Types of vacuum pumps used on the PPMS and their characteristics

PUMP CHARACTERISTIC	PUMP MANUFACTURER		
	Alcatel	**Edwards**	**Varian**
Color	Orange and black	Gray	Ivory and gray
Oil Spec.	Alcatel 100 Direct Drive Mechanical Vacuum Pump Fluid	Edwards Supergrade "A" oil	Varian General Purpose Mechanical Pump Fluid
Oil Level	Between upper and lower markings, best at 1/2 or more	Between "max" and "min"	Between arrows, best at 1/2 or more
Oil-fill cap	Top foremost cap	Top, front right	Top, front left
Drain plug	Lower plug	Bottom right	Bottom front center

4.7.3.1 CHECKING THE OIL IN THE PUMP

Weekly or sooner (depending on the amount of use), check the amount of oil that has collected in the bell jar that surrounds the oil-mist filter. If the filter becomes too full, oil can back up into the gas lines and plug the system. Monthly or sooner (depending on the amount of use), check the oil level in the pump, refill it to the full mark with the appropriate oil (see Table 4-4), and check the status of the filter cartridge.

1. Open the front panel of the electronics cabinet. Figure 4-20 illustrates the cabinet and pump.
2. Look at the oil-level window on the front of the pump. The oil level should be between the two outer markings (see Figure 4-21). Table 4-4 gives the specific level for each pump.
3. If the pump needs more oil, first check whether the oil needs to be changed. While the cabinet is open, compare the oil in the pump to clean oil.
   a. If the pump oil is clean, use the instructions in Section 4.7.3.2 to add oil.
   b. If the pump oil is dirty, use the instructions in Appendix C to drain the pump and replace the oil.
4. Check the amount of oil in the oil-mist filter and container.
   a. If the container is half full, use the instructions in Section 4.7.3.2 to empty it, unless you also need to change the filter cartridge. In the latter case, use the instructions in Appendix C.
   b. If the filter cartridge looks like it is full of oil, use the instructions in Appendix C to install a new one.

4.7.3.2 ADDING OIL AND DRAINING THE OIL-MIST CONTAINER

WARNING!

Put the system in shutdown mode and disconnect (but leave seated) the two metal pumping lines before you service the pump or related components. If there are leaks into the sample chamber and cooling annulus, ice can form and cause serious system malfunctions.

Prepare the PPMS for Pump Service

1. Place the PPMS in **Shutdown** mode (in MultiVu, select **Instrument** >> **Shutdown**). When you place the system in shutdown mode, it automatically seals the sample chamber, turns off the heaters, and restricts the flow-control valve.
2. Disconnect—but leave seated—the two metal pumping lines that come from the probe head. When the pumping lines are disconnected in this way the sample chamber and cooling annulus are sealed at the probe head.
3. Leaving the rest of the system components turned on, turn off the pump according to the instructions below. If the pump has been in operation, you might need to let it cool before you work on it.
   a. Early PPMS units without a toggle switch on the pump—unplug the pump to turn it off. *Do not turn off the switch on the power strip*—this strip powers other system equipment in addition to the pump.
   b. Recent PPMS units with a toggle switch on the back of the pump—turn off the toggle switch.
4. Open the console cabinet and hold your hand near the pump. If the pump is uncomfortably warm, let it sit until it has cooled before proceeding to the next section.

Fill the Pump

1. If the pump parts are difficult to access, slide the pump forward out of the electronics cabinet.
2. If the system has an Alcatel pump (Figure 4-21), remove the black faceplate that frames the oil-level window.
3. Remove the oil-fill cap on the top of the pump (see Table 4-4). Save the O-ring.
4. Fill the pump with oil to the top mark of the oil-level window (*do not overfill*).
5. Reinsert the O-ring and oil-fill cap.
6. If the system has an Alcatel pump, replace the faceplate that frames the oil-level window.

Drain the Oil-Mist Filter

1. Hold a container under the bottom of the bell jar and unscrew the plug.
2. When the oil has drained, pour the oil into a used-oil container.
3. Screw the plug back into the bell jar.

> **CAUTION!**
>
> Check the level of oil in the oil-mist filter at least once a week. If the filter becomes too full, oil can back up into the gas lines and plug the system.

Prepare the PPMS for Use

1. Slide the pump back into the electronics cabinet.
2. Turn the pump on and wait one minute so that the metal pumping lines can be evacuated. Verify that the pumping lines are seated in their connectors but not pressed in completely.
3. Reconnect the two metal pumping lines to the probe head.
4. Purge and seal the sample chamber.
5. Close the front door of the electronics cabinet.
6. The procedures are now complete. Please dispose of any used oil properly.

4.7.4 Using the Probe-Lifting Assembly

> **WARNING!**
>
> Always remove and insert the probe very slowly—raise it about one inch per minute. The probe could explode violently if it is removed from the dewar rapidly and there is a leak in the vacuum space.

You must use specific techniques to handle the probe, because it is fragile and easily damaged. Quantum Design provides a probe-lifting assembly (Figure 4-22) to help you move the probe in and out of the dewar. To prevent damage to the probe when it is out of the dewar, please use the probe-handling guidelines described in Section 4.2.1.

The steps below explain how to use the probe-lifting assembly. We recommend that you review the procedures before you begin, referring to Section A.4 and Figures 2-5, 4-19, and A-3 if necessary.

1. Open the helium-fill ports on the probe head by pulling the relief valves straight up (Figure 4-19).
2. Remove the hinge clamp from the sample-chamber access port (Figures 2-5 and A-3).
3. From the front of the probe (the side with the Quantum Design logo), slide the probe-lifting assembly onto the probe head so that the lifting assembly is underneath the sample-chamber access port but above the pressure-relief valve (Figure A-3).

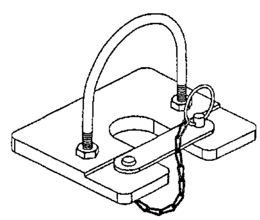


Figure 4-22. Probe-lifting assembly

4. Use the pin on the end of the chain to close the locking mechanism of the lifting assembly. *You must close the locking mechanism before you lift the probe.*
5. Attach the probe-lifting assembly to a hoist or a pulley, if necessary to lift or lower the probe.
6. When you have finished raising or lowering the probe, remove the assembly.

4.7.5 Inspecting O-Rings

You can increase the reliability and lifetime of the PPMS by maintaining the O-rings so they are always in good condition. The regularly accessible O-rings are on the top-plate assembly and on the helium and nitrogen fill-port fixtures. You also might see other O-rings when you perform maintenance and servicing.

All O-rings in the system should be clean and they should be lubricated with silicon vacuum grease. To ensure that the O-rings remain in prime condition, adopt the following habits.

- If you see an O-ring, visually inspect it.
- If an O-ring appears dirty, clean it with a clean, lint-free cloth (e.g., a Kimwipe).
- If an O-ring is dry, apply silicon vacuum grease to it.
- If an O-ring is cracked, replace it.
- If an O-ring is leaking, contact Quantum Design.

A P P E N D I X A

Connections, Ports, and Pinouts

A.1 Introduction

This appendix contains the following information:

- Section A.2 illustrates the connections between the system hardware components.
- Section A.3 illustrates and describes the ports on the rear panel of the Model 6000.
- Section A.4 illustrates and describes the ports on the rear of the PPMS probe head.
- Section A.5 contains pinout tables for all electrical ports.
- Section A.6 lists the recommended replacement fuse values.

A.2 System Connections

The proper connections between the probe head, Model 6000, Model 6700, and pump are shown in Figure A-1. Use the figure as a guide when you connect the components.

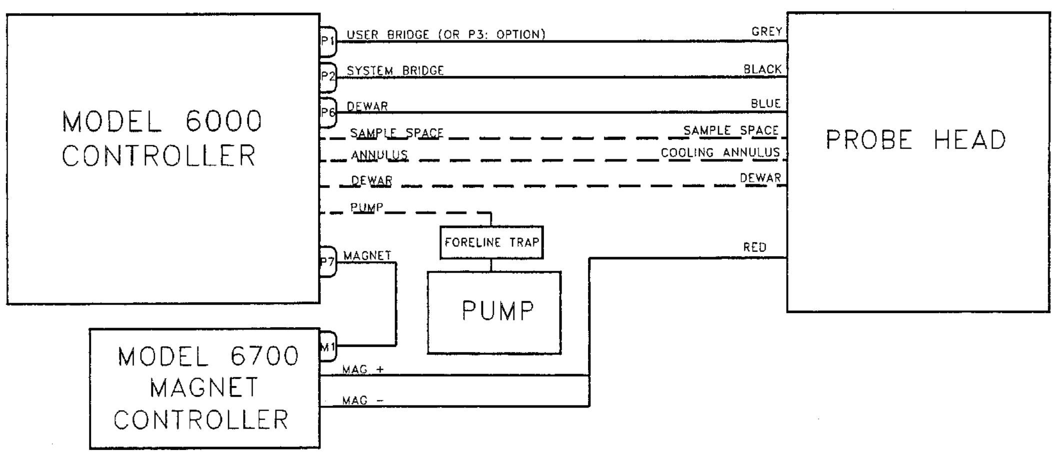


Figure A-1. Connections for PPMS hardware: solid lines identify electrical connections and dashed lines identify gas/vacuum lines.

Electrical connections to the probe have color-coded Lemo connectors at the probe end. Three separate pumping lines are attached to the probe: a smaller metal hose that attaches to the sample chamber, a larger metal hose that connects to the cooling annulus, and a small white polypropylene hose that connects to the dewar.

Figure A-1 does not illustrate connection of a personal computer to the system, which is through the "P4–IEEE488" (GPIB) port on the rear of the Model 6000 (see Section A.3.4).

A.3 Model 6000 Rear Panel Ports

Figure A-2 illustrates the rear panel of the Model 6000. The upper half contains electrical connections. The lower half houses the system fuses and connections to the gas lines for temperature and pressure control. Some ports provide access to standard PPMS hardware and others allow custom configuration.

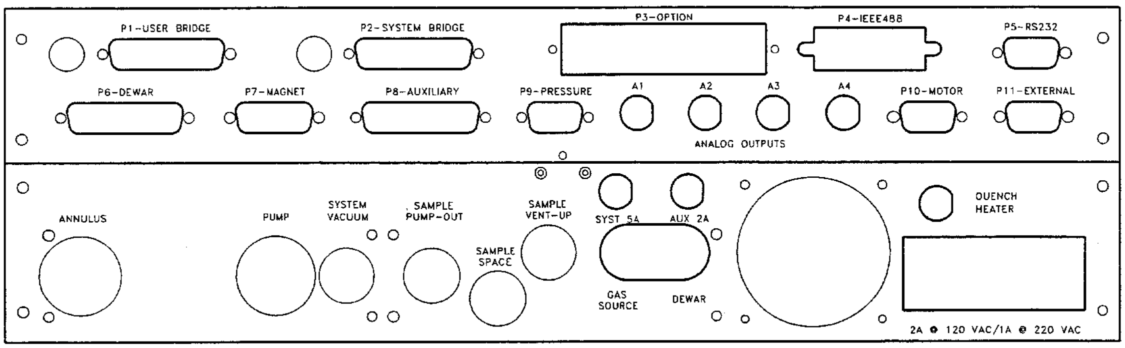


Figure A-2. Ports on rear panel of Model 6000

A.3.1 P1–User Bridge Port

If the system includes the Resistivity option, the "P1–User Bridge" port accesses the additional bridge board that is in the Model 6000. The "P1–User Bridge" port usually connects to the gray-ringed Lemo connector on the probe head and thus connects the user bridge board to the installed sample.

The optional resistance bridge board provides channels for four separate four-wire resistance measurements. In some models, the small round port next to the "P1–User Bridge" port provides parallel access to the fourth of these channels. The Model 6000 **Status–Bridge** screen displays the status of the user bridge channels. Use the **CTRL** >> **3. Immediate Operations** >> **06: Bridge** menu to control each bridge channel. To record the current and resistance of each channel, use the **CTRL** >> **3. Immediate Operations** >> **11: Measure** command.

The user bridge board also provides access to two additional current drivers of the Model 6000. These drivers, which provide up to 1 A or 20 W of current (whichever current limit is reached first), can be monitored with the **Status–System Cont.** screen. To monitor them, use the **CTRL** >> **3. Immediate Operations** >> **08: DrvOut** menu. To record the current and power through each driver channel, use the **CTRL** >> **3. Immediate Operations** >> **11: Measure** command.

A.3.2 P2–System Bridge Port

The "P2–System Bridge" port accesses (1) the two heater drivers for the heaters on the sample chamber and (2) the PPMS system bridge board that monitors the three system thermometers. The "P2" port connects to the black-ringed Lemo connector on the probe head.

The system bridge board is identical to the optional user bridge board, but is required for system thermometry. You cannot access three of the four system bridge channels. You can access the fourth channel, but it is reserved for some PPMS options that require their own thermometer. If you plan to use the PPMS for resistance measurements, Quantum Design recommends using one of the PPMS resistivity options, because the base PPMS is not configured for easy access to the fourth system bridge channel.

A.3.3 P3–Option Port

The "P3–Option" port accesses boards that are installed with certain PPMS options. For example, the AC Measurement System option and the AC Transport option use the AC board, which is installed behind the "P3–Option" port. For details about this port, refer to the appropriate option manual or contact your Quantum Design representative.

A.3.4 P4–IEEE488 Port

The "P4–IEEE488" port is the GPIB communications port for the Model 6000. The GPIB provides a standardized method of communication for all types of electronic instruments. Multiple GPIB-capable instruments can be connected in parallel. Use the **CONFIG** >> **3. IEEE-488 Setup** menu to configure the GPIB.

A.3.5 P5–RS232 Port

The "P5–RS232" port provides an RS-232 interface to the Model 6000. Personal computers or other devices with standard RS-232 ports can be connected to this port. Use the **CONFIG** >> **2. Serial Port Setup** menu to configure the "P5–RS232" port.

A.3.6 P6–Dewar Port

The "P6–Dewar" port connects the Model 6000 to the helium-level sensor, the impedance heater, and the superconducting magnet persistence switch heater. The "P6–Dewar" port connects to the blue-ringed Lemo connector on the probe head.

A.3.7 P7–Magnet Port

The "P7–Magnet" port connects the Model 6000 to the "M1" port on the Model 6700.

A.3.8 P8–Auxiliary Port

The "P8–Auxiliary" port offers several auxiliary outputs and inputs. Table A-8 lists the specific pinouts for the "P8–Auxiliary" port.

A.3.8.1 THREE 0 V/–24 V AUXILIARY SIGNAL DRIVES

The "P8–Auxiliary" port has three 0 V/–24 V auxiliary signal drives that act as relays. –24 V is considered the asserted state. The auxiliary signal drives might be used, for example, to open and close valves in the system. The total current available to these three drives, the motor actuator, and motor phase leads is 2 A.

The auxiliary signal drives are controlled from the **CTRL** >> **3. Immediate Operations** >> **07: DigSet** menu, via GPIB or serial port input, or from within a sequence. The asserted state of auxiliary signal drives 1 and 2 is represented in the **Status–System Cont.** screen by the "A1" and "A2" digital status codes. These status symbols are for digital inputs and outputs. Do not confuse them with the analog inputs or analog outputs called "A1" and "A2" on the Model 6000 rear panel.

A.3.8.2 CONSTANT +15 V AND –15 V OUTPUTS

The "P8–Auxiliary" port has constant +15 V and –15 V outputs that can be used as low-current power sources. For example, the +15 V and –15 V outputs can be used to power operational amplifiers. The +15 V and –15 V lines draw directly on the Model 6000 power supply, so it is important that these leads are never shorted.

Up to 200 mA of total current is available from the +15 V and –15 V lines when the ACMS and AC Transport options are not installed or active. However, this current is shared with the AC board. When the AC board is driving relatively large alternating currents for the ACMS or AC Transport option, the current that is available at these outputs drops to 10 mA.

A.3.8.3 TWO SENSE LINES

The "P8–Auxiliary" port has two sense lines that are essentially digital on/off inputs that operate at TTL levels (5 V = inactive, 0 V [shorted] = active). To record the status of each sense line, use the **CTRL** >> **3. Immediate Operations** >> **11: Measure** >> **DigIn** command. The Model 6000 does not control based on the status of the sense lines. The sense inputs can be used during an experiment, for example, simply to indicate when a certain instrument in the system is operating.

A.3.8.4 TWO ANALOG SIGNAL INPUTS

The “P8–Auxiliary” port has analog signal inputs (−10 V to +10 V) that can be digitized and recorded by the Model 6000. The Model 6000 records the two analog inputs at a rate of approximately 2 Hz. To measure the signal from each of these inputs, use the **CTRL >> 3. Immediate Operations >> 11: Measure >> Sig1** (or **Sig2**). The signal can be manipulated like any other data signal—that is, placed into data files, graphed with PPMS software, linked to the analog outputs, and so on. The status of these signal inputs can be observed in the **Status–System Cont.** screen when it has been enabled with the **CONFIG >> 5. Software >> 1. User Preferences** menu.

A.3.9 P9–Pressure Port

The “P9–Pressure” port provides power to and a signal from an external pressure gauge, such as a Pirani or Baratron gauge. The pinouts can be configured to match specific models of gauges. For more information, refer to Table A-9 and the manual for the gauge of interest, or contact a Quantum Design representative for more information about how to configure the pinouts for a gauge.

To see the port configuration, use the **CONFIG >> 6. Hardware >> 4. Pressure Sensor** menu. When this menu displays a selection other than “internal,” all system pressure information is rerouted to obtain information from the indicated gauge (or none at all), rather than from the internal solid-state silicon pressure sensor of the Model 6000. The pressure shown in the **Status–System** screen reflects this pressure information. To record the pressure reading, use the **CTRL >> 3. Immediate Operations >> 11: Measure >> More** command.

Up to 200 mA of total current is available from the +15 V and −15 V lines when the ACMS and AC Transport options are not installed or active. However, this current is shared with the AC board. When the AC board is driving relatively large alternating currents for the ACMS or AC Transport options, the current that is available at these outputs drops to 10 mA.

A.3.10 A1, A2, A3, and A4 Ports

The “A1,” “A2,” “A3,” and “A4” ports are the analog outputs. These four BNC connectors can be linked to any of about 30 different PPMS parameters, such as temperature, magnetic field, user bridge board resistance, or motor position. This allows −10 V to +10 V feedback to other instruments or connection to chart recorders, oscilloscopes, and so on. The “A1” output is also connected in parallel to the signal channel 1 connector on the front panel of the Model 6000.

When you link parameters to the analog outputs, you must specify a value for both 0 V and +10 V so that the appropriate gain and offset are used. Each channel has an output impedance of 100 Ω. You can use the **CTRL >> 3. Immediate Operations >> 12: Link** menu to link the channels to measurable parameters. You can also use the **CTRL >> 3. Immediate Operations >> 10: SigOut** menu to configure the analog outputs to supply constant voltages. The **Status–System Cont.** screen displays the status of each analog output.

A.3.11 P10–Motor Port

If the system includes options that use a Quantum Design sample transport or rotator motor, the motor is connected to the "P10–Motor" port. If a sample transport or rotator motor is not installed, then the "P10–Motor" port can be used to drive a small, 12 V, external stepper motor.

A 0/–24 V actuator, identical to the auxiliary digital signal drives in the "P8–Auxiliary" port, is included in the "P10–Motor" port. When this actuator is active, the **Status–System Cont.** screen displays the "AC" digital status code. The total current available to the motor actuator, motor phase leads, and three auxiliary signal drives is 2 A.

The "P10–Motor" port also includes a TTL-level index switch and limit switch leads in addition to the four phase leads and actuator leads. Index and limit switches should normally be wired closed. When these circuits are broken, the **Status–System Cont.** screen displays the "LM" and "NX" digital status codes to indicate that the limit and index switches are active. This occurs whenever a motor is *not* connected to the Model 6000 or whenever an index or limit switch is tripped.

You can use the **Status–System** screen to monitor the motor position. Commands pertinent to the motor configuration, position control, and position measurement are listed below. For more detailed information about each command, refer to the *Physical Property Measurement System Commands Manual.*

CTRL >> 1. Interactive Control >> 6. Move to Index

CTRL >> 1. Interactive Control >> 7. Move

CTRL >> 3. Immediate Operations >> 03: Move

CTRL >> 3. Immediate Operations >> 07: DigSet

CTRL >> 3. Immediate Operations >> 11: Measure

CONFIG >> 6. Hardware >> 3. Position Configuration

A.3.12 P11–External Port

The "P11–External" port has three optically isolated outputs and two digital input busy lines that can help synchronize PPMS activity with other instruments. The select line outputs provide TTL levels. A nominal 10 kΩ resistor must be used on the collector with the emitter tied to ground. The select line outputs can be controlled by using the **ExtSet** command within a sequence or by using the **CTRL >> 3. Immediate Operations >> 09: ExtSet** menu. When the select lines are activated, the symbols "S1," "S2," and "S3" appear in the **Status–System Cont.** digital status line.

You must provide the busy (input) lines with +5 V. When the busy lines sense the 5 V difference between this voltage and the input line, the channel is in a released state. When the input line is also at 5 V (the input lead shorted to the +5 V lead), the channel enters a hold state. There are two busy lines: a *user* line and a *hold* line. The hold state of each line is indicated in the **Status–System Cont.** screen by "UR" and "HL" on the digital input status line, respectively. You can also use the **CTRL >> 3. Immediate Operations >> 11: Measure** command to read the status. Furthermore, when you use the **sync** command within a sequence, the hold state of the hold line pauses sequence execution. This function applies only to the hold line, not the user line.

A.3.13 Annulus Port

The "Annulus" port connects the annulus to the flow-control valve in the Model 6000. The longer, 3/8-inch stainless steel hose connects the "Annulus" port to the QC quick-connect fitting on the probe head.

A.3.14 Pump Port

The "Pump" port connects the Model 6000 gas lines to the vacuum pump that pumps on the sample chamber and the annulus. The shorter, 3/8-inch stainless steel hose attaches to the "Pump" port.

A.3.15 System Vacuum Port

The "System Vacuum" port provides direct access to the system pump, allowing the connection of other gas and vacuum lines and devices between the vacuum pump and flush valve. Under normal circumstances, a short hose connects the "Sample Pump-Out" port to the "System Vacuum" port, allowing the pump to pump directly on the sample space.

A.3.16 Sample Pump-Out Port

The "Sample Pump-Out" port accesses the sample chamber through the flush valve in the Model 6000. When the flush valve is open, the sample chamber is open to this port. Under normal circumstances, this port is directly connected by a short hose to the "System Vacuum" port, which is internally connected to the "Pump" port and consequently to the vacuum pump.

A.3.17 Sample-Space Port

The "Sample Space" port connects the sample space to the vent valve, the flush valve, and the gas lines in the Model 6000. The 1/4-inch stainless steel hose connects the "Sample Space" port to the QC quick-connect fitting on the probe head.

A.3.18 Sample Vent-Up Port

The "Sample Vent-Up" port accesses the sample space through the vent valve in the Model 6000. Under normal circumstances, a small hose directly connects the "Sample Vent-Up" port to the "Gas Source" port, providing helium gas from the dewar boil-off for venting and purging the sample chamber. If you want to vent and purge the chamber with another gas, simply disconnect this hose and connect an alternate gas source to the "Sample Vent-Up" port. In this case, the "Gas Source" port must be plugged.

A.3.19 Gas Source Port

The "Gas Source" port connects internally to the dewar port to provide a helium gas source for sample chamber venting and purging. A short hose usually connects the "Gas Source" port to the "Sample Vent-Up" port, directing helium from the dewar into the sample space through the vent valve in the Model 6000. If you use an alternate gas source, the "Gas Source" port must be plugged.

A.3.20 Dewar Port

The polypropylene tubing provided with the system connects the "Dewar" port to the small Ultra fitting on the probe head. This connection to the dewar serves two purposes: (1) It provides a gas source for venting and purging the sample chamber, and (2) it allows monitoring of the pressure differential across the impedance assembly. This second function is necessary to allow proper low-temperature operation and control, so it is important to keep this line connected, even when an alternate gas source is used for venting the sample chamber.

A.3.21 Syst 5A Fuse

The "Syst 5A" fuse is the fuse for the system heater and stepper motor power supply. Replace the fuse only with an equivalent 5 A, 250 V, time-delay fuse.

A.3.22 Aux 2A Fuse

The "Aux 2A" fuse protects the auxiliary relays and external motor ports. Replace the fuse only with an equivalent 2 A, 3 AG fuse.

A.3.23 Quench Heater Fuse

The "Quench Heater" fuse is required to operate the Magnet Reset option used by the Ultra Low Field option. Replace the fuse only with an equivalent 630 mA, 280 V, time-delay fuse.

A.3.24 Power Receptacle

The power cord connection for the Model 6000 is at the rear in the lower right corner. The power receptacle contains two fuses for the controller power supply. Replace these fuses only with equivalent 2 A, time-delay fuses (120 VAC power environments), or with equivalent 1 A, time-delay fuses in 220 VAC power environments, as noted on the back panel. You can use a screwdriver or other flat instrument to pry open the door covering these fuses. Verify that the power setting, which is visible through a window in the door, is correct for the power being used.

A.4 Probe-Head Ports

The ports on the rear of the PPMS probe head connect the probe hardware to the Model 6000 and Model 6700.

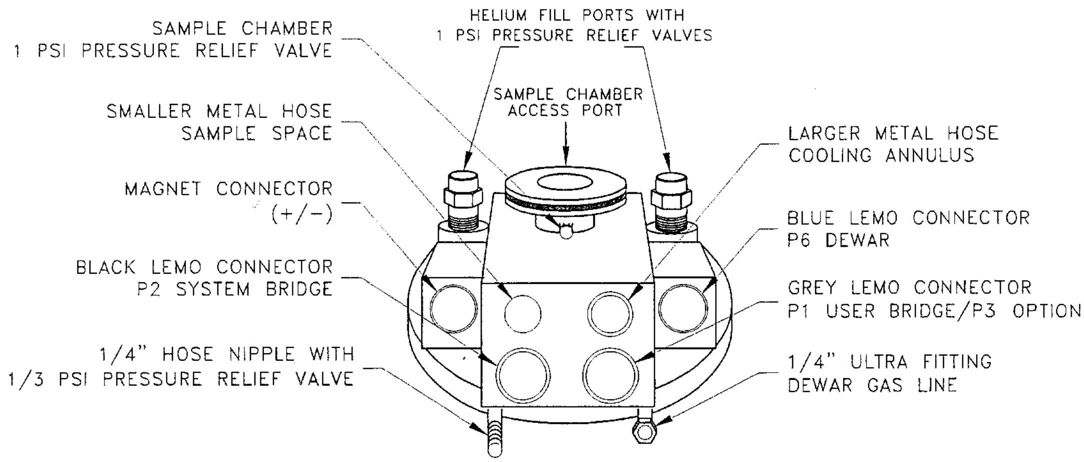


Figure A-3. Ports on rear of PPMS probe head

A.4.1 Helium-Fill Ports

You open the helium-fill ports by pulling the relief valves straight up, thus allowing access directly into the helium dewar for regular dewar fills. Each of the two helium-fill ports is fitted with a 1-psi pressure relief valve to allow pressure to be released before dangerous levels are reached. ***Do not*** tamper with these pressure-relief valves.

A.4.2 Sample-Chamber Access Port

The sample-chamber access port is used to move samples in and out of the sample chamber.

A blank flange with an O-ring seal normally covers the sample-chamber access port. A hinge clamp, which is provided with the system, holds the blank flange on the top of the port. Some PPMS options have hardware that attaches to the flange.

A.4.3 Sample-Chamber Pressure-Relief Valve

The sample-chamber pressure-relief valve prevents the buildup of dangerous pressures within the sample chamber. The valve extends from the back of the sample-chamber access port. ***Do not*** tamper with this pressure-relief valve.

A.4.4 Smaller Metal Hose Connector

The smaller, 1/4-inch metal hose connector attaches to the "Sample Space" gas port on the rear of the Model 6000. The 1/4-inch metal hose connector allows sample-space venting and evacuation.

A.4.5 Larger Metal Hose Connector

The larger, 3/8-inch metal hose connector attaches to the "Annulus" gas port on the rear of the Model 6000. The 3/8-inch metal hose connector allows the pump to pull helium through the impedance tube and annulus.

A.4.6 Hose Nipple

The hose nipple does not need to connect to anything. The hose nipple can let you access the helium in the dewar so that you can observe the helium boil-off rate. This gas line, however, passes through a 1/3-psi pressure relief valve first, so the dewar should not be pressurized with this port. You can attach a helium recovery unit to this port.

A.4.7 Ultra Fitting

The 1/4-inch Ultra fitting should be connected to the "Dewar" port on the rear of the Model 6000 with a 1/4-inch white polypropylene hose. This line allows the Model 6000 to monitor the pressure differential between the dewar and the annulus during low-temperature operations. Additionally, this line provides helium from the dewar boil-off for venting the sample space.

A.4.8 Magnet Connector (TCM or Red Lemo Connector)

The TCM connector (earlier model systems have a red-ringed Lemo connector) attaches to the two large, color-coded terminals on the rear of the Model 6700. The red- or blue-banded cable connects to the blue (+) terminal on the Model 6700, and the black (unbanded) cable connects to the black (–) terminal. These connectors are illustrated in Section A.5.7.

Important: Verify that the magnet polarity is correct by using Table A-7.

A.4.9 Black Lemo Connector

The black-ringed Lemo connector attaches to the "P2–System Bridge" port on the rear of the Model 6000. The black Lemo connector contains connections to the three system thermometers and the two sample-chamber heaters.

A.4.10 Blue Lemo Connector

The blue-ringed Lemo connector attaches to the "P6–Dewar" port on the rear of the Model 6000. The blue Lemo connector contains connections to the helium-level meter, impedance thermometer, impedance heater, and magnet persistence switch.

A.4.11 Gray Lemo Connector

The gray-ringed Lemo connector contains connections to the sample-puck connectors on the bottom of the sample chamber. The gray Lemo connector might connect to one of several ports. It might connect to the "P1–User Bridge" port for four-wire resistance measurements; to the "P3–Option" port for use with PPMS options, such as the ACMS option; or to other PPMS controllers, such as the Model 7100 AC Transport Controller or the Model 6500 PPMS Option Controller. You can access pins on the "P1–User Bridge" port for connection to instruments other than the Model 6000. A list of pinouts is in Section A.5.

A.5 Pinout Tables

The following tables detail the pinouts for the electrical ports in the PPMS, including ports on the Model 6000, probe head, and sample puck. None of these tables includes pinout information for the "P3–Option" port on the Model 6000. Refer to the appropriate option manual for the pinout information regarding this port.

Note: The diagrams that accompany the tables illustrate hardware ports, not connectors at the end of the cables.

A.5.1 Sample Connections

The sample connector is at the bottom of the sample chamber. The gray Lemo connector is on the probe head. Pins 1 and 2 on the gray Lemo connector are connected to wires that extend into the annulus. These wires are not used for any function, but they provide a site for system expansion. The “P1–User Bridge” “D” connector is on the Model 6000.

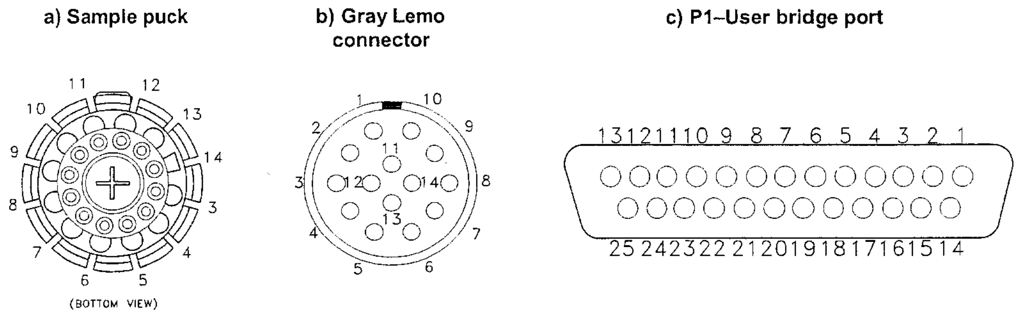


Figure A-4. Sample connections: a) Sample puck, b) Gray Lemo connector, c) P1–User bridge port

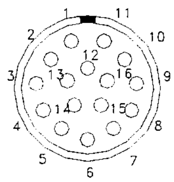
Table A-1. Sample connections

SAMPLE PUCK	SAMPLE CONNECTOR	GRAY LEMO CONNECTOR	P1–USER BRIDGE “D” CONNECTOR	USER BRIDGE BOARD FUNCTION
			1	Cur Driver 1+ (unused)
			14	Cur Driver 1– (unused)
			2	Cur Driver 2+ (unused)
			15	Cur Driver 2– (unused)
3	3	3	5	Channel 1 I+
4	4	4	18	Channel 1 I–
5	5	5	6	Channel 1 V+
6	6	6	19	Channel 1 V–
7	7	7	7	Channel 2 I+
8	8	8	20	Channel 2 I–
9	9	9	8	Channel 2 V+
10	10	10	21	Channel 2 V–
11	11	11	9	Channel 3 I+
12	12	12	22	Channel 3 I–
13	13	13	10	Channel 3 V+
14	14	14	23	Channel 3 V–
			11	Channel 4 I+
			24	Channel 4 I–
			12	Channel 4 V+
			25	Channel 4 V–
			13	Shield

A.5.2 System Bridge Connections

The black Lemo connector is on the probe head. The "P2–System Bridge" "D" connector is on the Model 6000.

a) Black Lemo connector



b) P2–System bridge port

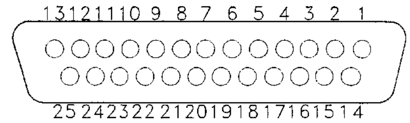


Figure A-5. System bridge connections: a) Black Lemo connector, b) P2–System bridge port

Table A-2. System bridge connections

BLACK LEMO CONNECTOR	P2–SYSTEM BRIDGE "D" CONNECTOR	SYSTEM BRIDGE BOARD FUNCTION
8	3	Cur Driver Ch3+ (Block Heater)
7	16	Cur Driver Ch3– (Block Heater)
2	4	Cur Driver Ch4+ (Neck Heater)
1	17	Cur Driver Ch4– (Neck Heater)
14	5	Channel 1 I+
13	18	Channel 1 I–
12	6	Channel 1 V+
11	19	Channel 1 V–
6	7	Channel 2 I+
5	20	Channel 2 I–
4	8	Channel 2 V+
3	21	Channel 2 V–
16	9	Channel 3 I+
15	22	Channel 3 I–
9	10	Channel 3 V+
10	23	Channel 3 V–
	11	Channel 4 I+
	24	Channel 4 I–
	12	Channel 4 V+
	25	Channel 4 V–
	13	Shield

A.5.3 Communication Port Connections (GPIB)

The "P4–IEEE488" port is on the Model 6000.

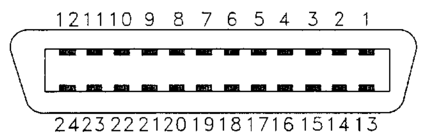


Figure A-6. GPIB communication port connections

Table A-3. Communication port connections (GPIB)

P4–IEEE488 CONNECTOR	GPIB FUNCTION
1	DIO1
2	DIO2
3	DIO3
4	DIO4
5	EOI
6	DAV
7	NRFD
8	NDAC
9	IFC
10	SRQ
11	ATN
12	SHLD
13	DIO5
14	DIO6
15	DIO7
16	DIO8
17	REN
18	GND
19	GND
20	GND
21	GND
22	GND
23	GND
24	GND

A.5.4 Communication Port Connections (RS-232)

The "P5–RS232" port is on the Model 6000.

P5-RS232 port

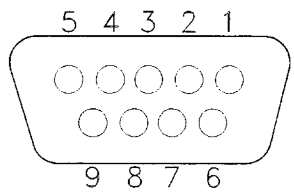


Figure A-7. RS-232 communication port connections

Table A-4. Communication port connections (RS-232)

P5–RS232 CONNECTOR	RS-232 FUNCTION
1	DCD
2	RXD
3	TXD
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	TRIG

A.5.5 Dewar Connections

The blue Lemo connector is on the probe head. The "P6–Dewar" port is on the Model 6000.

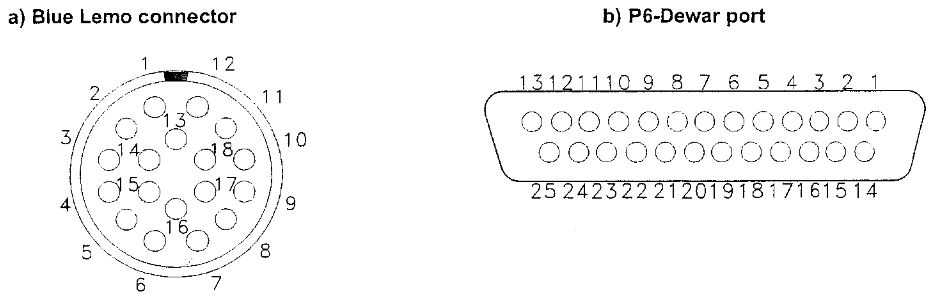


Figure A-8. Dewar connections: a) Blue Lemo connector, b) P6-Dewar port

Table A-5. Dewar connections

BLUE LEMO CONNECTOR	P6–DEWAR "D" CONNECTOR	FUNCTION
11	1	Level Meter +I
12	14	Level Meter –I
1	2	Level Meter +V
2	15	Level Meter –V
7	3	Impedance Htr Drv
8	16	Impedance Htr Rtn
9	4	Impedance Therm +
10	17	Impedance Therm –
15	5	Persist Switch Drv
16	18	Persist Switch Rtn
3	6	Mag Quench Htr (AC)
4	19	Mag Quench Htr (AC)
5	7	Magnet V+
6	20	Magnet V–
17	8	Magnet Trim +
18	21	Magnet Trim –
13	9	Special Function +
14	22	Special Function –
	10	Dewar Spare A
	23	Dewar Spare B
	11	Dewar Spare C
	24	Dewar Spare D
	12	Dewar Spare E
	25	Dewar Spare F
	13	Shield

A.5.6 Magnet Connections (Model 6700 to Model 6000)

The "M1" connector is on the Model 6700. The "P7–Magnet" port is on the Model 6000.

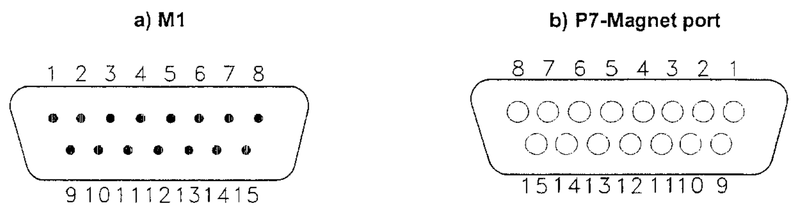


Figure A-9. Magnet connections: a) M1, b) P7-Magnet port

Table A-6. Magnet connections (Model 6700 to Model 6000)

M1 "D" CONNECTOR	P7–MAGNET "D" CONNECTOR	FUNCTION
1	1	Digital Gnd
2	2	Data Out
3	3	Sys Sync
4	4	Reset
5	5	Return (15 V)
6	6	–24 V
7	7	Magnet V+
8	8	Shield
9	9	Clock
10	10	Magnet Sel
11	11	Data In
12	12	+15 V
13	13	–15 V
14	14	Return (–24 V)
15	15	Magnet V–

A.5.7 Magnet Connections (Probe to Controller)

The magnet connector is on the probe head. Recent systems use a TCM connector and earlier systems use a red Lemo. The magnet current port is on the Model 6700.

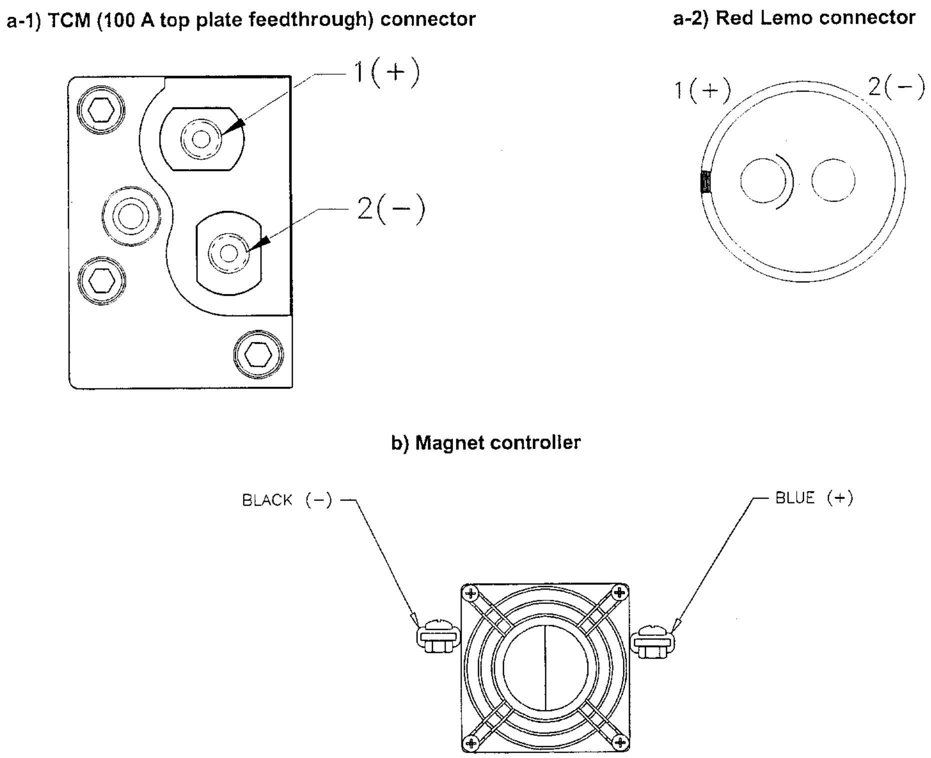


Figure A-10. Magnet connections: a-1) TCM (100 A Top plate feedthrough) connector or a-2) Red Lemo connector and b) Magnet controller

Table A-7. Magnet connections (probe to controller)

MAGNET CONNECTION	CONNECTOR	MAGNET CURRENT	FUNCTION
Red Lemo	1	Mag + (red- or blue-banded cable)	Current +
	2	Mag – (black cable)	Current –
TCM (100 A Top plate feedthrough)	1	Mag + (blue-banded cable)	Current +
	2	Mag – (black cable)	Current –

A.5.8 Expansion Connections (Auxiliary)

The "P8–Auxiliary" port is on the Model 6000.

P8–Auxiliary port

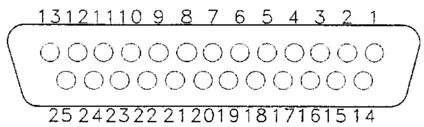


Figure A-11. Auxiliary expansion connections

Table A-8. Expansion connections (auxiliary)

P8–AUXILIARY "D" CONNECTOR	FUNCTION
1	Aux Drive 1
14	Aux Rtn 1
2	Aux Drive 2
15	Aux Rtn 2
3	Aux Drive 3
16	Aux Rtn 3
4	+15 V Out
17	–15 V Out
5	15 V Com
18	Sense 1
6	Sense 2
19	Sense Gnd
7	Sig In 1
20	Sig In 2
8	Sig In Gnd
21	Spare 1
9	Spare 2
22	Spare 3
10	Spare 4
23	Spare 5
11	Spare 6
24	Spare 7
12	Hi Vac Solenoid
25	Hi Vac Solenoid
13	Shield

A.5.9 Expansion Connections (Pressure Gauge)

The “P9–Pressure” port is on the Model 6000.

P9–Pressure port

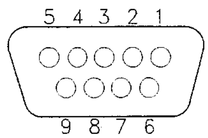


Figure A-12. Pressure gauge expansion connections

Table A-9. Expansion connections (pressure gauge)

P9–PRESSURE “D” CONNECTOR	GAUGE AND FUNCTION
1	Pirani Sig
6	Pirani Rtn
2	Baratron Sig
7	Baratron Rtn
3	+15 V
8	–15 V
4	Pwr Common
9	NC
5	NC

A.5.10 Expansion Connections (Motor)

The "P10–Motor" port is on the Model 6000.

P–10 Motor port

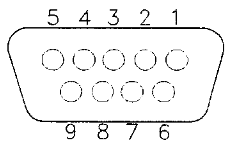


Figure A-13. Motor expansion connections

Table A-10. Expansion connections (motor)

P10–MOTOR "D" CONNECTOR	FUNCTION
1	Pos Ph1
6	Pos Ph2
2	Pos Ph3
7	Pos Ph4
3	Act Drv
8	Act Gnd
4	Limit 1 (Limit)
9	Limit 2 (Index)
5	Limit Gnd

A.5.11 Expansion Connections (External)

The "P11–External" port is on the Model 6000.

P11-External port

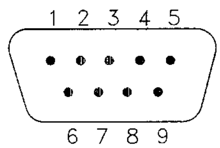


Figure A-14. External expansion connections

Table A-11. Expansion connections (external)

P11–EXTERNAL "D" CONNECTOR	FUNCTION
1	Select 1 (C)
6	Select 1 (E)
2	Select 2 (C)
7	Select 2 (E)
3	Select 3 (C)
8	Select 3 (E)
4	+5 V In
9	Busy 1 In (Hold)
5	Busy 2 In (User)

A.6 Replacement Fuse Values

Tables A-12 and A-13 list the manufacturers' recommended replacement fuse values. The Quantum Design stock number for each fuse is shown in the far-right column of each table.

Table A-12. Replacement fuse values for 100–120 VAC systems

HARDWARE	PORT	FUSE VALUE AND SIZE	QUANTUM DESIGN STOCK NUMBER
Model 6000	Pwr Entry Module Sys Aux Quench Heater	2 A, 5 × 20 mm Delayed Acting 5 A, 1¼ in. Fast Acting 2 A, 1¼ in. Fast Acting .63 A, 5 × 20 mm Delayed Acting	FD2A-20MM F35 F2.0A FD.63A-20MM
50-A Magnetic Power Supply	Pwr Entry Module	5 A, 5 × 20 mm Slow Blow	F5-20MMSB
100-A Magnetic Power Supply	Pwr Entry Module	10 A, 5 × 20 mm Slow Blow	F10-20MMSB
ACMS	Pwr Entry Module	1 A, 250 V, (20 mm) Delayed Acting	FD1A-20MM
ACT	Pwr Entry Module	1 A, 250 V, (20 mm) Delayed Acting	FD1A-20MM
Option Controller	Pwr Entry Module	1 A, 5 × 20 mm Fast Acting	F1-20MM
High Vacuum Cntr	Pwr Entry	3.15 A, 5 × 20 mm Slow Blow	FD3.15A-20MM

Table A-13. Replacement fuse values for 200–240 VAC systems

HARDWARE	PORT	FUSE VALUE AND SIZE	QUANTUM DESIGN STOCK NUMBER
Model 6000	Pwr Entry Module Sys Aux Quench Heater	1 A, 5 × 20 mm Delayed Acting 5 A, 1¼ in. Fast Acting 2 A, 1¼ in. Fast Acting .63 A, 5 × 20 mm Delayed Acting	FD1A-20MM F35 F2.0A FD.63A-20MM
50-A Magnetic Power Supply	Pwr Entry Module	2.5 A, 5 × 20 mm Slow Blow	FD2.5-20MMSB
100-A Magnetic Power Supply	Pwr Entry Module	5 A, 5 × 20 mm Slow Blow	FD5-20MMSB
ACMS	Pwr Entry Module	.5 A, 250 20 mm Delayed Acting	FD05A (.5A)
ACT	Pwr Entry Module	.63 A, 5 × 20 mm Slow Blow	FD.63A-20MM
Option Controller	Pwr Entry Module	.5 A, 5 × 20 mm Fast Acting	F.5-20MM
High Vacuum Cntr	Pwr Entry	3.15 A, 5 × 20 mm Slow Blow	FD3.15A-20MM

A P P E N D I X B

Filling Warm Dewars

B.1 Introduction

This appendix contains the following information:

- Section B.2 presents an overview of helium and nitrogen transfers into a warm dewar.
- Section B.3 explains how to transfer helium and nitrogen into warm nitrogen-jacketed dewars.
- Section B.4 explains how to transfer helium into a warm standard dewar (no nitrogen jacket).

B.2 Helium and Nitrogen Transfers into Warm Dewars

WARNING!

- Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid nitrogen, liquid helium, or any other cryogen. Review Section 1.4.1, "Cryogens," before you transfer liquid nitrogen.
- Always use a well-ventilated room to perform these procedures.
- Immediately vent the room by opening windows and doors if there is an excessive helium release.

The procedures in this appendix explain how to fill a "warm" dewar, which refers to situations in which the PPMS dewar has never been filled with helium or the dewar has been unused for an extended period of time and is dry. If there is any liquid helium in the dewar, use the routine transfer procedures described in Sections 4.7.2.

These warm-dewar-fill procedures include safeguards to prevent frozen contaminants from blocking the impedance tube—such a blockage would disable temperature control in the PPMS. To use these procedures, you must have installed the probe in the dewar and connected the system pumping lines and electrical lines, as shown in Figure A-1. The magnet and user bridgeboard connections are not necessary to perform a dewar fill, but they are needed to use the system fully.

If you are not experienced at transferring liquid helium, ask for help from someone who is familiar with the liquid-helium supply vessel. At the least, read over these instructions to familiarize yourself with the process and materials before you begin the helium transfer.

B.2.1 Nitrogen-Jacketed Dewars

There are two methods for refilling a warm nitrogen-jacketed dewar. The quickest method involves a simultaneous transfer of liquid nitrogen and liquid helium (Section B.3.1). The other method minimizes helium loss during the transfer by using a sequential transfer of liquid nitrogen and liquid helium (Section B.3.2). The sequential procedure requires a continuous flow of helium gas through the probe impedance tube during the liquid-nitrogen transfer and for a subsequent 8–12 hour cooling period.

B.2.2 Standard Dewars

To fill a warm standard dewar (no nitrogen jacket), use the instructions in Section B.4.

B.2.3 Materials

- Rubber or plastic tubing, 1–2 m
- A helium backfill adapter (sequential transfer only)
- A helium transfer line with input extension and long output extension, an output adapter, and an input adapter (see Figure B-1)

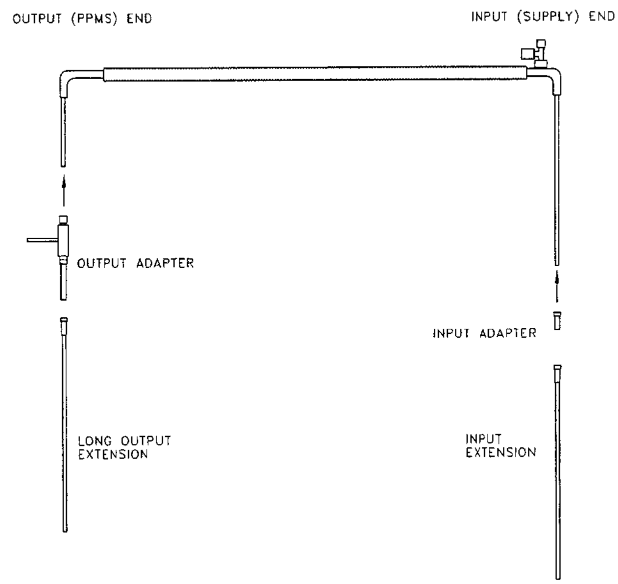


Figure B-1. Helium transfer line arrangement

- A liquid-helium supply dewar for filling the dewar, 100 liters, except systems with magnets, 14 T and above, which need 200 liters.
- A helium-gas cylinder (standard size) to pressurize the liquid-helium supply dewar or to provide a helium backfill. For systems with an EverCool dewar, this cylinder is in addition to the helium-gas supply cylinder that is used to replenish the system.
- A liquid-nitrogen supply dewar (nitrogen jacketed dewars only), about 80 liters.
- A liquid-nitrogen transfer adapter (included with the nitrogen-jacketed dewars)
- A liquid-nitrogen supply line (*not* included with the nitrogen-jacketed dewars)
- An optional warm air blower for removing hardware (nitrogen-jacketed dewars only)
- Rags to wipe up liquids, such as condensed water from the air

Important: If you do not have a Quantum Design helium-transfer kit, your hardware might differ from the hardware described in this appendix.

B.3 Warm Fill: Nitrogen-Jacketed Dewars

WARNING!

Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium or any other cryogen. Review Section 1.4.1, "Cryogens," before you transfer liquid helium.

B.3.1 Simultaneous Nitrogen and Helium Transfer

You can save time by filling the nitrogen jacket and helium dewar belly simultaneously. Note that more helium will boil away during a simultaneous transfer than during a sequential transfer (Section B.3.2), but a sequential transfer includes an 8–12 hour waiting period that is not needed for a simultaneous transfer.

The procedures for a simultaneous transfer are not difficult but involve many steps. To facilitate a trouble-free transfer, we recommend that you review the entire set of instructions before you begin. As noted in Section B.2.3, "Materials," you will be working with transfer lines and valves for three dewars (the PPMS dewar, a liquid-nitrogen supply dewar, and a liquid-helium supply dewar) as well as a helium-gas supply cylinder. The transfer setup is shown below in Figure B-2 (the liquid-nitrogen dewar is not shown). The entire process will be easier if there are two people.

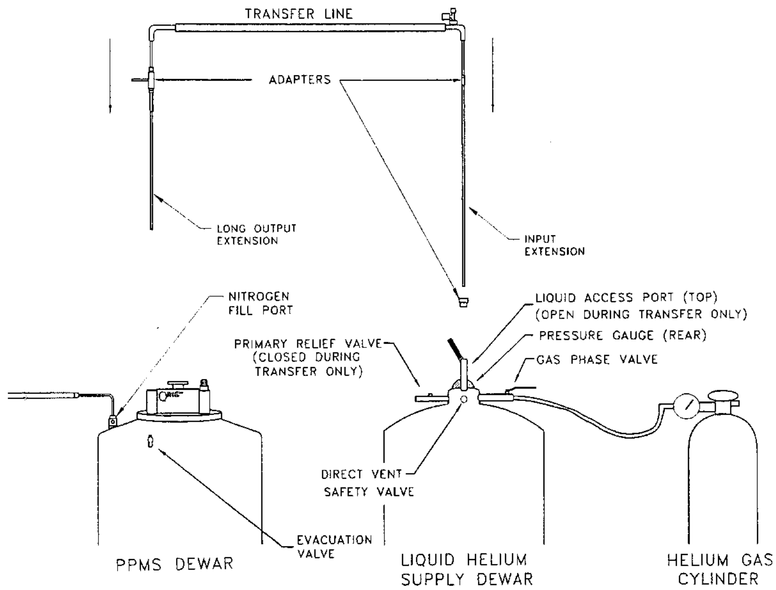


Figure B-2. Arrangement for the simultaneous transfer of nitrogen and helium into a warm nitrogen-jacketed dewar. The supply line for liquid nitrogen is indicated at the left of the figure (nitrogen cylinder is not shown).

Set Up

1. Verify that the system pump and the Model 6000 are turned on and operating properly. If either the pump or the Model 6000 is turned off, turn it on. If either the pump or the Model 6000 is on but appears to be malfunctioning, contact a Quantum Design representative.
2. Using the Model 6000 or the MultiVu **Temperature** dialog shown in Figure B-3 (**Instrument** >> **Temperature**), set the temperature to 5 K, the rate to 10 K/min, and the approach mode to fast settle.

   By setting the temperature to 5 K, you open the flow-control valve and ensure the maximum flow through the impedance tube. Maximum flow is necessary to flush out the impedance and keep contaminants from freezing inside it while it cools to cryogenic temperatures. (The temperature will not actually drop to 5 K because there is no liquid helium in the dewar.)

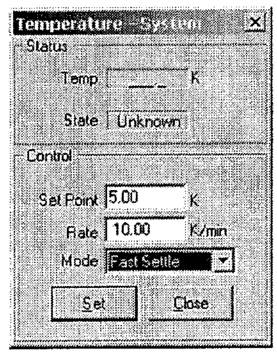


Figure B-3. **Temperature** dialog and settings for helium transfer

3. At the PPMS dewar, prepare to attach the transfer hoses:
   a. Remove the brass fittings from one of the two liquid-nitrogen fill ports by turning the large fitting counter-clockwise until it comes off the dewar. This prevents the O-ring from freezing.
   b. Open the other nitrogen fill port by turning the large brass fitting counter-clockwise to loosen it and then removing the small insert plug when it is loose (see Figure B-4).

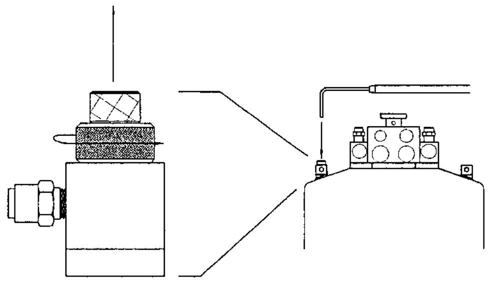


Figure B-4. Preparing for a liquid-nitrogen transfer

4. Screw the liquid-nitrogen transfer adapter onto the end of the liquid-nitrogen supply line.
5. At the PPMS dewar, insert the small end of the liquid-nitrogen transfer adapter into the open liquid-nitrogen fill port and turn the brass fitting clockwise to secure the adapter in place. *Do not begin transferring nitrogen yet*—leave the nitrogen supply line closed.
6. Bring the liquid-helium supply dewar close to the PPMS dewar.
7. Verify that the proper adapters and extensions are installed on the helium transfer line (see Figure B-1). Note that the long extensions perform an essential function: The extension on the input line ensures that liquid can always enter the transfer line, even as the liquid level in the dewar changes. The extension on the output line forces liquid helium all the way to the bottom of the PPMS dewar, so that escaping cold gas will cool all the system components before it leaves the dewar.
8. At the liquid-helium supply dewar, set the valves and liquid access port:
   a. Vent the pressure by slightly opening the gas-phase valve.
   b. Close the gas-phase valve after the pressure has been reduced.
   c. Open the liquid access port. *This port is open only during the transfer.*
   d. Close the primary relief valve. *This valve remains closed only during the transfer.*
9. At the PPMS dewar, open one of the two helium fill ports on the probe head by pulling the entire fill-port fixture straight up (see Figure 4-19).
10. Simultaneously insert (a) the output end of the transfer line into the PPMS dewar through the open helium fill port and (b) the input end of the transfer line into the liquid-helium supply dewar through the liquid access port (see Figures B-1 and B-2).
11. Carefully lower both ends of the transfer line completely into the dewars and seat the adapters in their respective ports. Gas will begin flowing from the output adapter. Point the output-adapter-exhaust-tube ***away*** from all hardware on top of the dewar. The exhaust will get extremely cold and could damage some of the parts, especially O-rings and sealed valves.

CAUTION!

Point the output-adapter-exhaust-tube ***away*** from all hardware on the dewar and probe head. The extremely cold exhaust can damage parts, especially O-rings and sealed valves.

12. Verify that each adapter on the transfer line is properly seated and is sealing the transfer line.

13. Raise the input side of the transfer line about 1 cm (1/2 in.) off the bottom of the supply dewar so that it does not collect ice or other debris that might have settled on the bottom.
14. Using rubber or plastic tubing, connect a helium-gas cylinder to the gas-phase port on the liquid-helium supply dewar.

Transfer

1. At the liquid-helium supply dewar, open the gas-phase valve.
2. At the helium-gas cylinder, open the regulator and adjust the pressure to approximately 7 kPa (1 psi). This pressurizes the supply dewar and maintains positive flow from the supply dewar to the PPMS dewar.
3. Keep the dewar pressurized this way for 2 minutes before you perform Step 4.
4. Use the **Chamber** dialog in MultiVu (select **Instrument** >> **Chamber** >> **Purge/Seal**) or the Model 6000 (**CTRL** >> **1. Interactive Control** >> **2. Purge & Seal)** to remove air from the sample chamber.
5. At the liquid-nitrogen supply dewar, open the liquid supply valve. Exhaust should begin coming from the second nitrogen fill port on the PPMS dewar.
6. At the PPMS dewar, visually monitor the exhaust from the second nitrogen fill port during the entire fill process. *Do not leave the PPMS unattended during this step, and always stand at least 0.5 m (1.5 ft) from the exhaust plume.*
7. Monitor the helium transfer with the **Liquid Helium Fill Status** dialog (in MultiVu select **Utilities** >> **Helium Fill**) or through the Model 6000 (select **CTRL** >> **1. Interactive Control** >> **0. Fill Dewar**).
8. At the liquid-nitrogen supply dewar, close the liquid supply valve when the exhaust turns to liquid (this indicates that the nitrogen jacket is full). It will take about 1 hour to fill the jacket of a warm dewar, because most of the liquid nitrogen will evaporate until the jacket walls have cooled.

   Note: The dewar belly will take slightly longer to fill than the nitrogen jacket, because helium has a lower boiling point than nitrogen. The helium-level reading will be negative until the helium in the dewar has reached the base of the helium-level meter.
9. When the helium level reads 30–40%, the impedance tube will no longer be exposed. You can then set a system temperature so that the PPMS will be ready to use when the transfer procedures have been completed.

CAUTION!

Let the liquid-helium level reading reach 30–40% before you change the PPMS set-point temperature.

Shut Off and Disassembly

1. When the liquid-helium level reaches 97–100% in the PPMS dewar (after about 1 hour), close the regulator at the helium-gas cylinder to stop the transfer.
2. At the liquid-helium supply dewar, reset the valves:
   a. Close the gas-phase valve.
   b. Open the primary relief valve.
3. Remove the helium transfer line and adapters from the liquid-helium supply dewar and the PPMS dewar.

4. At the PPMS dewar, close the helium fill port on the probe head by reinserting the relief valve.
5. At the liquid-helium supply dewar, close the valve on the liquid access port.
6. At the PPMS dewar, perform in sequence the steps below:
   a. Put on your protective gear. This gear is necessary to prevent serious burns from the extremely cold fitting, supply line, and transfer adapter.
   b. Remove the liquid-nitrogen transfer adapter by turning the brass fitting counter-clockwise and lifting the transfer adapter out of the dewar.

      In the event that the fitting and adapter are frozen together, you can use a warm air blower to accelerate the thawing process. Otherwise, you must wait until the parts thaw enough to be separated.
   c. Close both nitrogen fill ports by reinstalling the brass fittings and turning the large brass fittings clockwise.

CAUTION!

Always re-install the fill-port fittings and/or O-rings onto the nitrogen fill ports after you have transferred liquid nitrogen into the dewar. These fittings prevent dangerous ice blockages in the fill ports.

7. The liquid-helium transfer is now complete. The helium-level meter will turn itself off when you exit the **Fill Dewar** screen or if the fill time exceeds 30 minutes.

B.3.2 Sequential Nitrogen and Helium Transfers

You can conserve liquid helium by cooling the system before you perform the helium transfer. To do this, you fill the liquid-nitrogen jacket and then let the system sit for 8–12 hours before you transfer in the liquid helium.

Important: When you transfer nitrogen and helium separately, you must maintain a continuous flow of helium through the impedance tube so that ice does not form within the tube. The procedures below will ensure a continuous helium flow.

The procedures for a sequential transfer are not difficult but involve many steps. To facilitate a trouble-free transfer, we recommend that you review the entire set of instructions before you begin. As noted in Section B.2.3, "Materials," you will be working with transfer lines and valves for three dewars (the PPMS dewar, a liquid-nitrogen supply dewar, and a liquid-helium supply dewar) and a helium-gas cylinder. The transfer setup is shown below in Figure B-5 (the liquid-nitrogen dewar is not shown). The entire process will be easier if there are two people.

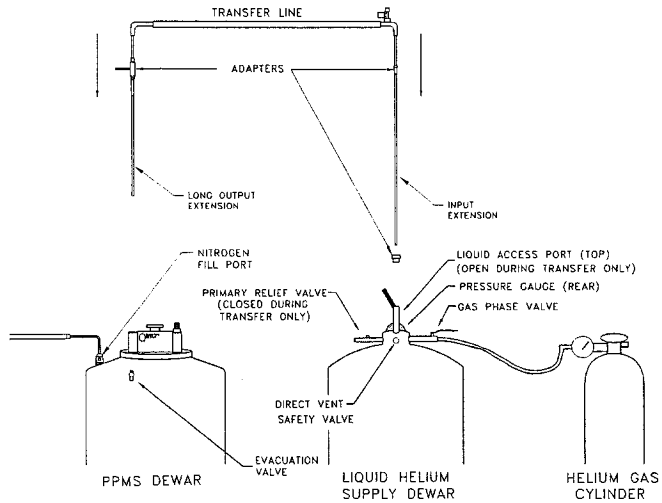


Figure B-5. Arrangement for sequential transfer of nitrogen and helium into warm nitrogen-jacketed dewar, with the supply line for liquid nitrogen indicated at left of figure (nitrogen cylinder is not shown)

Set Up

1. Verify that the system pump and the Model 6000 are turned on and operating properly. If either the pump or the Model 6000 is on but appears to be malfunctioning, contact a Quantum Design representative.
2. Using rubber or plastic tubing, connect a helium backfill adapter to a helium-gas cylinder, as shown in Figure B-6. The helium backfill adapter is a fixture that fits into one of the helium fill ports on the probe head. The helium-gas cylinder provides the helium backfill during the liquid-nitrogen transfer and during the dewar cool-down period.
3. Open one of the two helium fill ports on the probe head by pulling the relief valve straight up, as shown in Figure 4-19.
4. Insert the helium backfill adapter into the helium fill port. Verify that the adapter fits snugly.

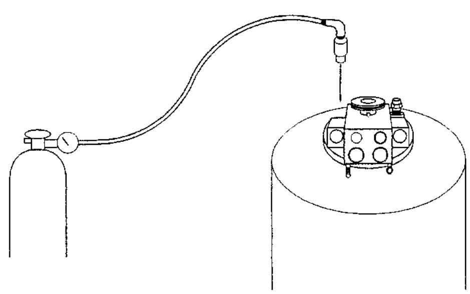


Figure B-6. Inserting a helium backfill adapter

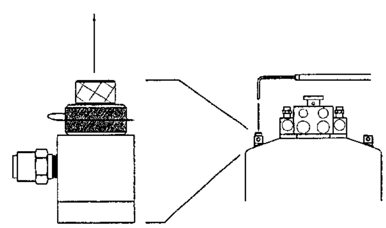


Figure B-7. Preparing for a liquid-nitrogen transfer

5. At the PPMS dewar, prepare for the liquid-nitrogen transfer:
   a. Remove the brass fittings from one of the two liquid-nitrogen fill ports by turning the large fitting counter-clockwise until it comes off the dewar (see Figure B-7). This will prevent the O-ring from freezing.
   b. Open the other nitrogen fill port by turning the large brass fitting counter-clockwise to loosen it and then removing the small insert plug when it is loose.

6. Screw the liquid-nitrogen transfer adapter onto the end of the nitrogen supply line.
7. At the PPMS dewar, insert the small end of the liquid-nitrogen transfer adapter into the open liquid-nitrogen fill port and turn the brass fitting clockwise to secure the adapter in place.
8. Using the Model 6000 or the MultiVu **Temperature** dialog shown in Figure B-3 (**Instrument** >> **Temperature**), set the temperature to 5 K, the rate to 10 K/min, and the approach mode to fast settle.

   By setting the temperature to 5 K you open the flow-control valve to ensure the maximum flow through the impedance tube. Maximum flow is necessary to flush out the impedance and keep contaminants from freezing inside it while it cools to cryogenic temperatures. The temperature will not actually drop to 5 K because there is no liquid helium in the dewar.
9. At the helium-gas cylinder, prepare it to act as a backfill:
   a. Open the regulator to allow helium gas into the dewar and through the impedance tube.
   b. Adjust the regulator on the helium-backfill cylinder so that gaseous helium is expelled from the 1/3-psi relief valve (the hose nipple on the back of the probe head) and from the 1-psi relief valve (on the closed helium fill port).
   c. Keep the dewar pressurized this way for 2 minutes before you proceed.
10. Use the **Chamber** dialog in MultiVu (select **Instrument** >> **Chamber** >> **Purge/Seal**) or the Model 6000 (**CTRL** >> **1. Interactive Control** >> **2. Purge & Seal**) to remove air from the sample chamber.
11. At the helium-backfill cylinder, adjust the regulator so that helium is expelled from only the hose nipple. Place a wetted finger in front of the hose nipple to verify that helium is exiting there.

Nitrogen Transfer

1. At the liquid-nitrogen supply dewar, open the valve on the nitrogen supply line. Exhaust should begin coming from the second nitrogen fill port on the PPMS dewar.
2. At the PPMS dewar, visually monitor the exhaust from the second nitrogen fill port during the entire fill process. *Do not leave the PPMS unattended during this step, and always stand at least 0.5 m (1.5 ft.) from the exhaust plume.*

   Important: Periodically check the flow from the helium-backfill cylinder by placing a wetted finger in front of the hose nipple on the probe head. If helium is not being released from the 1/3-psi relief valve behind this fixture, increase the flow of helium by adjusting the regulator of the helium-gas cylinder.
3. At the liquid-nitrogen supply dewar, close the liquid supply valve on the nitrogen-supply-line when the exhaust turns to liquid (this indicates that the jacket is full). It will take about 1 hour to fill the jacket of a warm dewar, because most of the liquid nitrogen will evaporate until the jacket walls have cooled.
4. At the PPMS dewar, remove the liquid-nitrogen transfer adapter and re-install the nitrogen fill-port fittings:
   a. Put on your protective gear so that you do not receive serious burns from the extremely cold fitting, supply line, and transfer adapter.
   b. Remove the liquid-nitrogen transfer adapter by turning the brass fitting counter-clockwise and lifting the transfer adapter out of the dewar.

      In the event that the fitting and adapter are frozen together, you can use a warm air blower to accelerate the thawing process. Otherwise, you must wait until the parts thaw enough to be separated.
   c. Close both nitrogen fill ports by reinstalling the brass fittings and turning the large brass fittings clockwise.

CAUTION!

Always re-install the fill-port fittings and/or O-rings onto the nitrogen fill ports after you have transferred liquid nitrogen into the dewar. These fittings prevent dangerous ice blockages in the fill ports.

   d. Periodically hold a wetted finger in front of the hose nipple on the probe head to verify that the helium-backfill cylinder is still providing helium to the dewar.

5. Leave the system standing for 8–12 hours with a full nitrogen jacket and an active helium-backfill cylinder.

   Important: To avoid excessive helium loss, you should allow 8–12 hours (24 hours is optimal) for the dewar and probe to cool before you begin to transfer liquid helium.

Helium Transfer

1. Verify that the system pump and the Model 6000 are turned on and operating properly. If either the pump or the Model 6000 is turned off, turn it on. If either the pump or the Model 6000 is on but appears to be malfunctioning, contact a Quantum Design representative.
2. Using the Model 6000 or the MultiVu **Temperature** dialog shown in Figure B-3 (**Instrument** >> **Temperature**), set the temperature to 5 K, the rate to 10 K/min, and the approach mode to fast settle.

   By setting the temperature to 5 K, you open the flow-control valve and ensure the maximum flow through the impedance tube. Maximum flow is necessary to flush out the impedance and keep contaminants from freezing inside it while it cools to cryogenic temperatures. (The temperature will not actually drop to 5 K because there is no liquid helium in the dewar.)
3. Bring the liquid-helium supply dewar close to the PPMS dewar.
4. Verify that the proper adapters and extensions are installed on the helium transfer line (see Figures B-1 and B-5). Note that the long extensions perform an essential function: The long extension on the input line ensures that liquid can always enter the transfer line, even as the liquid level in the storage dewar changes. The long extension on the output line forces liquid helium to the bottom of the PPMS dewar so that escaping cold gas will cool all the system components before it leaves the dewar.
5. At the liquid-helium supply dewar, set the valves and liquid access port:
   a. Vent the pressure by slightly opening the gas-phase valve.
   b. After the pressure has been vented, close the gas-phase valve.
   c. Open the liquid access port. *This port is open only during the transfer.*
   d. Close the primary relief valve. *This valve remains closed only during the transfer procedure.*
6. At the helium-backfill cylinder, close the regulator.
7. At the liquid-helium supply dewar, insert the input end of the transfer line into the liquid access port (see Figures B-1 and B-5)
8. At the PPMS dewar, remove the helium backfill adapter from the helium fill port on the probe head. Then, quickly insert the output end of the transfer line into the PPMS dewar through the open helium fill port.
9. Carefully lower both ends of the transfer line completely into the dewars and seat the adapters in their respective ports. When gas begins to flow from the output adapter, point the output-adapter-exhaust-tube ***away*** from all hardware on top of the dewar. The exhaust will be extremely cold and it could damage some of the parts, especially O-rings and sealed valves.

CAUTION!

Point the output-adapter-exhaust-tube ***away*** from all hardware on the dewar and probe head. The extremely cold exhaust can damage parts, especially O-rings and sealed valves.

10. Verify that each adapter on the transfer line is properly seated and is sealing the transfer line.
11. Raise the input side of the transfer line about 1 cm (1/2 in.) off the bottom of the supply dewar so that it does not collect ice or other debris that might have settled on the bottom.
12. At the liquid-helium supply dewar, prepare for the transfer:
    a. Connect the helium-gas cylinder to the gas-phase port.
    b. Open the gas-phase valve.
13. At the helium-gas cylinder, open the regulator and adjust the pressure to approximately 7 kPa (1 psi).
14. Monitor the helium transfer with the **Liquid Helium Fill Status** dialog (in MultiVu select **Utilities** >> **Helium Fill**) or through the Model 6000 (select **CTRL** >> **1. Interactive Control** >> **0. Fill Dewar**). The helium-level reading will be negative until the helium in the dewar has reached the base of the helium-level meter.

    Note: The dewar belly will take slightly longer to fill than the jacket, because helium has a lower boiling point than nitrogen.
15. When the helium-level meter reads 30–40%, the impedance tube will no longer be exposed. You can then set a system temperature so that the PPMS will be ready to use when the transfer procedures have been completed.

CAUTION!

Let the liquid-helium level reading reach 30–40% before you change the PPMS temperature set point.

Shut Off and Disassembly

1. When the helium level reaches 97–100% (after about 1 hour), close the regulator of the helium-gas cylinder to stop the transfer.
2. At the liquid-helium supply dewar, reset the valves:
    a. Close the gas-phase valve.
    b. Open the primary relief valve.
3. Remove the transfer line and adapters from the liquid-helium supply dewar and the PPMS dewar.
4. At the PPMS dewar, close the helium fill port on the probe head by reinserting the relief valve.
5. At the liquid-helium supply dewar, close the liquid access port.

The liquid-helium transfer is now complete. The helium-level meter will turn itself off when you exit the **Fill Dewar** screen or if the fill time exceeds 30 minutes.

B.4 Warm Fill: Standard Dewars

WARNING!

- ◇ Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium or any other cryogen. Review Section 1.4.1, "Cryogens," before you transfer liquid helium.
- ◇ Always use a well-ventilated room to perform this procedure.
- ◇ Immediately vent the room by opening windows and doors if there is an excessive helium release.

The procedures for a filling a warm standard (non-nitrogen jacketed) dewar with liquid helium are not difficult but involve many steps. Quantum Design staff strongly recommend that you read the entire set of procedures before beginning the transfer. As noted in Section B.2.3, "Materials," you will be working with transfer lines and valves for two dewars (the PPMS dewar and a liquid-helium supply dewar) and a helium-gas supply cylinder. The transfer setup is shown below in Figure B-8. Your preparation will facilitate the process, which also will be smoother if there are two people.

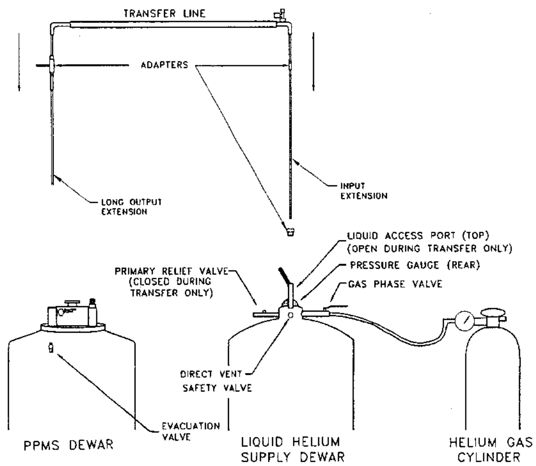


Figure B-8. Liquid-helium transfer arrangement for transferring helium into a warm non-jacketed dewar

Set Up

1. Verify that the system pump and the Model 6000 are turned on and operating properly. If either the pump or the Model 6000 is on but appears to be malfunctioning, contact a Quantum Design representative.
2. Using the MultiVu **Temperature** dialog shown in Figure B-3 (**Instrument >> Temperature**) or the Model 6000, set the temperature to 5 K, the rate to 10 K/min, and the approach mode to fast settle.

   By setting the temperature to 5 K you open the flow-control valve and ensure the maximum flow through the impedance tube. Maximum flow is necessary to flush out the impedance and keep contaminants from freezing inside it while it cools to cryogenic temperatures. Note that the temperature will not actually drop to 5 K because there is no liquid helium in the dewar.

3. Bring the liquid-helium supply dewar close to the PPMS dewar.
4. Verify that the proper adapters and extensions are installed on the helium transfer line (see Figure B-1). Note that the extensions perform an essential function: The long extension on the input line ensures that liquid can always enter the transfer line, even as the liquid level in the storage dewar changes. The long extension on the output line forces liquid helium all the way to the bottom of the PPMS dewar, so that escaping cold gas will cool all the system components before it leaves the dewar.
5. At the liquid-helium supply dewar, set the valves:
   a. Vent the pressure by slightly opening the gas-phase valve.
   b. Close the gas-phase valve after the pressure has been reduced.
   c. Close the primary relief valve. *This valve remains closed only during the transfer.*
6. Using rubber or plastic tubing, connect a helium-gas cylinder to the gas-phase port on the liquid-helium supply dewar.
7. At the PPMS dewar, open one of the two helium fill ports on the probe head by pulling the entire fill-port fixture straight up (see Figure 4-19).
8. At the liquid-helium supply dewar, open the liquid access port. *This port remains open only during the transfer.*
9. Simultaneously insert (a) the output end of the transfer line into the PPMS dewar through the open helium fill port and (b) the input end of the transfer line into the liquid-helium supply dewar through the liquid access port (see Figure B-8).
10. Carefully lower both ends of the transfer line completely into the dewars and seat the adapters in their respective ports. Gas will begin flowing from the output adapter. Point the output-adapter-exhaust-tube ***away*** from all hardware on top of the dewar. The exhaust will get extremely cold and could damage some of the parts, especially O-rings and sealed valves.

CAUTION!

Point the output-adapter-exhaust-tube ***away*** from all hardware on the dewar and probe head. The extremely cold exhaust can damage parts, especially O-rings and sealed valves.

11. Verify that each adapter on the transfer line is properly seated and sealing the transfer line.
12. Raise the input side of the transfer line about 1 cm (1/2 in.) off the bottom of the supply dewar so that it does not collect ice or other debris that might have settled on the bottom.

Transfer

1. At the liquid-helium supply dewar, open the gas-phase valve.
2. At the helium-gas cylinder, open the regulator and adjust the pressure to approximately 7 kPa (1 psi).
3. Keep the dewar pressurized this way for 2 minutes before you proceed.
4. Use the **Chamber** dialog (in MultiVu select **Instrument** >> **Chamber** >> **Purge/Seal**) or the Model 6000 commands (**CTRL** >> **1. Interactive Control** >> **2. Purge & Seal)** to remove air from the sample chamber.
5. Monitor the helium transfer with the **Liquid Helium Fill Status** dialog (in MultiVu select **Utilities** >> **Helium Fill**) or through the Model 6000 (select **CTRL** >> **1. Interactive**

Control >> **0. Fill Dewar**). The helium-level reading will be negative until the helium in the dewar has reached the base of the helium-level meter.

6. When the helium level reads 30–40%, the impedance tube will no longer be exposed. You can then set a system temperature so that the PPMS will be ready to use when the transfer procedures have been completed.

CAUTION!

Let the liquid-helium level reading reach 30–40% before you change the PPMS set-point temperature.

Shut Off and Disassembly

1. When the helium level reaches 97–100%, close the regulator at the helium-gas cylinder to stop the transfer. It takes approximately 1 hour to fill the dewar.
2. At the liquid-helium supply dewar, reset the valves:
   a. Close the gas-phase valve.
   b. Open the primary relief valve.
3. Remove the transfer line and adapters from the PPMS dewar and the liquid-helium supply dewar.
4. At the PPMS dewar, close the helium fill port on the probe head by reinserting the relief valve.
5. At the liquid-helium supply dewar, close the liquid access port.

The liquid-helium transfer is now complete. The helium-level meter will turn itself off when you exit the **Fill Dewar** screen or if the fill time exceeds 30 minutes.

A P P E N D I X C

Vacuum-Pump Assembly Maintenance

C.1 Introduction

This appendix contains the following information:

- Section C.2 provides an overview of the vacuum-pump assembly and its maintenance requirements.
- Section C.3 describes the three types of vacuum pumps provided with the PPMS.
- Section C.4 has instructions for changing the oil and the oil-mist filter cartridge in the rotary vane pump.
- Section C.5 has instructions for changing the activated alumina in the foreline trap.
- Section C.6 is a maintenance record.

C.2 Vacuum-Pump Assembly

The vacuum-pump assembly is located inside the electronics cabinet (see Figure C-1). It includes a rotary-vane pump that uses oil to help pull the vacuum, a foreline trap with activated alumina to filter the intake air, and an oil-mist filter that cleans the exhaust.

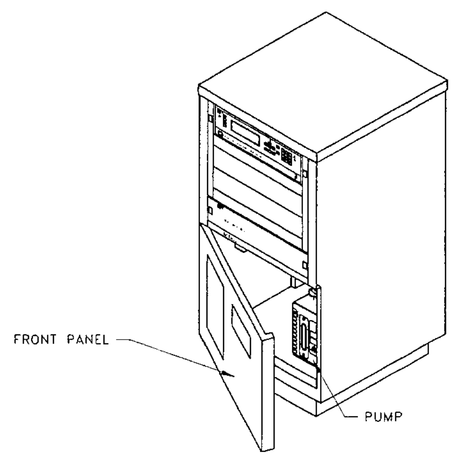


Figure C-1. PPMS electronics cabinet with front panel opened

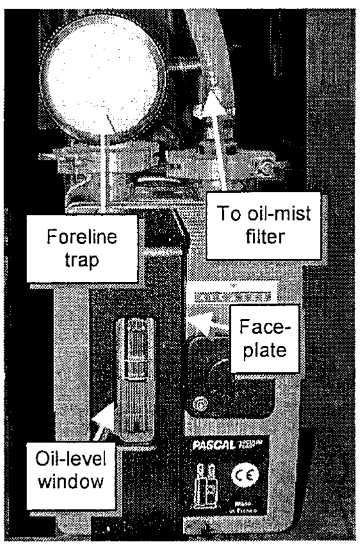
For optimal performance of your system, the pump, oil-mist filter, and foreline trap require regular maintenance, as shown in Table C-1. Instructions for more major types of service are provided here, while instructions for basic services (e.g., adding oil to the pump) are in Chapter 4.

Table C-1. Maintenance schedule for PPMS rotary-vane pumps

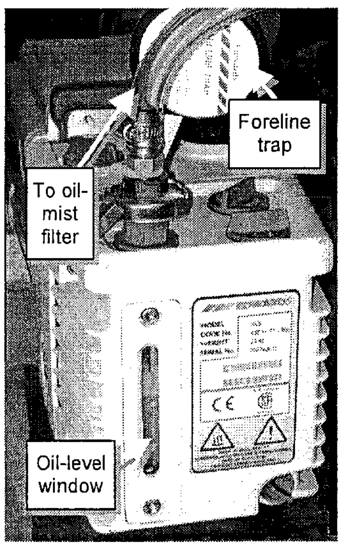
COMPONENT	SERVICE	FREQUENCY
Pump	Check oil level	Check monthly (sooner with heavy use)
	Add oil	When reaches lower part of oil-level window
	Change oil	When dirty, when vacuum is unsatisfactory, or yearly
Oil-mist filter	Dump oil	Check monthly and dump when half full or sooner
	Change cartridge	When saturated with oil
Foreline trap	Check activated alumina	Twice a year
	Change activated alumina	When discolored and yellowish

C.3 Pump Versions

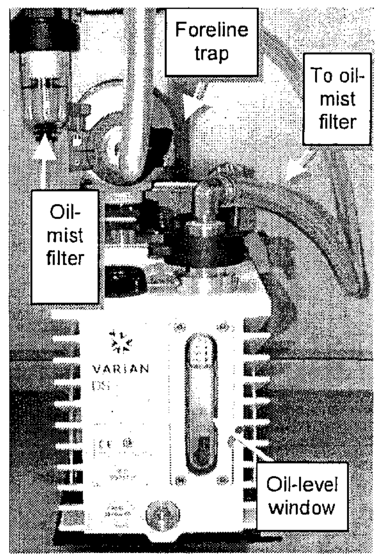
The PPMS is generally equipped with one of three pumps: an Alcatel pump, an Edwards pump, or a Varian pump. Since 1997, all systems have used CE-compliant Edwards or Varian pumps. Figure C-2 shows the three pumps and Table C-2 lists some basic characteristics of each. For detailed information about your pump, refer to the separate vacuum-pump manual that was supplied with the system.



Alcatel rotary-vane pump



Edwards rotary-vane pump



Varian rotary-vane pump

Figure C-2. Versions of the PPMS vacuum pump

Table C-2. Characteristics of vacuum pumps used on the PPMS

COMPONENT	MANUFACTURER		
	Alcatel	**Edwards**	**Varian**
Color	Orange and black	Gray	Ivory and gray
Oil Type	Alcatel 100 Direct Drive Mechanical Vacuum Pump Fluid	Edwards Supergrade "A" oil	Varian General Purpose Mechanical Pump Fluid
Oil Level	Between upper and lower markings, best at 1/2 or more	Between "max" and "min"	Between arrows, best at 1/2 or more
Oil-fill cap	Top foremost cap	Top, front right	Top, front left
Drain plug	Lower plug	Bottom right	Bottom front center

C.4 Changing the Pump Oil and Oil-Mist Cartridge

The pump oil must be changed once a year, unless it is dirty (compare it to clean oil) or the pump is not producing a satisfactory vacuum. In the latter cases, you should immediately change the oil, even if it has been less than a year since the last change. Check the oil-mist cartridge at the same time as the pump-oil levels and change it when it is full of oil. Use the same oil type that was provided with the equipment (see Table C-2).

WARNING!

Put the system in **Shutdown** mode and disconnect the two metal pumping lines before you service the pump or related components. If there are leaks into the sample chamber and cooling annulus, ice can form and cause serious system malfunctions.

C.4.1.1 PREPARE PPMS FOR SERVICE

1. Place the PPMS in **Shutdown** mode (in MultiVu, select **Instrument** >> **Shutdown**). When you place the system in **Shutdown** mode, the software automatically seals the sample chamber, turns off the heaters, and restricts the flow-control valve.
2. Disconnect—but leave seated—the two metal pumping lines that come from the probe head. When the pumping lines are disconnected the sample chamber and cooling annulus are sealed at the probe head.
3. Leaving the rest of the system components turned on, turn off the pump according to the instructions below. If the pump has been in operation, you might need to let it cool before you begin to work on it.
   a. Early PPMS units without a toggle switch on the pump—unplug the pump to turn it off. *Do not turn off the switch on the power strip*—this strip powers other system equipment in addition to the pump.
   b. Recent PPMS units with a toggle switch on the back of the pump—turn off the toggle switch.

4. Open the console cabinet and hold your hand near the pump. If the pump is uncomfortably warm, let it cool before you proceed to the next section.

C.4.1.2 DRAIN PUMP OIL

1. If the system has an Alcatel pump, remove the black faceplate that frames the oil-level window (Figure C-2).
2. Remove the oil-fill cap on the top of the pump. Save the O-ring.
3. Slide the pump forward, out of the cabinet, so the oil will be able to drain into a container.
4. Place an empty container (capacity at least one liter) under the drain plug on the front of the pump.
5. Remove the drain plug and allow the oil to drain completely, lifting the rear of the pump if necessary to empty it.
6. Reinstall the drain plug.

C.4.1.3 DRAIN (REPLACE*)* OIL-MIST FILTER CARTRIDGE

1. Unscrew the bell jar of the oil-mist filter, which is mounted on the inside wall of the electronics cabinet.
2. Pour the oil into the used-oil container.
3. Examine the filter cartridge. If the filter cartridge is not saturated with oil, go to Step 4 of this section. If the filter cartridge is saturated with oil, you must replace it (contact Quantum Design if you need a replacement).
   a. Unscrew the oil-mist filter cartridge.
   b. Lubricate and install the new O-ring (supplied with the cartridge) on the filter.
   c. Lubricate and install the new seal (supplied with the cartridge) for the bell jar.
   d. Screw on the new filter cartridge.
4. Screw the bell jar back into place.

C.4.1.4 FILL AND RE-INSTALL PUMP

1. Fill the pump with oil to the top mark of the oil-level window (*do not overfill*).
2. Reinstall the oil-fill cap.
3. If the system has an Alcatel pump, replace the faceplate that frames the oil-level window (Figure C-2).
4. Slide the pump back into the electronics cabinet.
5. Turn the pump on and wait one minute so that the metal pumping lines can be evacuated. Verify that the pumping lines are seated in their connectors but not pressed in completely.
6. Reconnect the two metal pumping lines to the probe head.
7. Purge and seal the sample chamber.
8. Close the front door of the electronics cabinet.
9. The oil-change procedure is now complete. Please dispose of the used oil properly.

C.5 Servicing the Foreline Trap

The foreline trap acts as the inlet filter for the pump. The filtering component is activated alumina, which needs to be checked twice a year.

WARNING!

Put the system in **Shutdown** mode and disconnect the two metal pumping lines before you service the pump or related components. Any leaks into the sample chamber and cooling annulus can produce ice and serious system malfunctions.

C.5.1.1 PREPARE PPMS FOR SERVICE

1. Open the front panel of the electronics cabinet (Figure C-1).
2. Place the PPMS in shutdown mode (in MultiVu, select **Instrument** >> **Shutdown**). When you place the system in shutdown mode, the software automatically seals the sample chamber, turns off the heaters, and restricts the flow-control valve.
3. Disconnect—but leave seated—the two metal pumping lines from the probe head. This seals the sample chamber and cooling annulus at the probe head.
4. Leaving the rest of the system components turned on, turn off the pump according to the instructions below. If the pump has been in operation, you might need to let it cool before you work on it.
   a. Early PPMS units without a toggle switch on the pump—unplug the pump to turn it off. *Do not turn off the switch on the power strip*—this strip powers other system equipment in addition to the pump.
   b. Recent PPMS units with a toggle switch on the back of the pump—turn off the toggle switch.
5. Open the console cabinet and hold your hand near the pump. If the pump is uncomfortably warm, let it cool before you proceed to the next section.

C.5.1.2 REMOVE ALUMINA CANISTER AND EXAMINE THE PELLETS

1. Carefully unscrew the cap on the front of the foreline trap (see Figure C-2). Note that there is a spring located on the shaft inside the canister.
2. Remove the activated alumina canister.
3. Hold the canister by the bottom (*not the edges*) and remove the items listed below, in order, from the top of the canister. (The bottom will fall out and spill the activated alumina if you hold the canister by the edges.)
   a. long spring
   b. wing nut
   c. washer
   d. lid
   e. washer
   f. short spring
   g. grille

4. Examine the activated alumina pellets. If they are discolored and yellowish, replace them with fresh pellets. If you need replacement material, contact Quantum Design.

C.5.1.3 REASSEMBLE THE CANISTER, TRAP, AND PUMP

1. To reassemble the activated alumina canister, install the items in the order listed below (a reversal of the removal procedures):
    a. grille
    b. short spring
    c. washer
    d. lid
    e. washer
    f. wing nut
    g. long spring
2. Insert the activated alumina canister into the foreline trap with the spring facing the opened end of the trap.
3. Screw the cap back onto the front of the foreline trap.
4. Turn on the pump and wait one minute so that the metal pumping lines can be evacuated.
5. Reconnect the two metal pumping lines to the probe head.
6. Purge and seal the sample chamber.
7. Close the front door of the electronics cabinet.

C.6 PPMS Vacuum-Pump Assembly Service Record

Use this service record to help schedule and track servicing of the vacuum-pump assembly (see Sections 4.7.4 and C.2–C.5. We provide two blank sheets for your convenience.

Pump Assembly

COMPONENT	MANUFACTURER	SERIAL NUMBER
Pump		
Foreline trap		

SERVICE TYPE	SERVICE DATE
Change rotary-vane pump oil	
Empty oil in oil-mist filter	
Change oil-mist filter cartridge	
Check activated alumina in foreline trap	
Change activated alumina in foreline trap	
Other (explain)	

COMMENTS

SERVICE TYPE	SERVICE DATE
Change rotary-vane pump oil	
Empty oil in oil-mist filter	
Change oil-mist filter cartridge	
Check activated alumina in foreline trap	
Change activated alumina in foreline trap	
Other (explain)	

COMMENTS

References

Quantum Design. 1995. *Physical Property Measurement System Commands Manual.*

———. 1996. *Physical Property Measurement System Firmware Manual.*

———. 1998. *Physical Property Measurement System: PPMS MultiVu Application User's Manual.*

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Vacuum Solutions

Application Support

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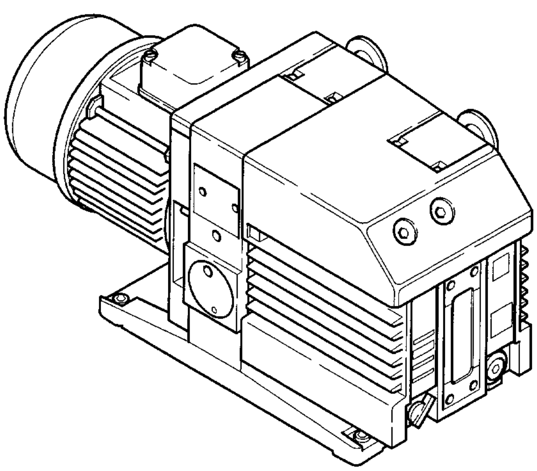


TRIVAC® B

Rotary Vane Vacuum Pump
D 4 B / D 8 B

Cat. No.

112 45/46/55/56

113 03/04/06/07/08/09
113 13/14/16/17/18/21

150 Years

Operating Instructions

Contents

We strongly recommend that you read these Operating Instructions with care so as to ensure optimum operation of the pump right from the start.

Warning Indicates procedures that must be strictly observed to prevent hazards to persons.

Caution Indicates procedures that must strictly be observed to prevent damage to, or destruction of the pump.

Figures
The references to diagrams, e.g. (1/2) consist of the Fig. No. and the Item No. in that order.

Leybold-Service

If a pump is returned to LEYBOLD, indicate whether the pump is free of substances damaging to health or whether it is contaminated.

If it is contaminated also indicate the nature of the hazard. LEYBOLD must return any pumps without a „Declaration of Contamination“ to the sender's address.

Disposal of Waste Oil

Owners of waste oil are entirely self-responsible for proper disposal of this waste.

Waste oil from vacuum pumps must not be mixed with other substances or materials.

Waste oil from vacuum pumps (Leybold oils which are based on mineral oils) which are subject to normal wear and which are contaminated due to the influence of oxygen in the air, high temperatures or mechanical wear must be disposed of through the locally available waste oil disposal system.

Waste oil from vacuum pumps which is contaminated with other substances must be marked and stored in such a way that the type of contamination is apparent. This waste must be disposed of as special waste.

European, national and regional regulations concerning waste disposal need to be observed. Waste must only be transported and disposed of by an approved waste disposal vendor.

IMPORTANT SAFETY CONSIDERATIONS

The Leybold TRIVAC B vacuum pump is designed for safe and efficient operation when used properly and in accordance with this manual. It is the responsibility of the user to carefully read and strictly observe all safety precautions described in this section and throughout the manual. This product must be operated and maintained by trained personnel only. Consult local, state, and national agencies regarding specific requirements and regulations. Address any further safety, operation and/or maintenance questions to your nearest Leybold Vacuum office.

Warning **Failure to observe the following precautions could result in serious personal injury:**

- Before beginning with any maintenance or service work on the TRIVAC B, disconnect the pump from all power supplies.
- Do not operate the pump with any of the covers removed. Serious injury may result.
- If exhaust gases must be collected or contained, do not allow the exhaust line to become pressurised.
- Make sure that the gas flow from the exhaust port is not blocked or restricted in any way.
- The standard version of the TRIVAC B is not suited for operation in explosion hazard areas. Contact us before planning to use the pump under such circumstances.
- Before starting up for the first time, the motor circuit (3 phase) must be equipped with a suitable protective motor switch. Please take note of the information in these Operating Instructions or on the electric motor (wiring diagram).
- The TRIVAC B is not suited for pumping of:
  - combustible and explosive gases or vapours
  - radioactive and toxic substances
  - pyrophorous substances.
- Avoid exposing any part of the human body to the vacuum.
- Never operate the TRIVAC B without a connected intake line or blank flange.
- The location at which the TRIVAC B (including its accessories) is operated should be such that angles over 10° from the vertical are avoided.
- The location of the TRIVAC B should be such that all controls are easily accessible.
- Under certain ambient conditions the TRIVAC B may attain a temperature of over 80 °C (176 °F). There then exists the danger of receiving burns.
  Note the symbols on the pump pointing to the hazards, and in the case of a hot pump wear the required protective clothing.
- Before pumping oxygen (or other highly reactive gases) at concentrations exceeding the concentration in the atmosphere (> 21 % for oxygen) it will be necessary to use a special pump. Such a pump will have to be modified and de-greased, and an inert special lubricant (like PFPE) must be used.
- Before operating the TRIVAC B with atmospheric gas ballast (optional) check first compatibility with the pumped media so as to avoid hazardous conditions during operation right from the start.
- Before commissioning the TRIVAC B, make sure that the media which are to be pumped are compatible with each other so as to avoid hazardous situations.
  All relevant safety standards and regulations must be observed.
- It is recommended to always operate the TRIVAC B with a suitable exhaust line which is properly connected. It must slope down and away from the pump.
- When moving the TRIVAC B always use the allowed means.
  A lifting eye is provided as standard on the pump.

Caution **Failure to observe the following precautions could result in damage to the pump:**

- Do **not** allow the ingestion of small objects (screws, nuts, washers, pieces of wire, etc.) through the inlet port. Always use the screen which is supplied with every pump.
- Do **not** use the pump for applications that produce abrasive or adhesive powders or condensable vapours that can leave adhesive or high viscosity deposits. Please contact Leybold Sales or Service to select a suitable separator. Also pease contact Leybold Sales or Service when planning to pump vapours other than water vapour.
- This pump is suited for pumping water vapour within the specified water vapour tolerance limits.
- Avoid vapours that can condense into liquids upon compression inside the pump, if these substances exceed the vapour tolerance of the pump (> 25 mbar for water vapour).
- Before pumping vapours, the TRIVAC B should have attained its operating temperature, and the gas ballast should be set to position I (position 0 = closed, position I = max. water vapour tolerance, 25 mbar).

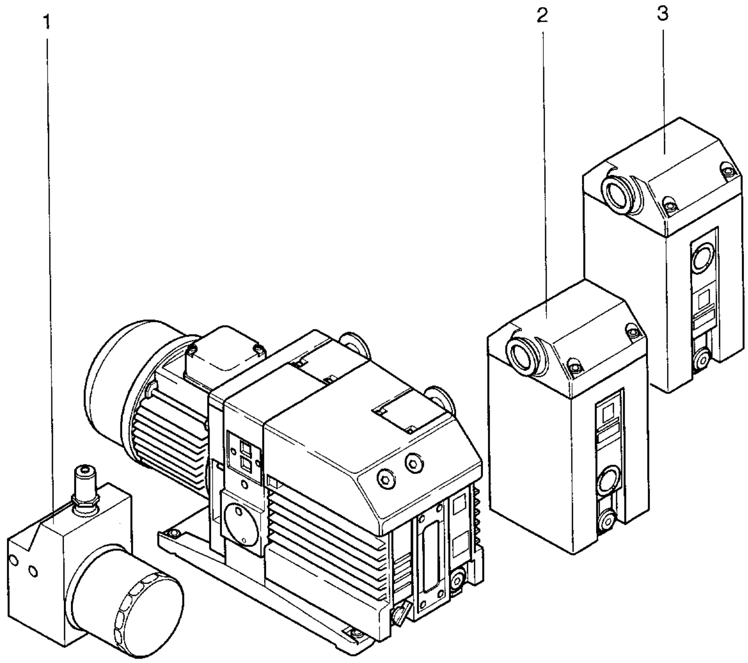
  The pump will have attained its operating temperature about 30 minutes after starting the pump. During this time the pump should be separated from the process, by a valve in the intake line, for example.
- In the case of wet processes we recommend the installation of liquid separators upstream and downstream of the pump as well as the use of the gas ballast.
- The exhaust line should be laid so that it slopes down and away from the pump so as to prevent condensate from backstreaming into the pump. For this preferably use the flange on the side of the motor.
- The entry of particles and fluids must be avoided under all circumstances.
- Reactive or aggressive substances in the pump chamber may impair the operating oil or modify it. In addition, such substances may be incompatible with the materials of the pump (Viton, grey cast iron, aluminium, steel, resins, glass etc.).
- Corrosion, deposits and cracking of oil within the pump are not allowed.

Note **This information will help the operator to obtain the best performance from the equipment:**

- Normal amounts of humidity within the range of the pump's vapour tolerance will not significantly affect pump performance when the gas ballast is active. Preferably use the exhaust flange located on the side of the motor.

Caution:

In the case of custom pumps (with a Cat. No. deviating from the Cat No. stated in the EC Declaration of Conformity) please note the information provided on a separate sheet.



Key to Fig. 1
1 Oil filter OF 4-25
2 Exhaust filter AF 4-8
3 Condensate trap AK 4-8

Fig. 1 TRIVAC-B with accessories

1 Description

TRIVAC-B pumps are oil-sealed rotary vane pumps. The TRIVAC D 4 B and D 8 B are dual-stage pumps. The number in the type designation (4 or 8) indicates the pumping speed in $m^3 \cdot h^{-1}$.

TRIVAC-B pumps can pump gases and vapours and evacuate vessels or vacuum systems in the fine vacuum range. Those of standard design are not suitable for pumping greater than atmospheric concentrations of oxygen, hazardous gases, or extremely aggressive or corrosive media.

The drive motor of the TRIVAC-B is directly flanged to the pump at the coupling housing. The pump and motor shafts are directly connected by a flexible coupling. The bearing points of the pump module are force lubricated sliding bearings. All controls as well as the oil-level glass and the nameplate are arranged on the front. All connections are to be found at the sides of the pump. The oil-level glass is provided with prisms for better observation of the oil level.

The pump module consists of assembly parts which are pin-fitted so as to allow easy disassembly and reassembly. The pump module can be easily removed without special tools.

1.1 Function

The rotor (2/7), mounted eccentrically in the pump housing (2/6) (pump chamber), has two radially sliding vanes (2/5) which divide the pump chamber into several compartments. The volume of each compartment changes periodically with the rotation of the rotor.

As a result, gas is sucked in at the intake port (2/1). The gas passes through the dirt trap sieve (2/2), flows past the open anti-suckback valve (2/3) and then enters the pump chamber. In the pump chamber, the gas is passed on and compressed, after the inlet aperture is closed by the vane.

The oil injected into the pump chamber is used for sealing and lubricating. The slap noise of the oil in the pump which usually occurs when attaining the ultimate pressure is prevented by admitting a very small amount of air into the pump chamber.

The compressed gas in the pump chamber is ejected through the exhaust valve (2/10). The oil entrained in the gas is coarsely trapped in the internal demister (2/11); there the oil is also freed of mechanical impurities. The gas leaves the TRIVAC-B through the exhaust port.

During compression, a controlled amount of air – the so-called gas ballast – can be allowed to enter the pump chamber by opening the gas ballast valve (position I).

Key to Fig. 2
1 Intake port
2 Dirt trap
3 Anti-suckback valve
4 Intake channel
5 Vanes
6 Pump chamber
7 Rotor
8 Cover plate, connection for inert gas ballast
9 Exhaust channel
10 Exhaust valve
11 Internal demister
12 Spring buckles
13 Cover plate, connection for oil filter

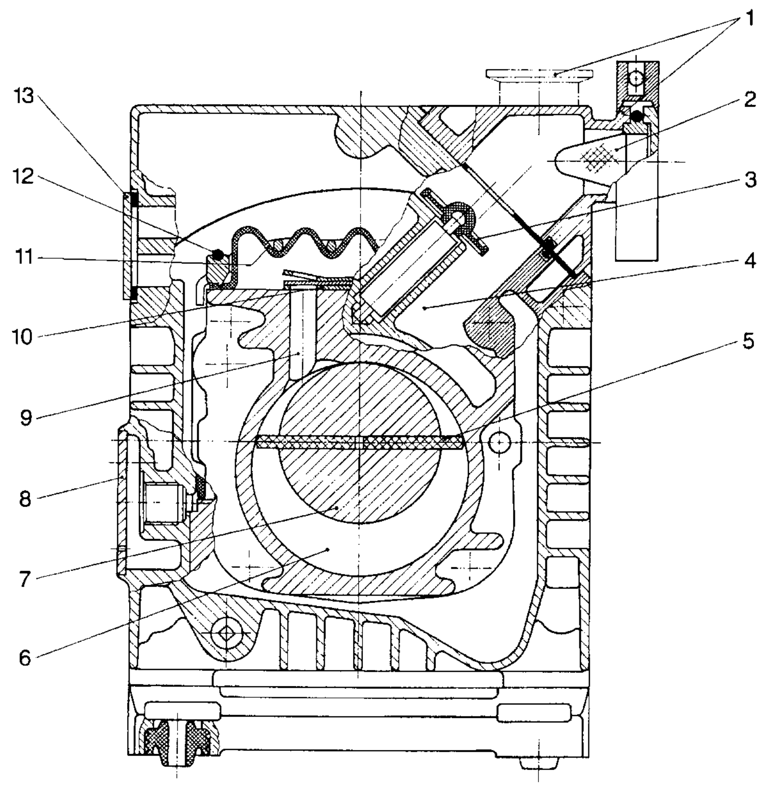


Fig. 2 Sectional drawing of the TRIVAC-B

The gas ballast stops condensation of vapours in the pump chamber up to the limit of vapour tolerance as specified in the technical data for the pump (the data refer to water vapour).

The gas ballast valve is opened (position I) and closed (position 0) by turning the gas ballast knob (7/5) on the front.

To enable the TRIVAC-B to be used at intake pressures as high as 1,000 mbar, a special lubricating system was developed featuring force-lubrication of the sliding bearings.

An oil pump (3/6) pumps the oil from the oil reservoir (3/5) into a pressure-lubrication system which supplies oil to all bearing points (3/2). From there the oil enters the pump chamber area (3/4) of the vacuum pump.

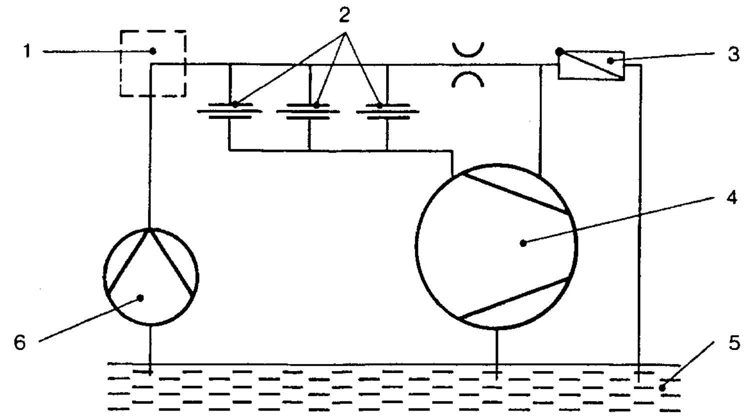
The oil pump is fitted in the front end plate on the coupling side of the pump module. The oil suction line is placed low, resulting in a large usable oil reservoir.

The oil is separated from the gas in the TRIVAC-B in two steps as described above. First, small droplets are coalesced into large drops in the internal demister (2/11) fitted above the exhaust valve (2/10). Then, the large drops fall into the oil reservoir as the exhaust gas is diverted by the inner walls of the oil case. Thus a low loss of oil is obtained. This and the large usable oil reservoir ensure long intervals between oil changes even at high intake pressures.

The vacuum is maintained by the TRIVAC-B through an integrated hydropneumatic anti-suckback valve (2/3) which is controlled via the oil pressure.

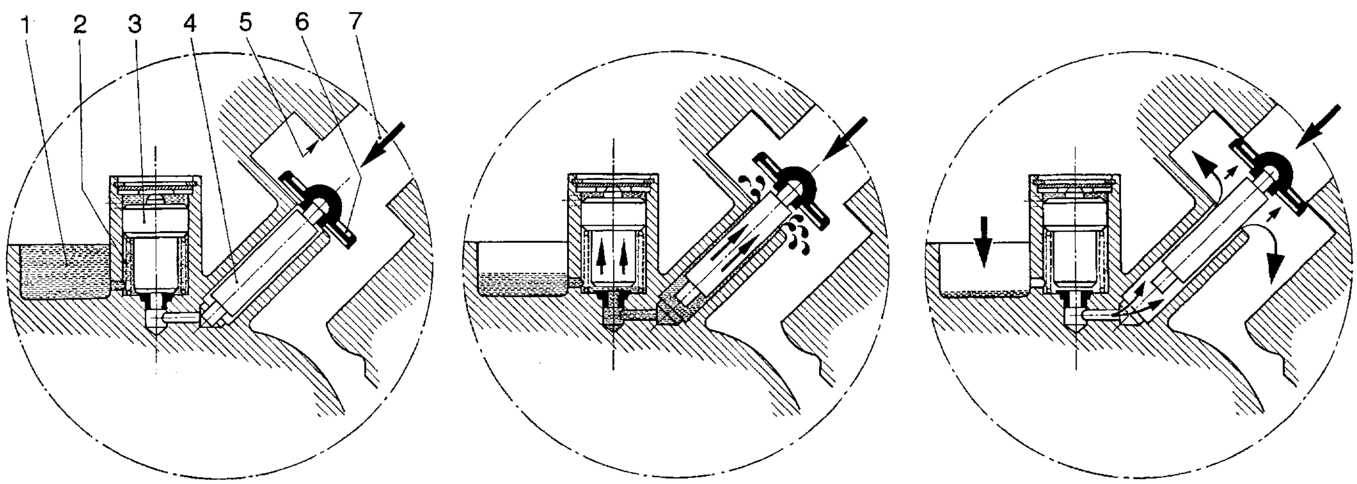
During operation of the TRIVAC-B the control piston (4/3) remains sealed against a spring (4/2) by the oil pressure. The valve disc (4/6) of the anti-suckback valve is held at the lower position by its own weight (valve open). When the pump stops (because it has been switched off or because of a failure), the oil pressure drops and the spring (4/2) presses the control piston (4/3) up. Thus a connection is provided between the oil case or the oil reservoir (4/1) and the piston (4/4) of the anti-suckback valve. Due to the pressure difference between the oil case and the intake port the oil presses the piston (4/4) up and the valve plate (4/6) against the valve seat (4/5). The quantity of oil in the oil reservoir (4/1) prevents the entry of air into the intake port (2/1) at the beginning of this process.

After the oil has flowed out from the reservoir and when the valve plate rests on the valve seat, air follows in, which vents the pump chamber and forces the valve disc (4/6) against its seat. This effectively prevents backstreaming of oil. The anti-suckback valve (2/3) operates independently of the operating mode of the pump, i.e. also with gas ballast.



Key to Fig. 3
1 Accessories
2 Bearings
3 Non-return valve
4 Pump chamber of the TRIVAC
5 Oil reservoir
6 Oil pump

Fig. 3 Schematic of the lubricating system



Key to Fig. 4
1 Oil reservoir
2 Spring
3 Control piston
4 Anti-suckback piston
5 Valve seat
6 Valve disk
7 Gas inlet

Fig. 4 Hydropneumatic anti-suckback valve

1.2 Supplied Equipment

The equipment supplied with the TRIVAC-B pump includes:

Pump with motor, including initial filling of N 62, HE-200 oil or Arctic oil SHC 224 (for Cat. No. 113 08 and 113 18).

1 centering ring,

1 centering ring with dirt trap,

2 clamping rings DN 16 KF.

As protection during shipment, the connection ports are each blanked off by rubber diaphragms and supporting rings.

TRIVAC-B pumps with single-phase AC motor are supplied ready to operate with switch, built-in thermal motor protection switch, mains cable (2 m) and mains plug.

For TRIVAC-B pumps with three-phase AC motor, the switch, motor protection switch, mains cable etc. are not included but can be delivered upon request with motor protection switch, mains plug and mains cable.

1.3 Accessories

Cat. No. / Ref. No.

Condensate trap AK 4-8, DN 16 KF 188 06
Exhaust filter AF 4-8, DN 16 KF 189 06

Drain tap for condensate trap, exhaust filter,
oil drain of the pump,
vacuum-tight 190 90
oil tight 190 90

Exhaust filter with lubricant return
AR 4-8, DN 16 KF 189 20

Dust filter FS 2-4 .... 186 05

Fine vacuum adsorption trap FA 2-4
(with zeolite) 187 05
Adsorption trap
(with aluminium oxide) 854 14
(with cryo insert) 854 17
Cold trap TK 4-8 .... 188 20
Oil filter OF 4-25 .... 101 91
Chemical filter CF 4-25 .... 101 96

Adapter for gas ballast port
M 16 x 1.5 – DN 16 KF 168 40
M 16 x 1.5 – 3/8 inch NPT 99 175 011

Oil N 62	1 l	177 01
	5 l	177 02
	20 l	177 03
Arctic oil SHC 224	1 l	200 28 181

(Order from LH Cologne, Germany)

Oil HE-200	1 qt	98 198 006
	12 qt case	98 198 049
	1 gal	98 198 007
	5 gal	98 198 008

(Order from LHVP, Export Pa., USA)

The oil grades N 62 and HE-200 are interchangeable. Special oils upon request.

Caution Only use the kind of oil specified by Leybold. Alternative types of oil are specified upon request.

1.4 Spare Parts

Set of gaskets		197 20
Pump module, complete	D 4 B	200 10 989
	D 8 B	200 10 991
Module-gasket		200 10 730*)
Oil case gasket		200 10 733*)
Internal demister	D 4 B	390 26 010*)
	D 8 B	390 26 011*)

*) included in gasket set

1.5 Transportation

Caution

- Pumps which are filled with operating agents must only be moved while standing upright. Otherwise oil may escape. Avoid any other orientations during transport.

Warning

- Check the pump for the presence of any oil leaks, since there exists the danger that someone may slip on spilt oil.
- When lifting the pump you must make use of the crane eyes provided on the pump for this purpose; also use the recommended type of lifting device.

1.6 Technical Data

		TRIVAC D 4 B		TRIVAC D 8 B	
		50 Hz	60 Hz	50 Hz	60 Hz
Nominal pumping speed 1)	$m^3 \times h^{-1}$ (cfm)	4.8 (2.8)	5.8 (3.4)	9.7 (5.7)	11.6 (6.9)
Pumping speed 1)	$m^3 \times h^{-1}$ (cfm)	4.2 (2.5)	5 (3)	8.5 (5)	10.2 (6)
Ultimate partial pressure without gas ballast 1)	mbar (Torr)	10^{-4} (0.75×10^{-4})			
Ultimate total pressure without gas ballast 1)	mbar (Torr)	$< 2 \times 10^{-3}$ ($< 1.5 \times 10^{-3}$)			
Ultimate total pressure with gas ballast 1)	mbar (Torr)	$< 5 \times 10^{-3}$ ($< 3.8 \times 10^{-3}$)			
Water vapor tolerance 1)	mbar (Torr)	30 (22.5)		25 (18.8)	
Water vapor capacity	gm/h	93		157	
Oil filling, min./max.	l (qt)	0.3 / 0.8 (.3 / .85)		0.3 / 0.9 (.3 / .95)	
Noise level * to DIN 45 635, without/with gas ballast	dB(A)	50 / 52			
Admissible ambient temperature	°C (°F)	12 - 40 (54 - 104)			
Motor rating *	W (HP)	370 (.50)			
Nominal speed	rpm	1500	1800	1500	1800
Type of protection	IP	54			
Weight*	kg (lbs)	18.7 (41.2)		21.2 (46.7)	
Connections, Intake and Exhaust	DN	16 KF			

1) To DIN 28 400 and following numbers

* Weight, motor rating and noise levels for the pumps with 230 V, 50 Hz AC motor only.

Caution We can only guarantee that the pump will meet its specifications when using the type of lubricant which has been specified by us.

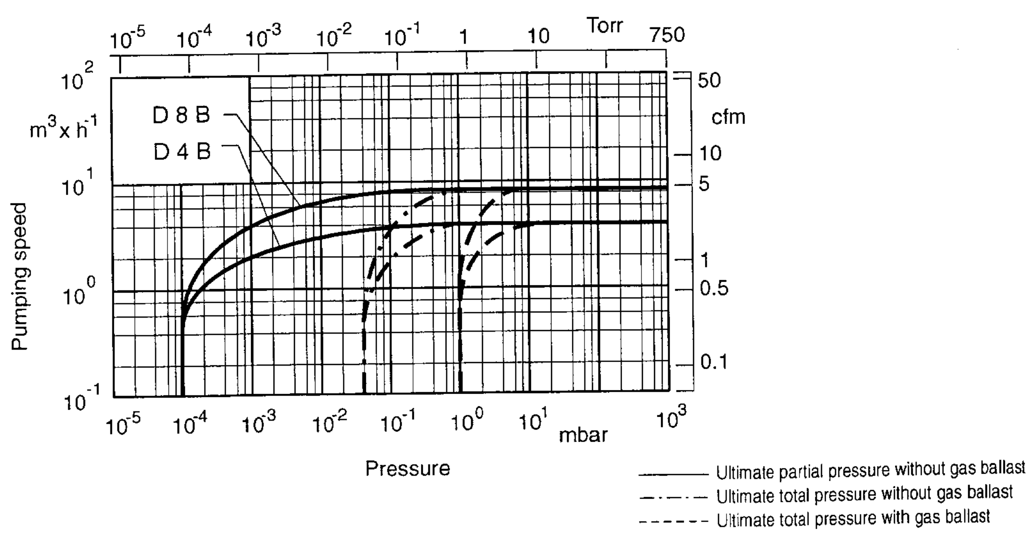
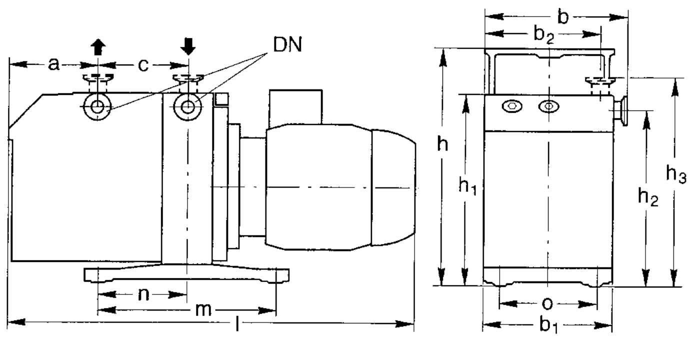


Fig. 5 Pumping speed characteristics at 50 Hz (60 Hz curves at the end of the section)

1.6.1 Motor related data

D 4 B			D 8 B								
Cat. No.	l (mm)	W (kg)	Cat. No.	l (mm)	W (kg)	Motor connection voltage, frequency	Motor power	Rated current	Speed	Motor noise level	Order No. motor
112 45	430	18,7	**112 55**	455	21.2	1~, 230 V, 50 Hz	370 W	2,9 A	1400	47 dB(A)	360 66 008
113 03	430	18,7	**113 13**	455	21,2	1~, 115 V, 60 Hz	370 W	5,6 A	1700	51 dB(A)	200 10 403
113 04	470	19,7	**113 14**	495	25,2	1~, 100 V, 50 Hz	370 W	8,7 A	1400	53 dB(A)	200 10 404
113 08[1)]	470	19,7	**113 18**[1)]	495	25,2	1~, 110 V, 60 Hz	370 W	6,1 A	1700	56 dB(A)	200 10 404
112 46	438	16,4	**112 56**	463	18,6	3~, 230/400 V, 50 Hz 250/440 V, 60 Hz	370 W	1,95/1,12 A 1,73/1,0 A	1970 1680	46 dB(A) 50 dB(A)	380 66 006
113 06	430	18	**113 16**	455	18,6	3~, 230/400 V, 50 Hz	370 W	1,92/1,11 A	1395	45 dB(A)	200 10 406
113 07	223	10,6	**113 17**	248	12,8	ohne Motor	-	-	-	48 dB(A)	-
113 09			**113 21**			1~, 230 V, 50/60 Hz	370 W	4,9/3,3 A	1400 1700	53/56 dB(A)	200 39 867

1) Motor with UL cable NEMA 5-158 and 2.5 m long cable

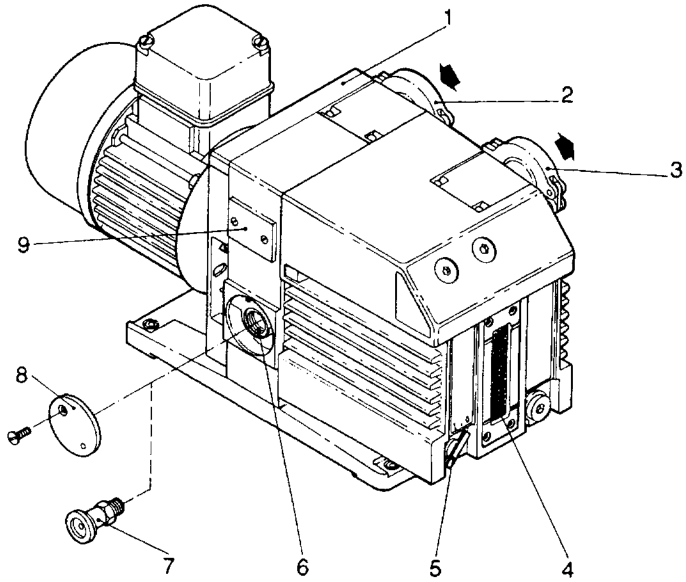


Type	DN		a	b	b_1	b_2	c	h	h_1	h_2	h_3	l*	m	n	o
D 4 B	16 KF	mm	75	162	147	132	100	265	215	200	230	430	198	99	108
		in.	2.95	6.38	5.79	5.20	3.94	10.4	8.46	7.84	9.06	16.9	7.80	3.90	4.25
D 4 B (Part No. 113 04)		mm	75									470			
		in.	2.95									18.5			
D 4 B (Part No. 113 14)		mm	75									495			
		in.	2.95									19.5			
D 8 B		mm	100									455			
		in.	3.94									17.9			
D 8 B (Part No. 113 18 (Arctic)		mm	100									495			
		in.	3.94									19.5			

** Depending on the motor*

USA pumps max. length
D 4 B 485 mm (19.1")
D 8 B 555 mm (21.9")

Fig. 6 Dimensional drawing for the TRIVAC rotary vane pumps (Dimensions a, l, b to b_2 and h_1 are approximate)



Key to Fig. 7
1 Handle
2 Intake port
3 Exhaust port
4 Oil-level glass
5 Gas ballast knob
6 Threaded connection M 16 x 1.5 for inert gas ballast
7 Adapter
8 Cover plate
9 Cover plate; connection for oil filter

Fig. 7 Connections and controls

2 Operation

2.1 Installation

Warning The standard pump (except the versions equipped with an explosion hazard rated motor) is not suited for installation in explosion hazard areas. When planning such an application please contact us first.

The TRIVAC-B pump can be set up on a flat, horizontal surface. Rubber feet under the coupling housing ensure that the pump can not slip.

If you wish firmly install the pump in place, insert bolts through bore holes in the rubber feet.

Caution Max. tilt for the pump (without further attachment) with possibly fitted standard accessories is 10ϒ from the vertical.

The rubber feet act as vibration absorbers. They must therefore not be compressed by screws. When installing the TRIVAC-B pump, make sure that the connections and controls are readily accessible.

The site chosen should allow adequate air circulation to cool the pump (keep front and rear unobstructed). The ambient temperature should not exceed +40 ϒC (104 ϒF) and not drop below +12 ϒC (55 ϒF) (see Section 2.5.3).
The max. amount of heat given off approximately corresponds to the rated motor power.

2.2 Connection to the System

Before connecting the TRIVAC-B, remove the shipping seals from the connection flanges (7/2) and (7/3).

Caution Retain the shipping seals in case you need to store the pump in the future.

The pump is shipped with intake and exhaust flanges mounted for horizontal connection of the connecting lines. You can easily convert the ports for vertical connection by removing the four capscrews, rotating the flanges as required, and reinstalling the capscrews.

Connect the intake and exhaust lines with a centering ring and a clamping ring each. Use the centering ring with dirt trap for the intake port.

Connect the intake and exhaust line using anti-vibration bellows, without placing any strain on the pump.

The intake line must be clean. Deposits in the intake line may outgas and adversely affect the vacuum. The connecting flanges must be clean and undamaged.

The maximum throughput of the pump is equivalent to the pumping speed of the pump (see Section 1.6).

Caution The cross-section of the intake and exhaust lines should be at least the same size as the connection ports of the pump. If the intake line is too narrow, it reduces the pumping speed. If the exhaust line is too narrow, overpressures may occur in the pump; this might damage the shaft seals and cause oil leaks. The maximum pressure in the oil case must not exceed 1.5 bar (absolute).

When pumping vapours, it is advisable to install condensate traps on the intake and exhaust sides.

Install the exhaust line with a downward slope (lower than the pump) so as to prevent condensate from flowing back into the pump. If this is not possible, insert a condensate trap.

The exhaust gases from the vacuum pump must be safely lead away and subjected to post-treatment as required. In order to reduce the emission of oil vapours we recommend the installation of an additional exhaust filter (Leybold accessory).

Depending on the type of application or the kind of pumped media, the corresponding regulations and information sheets must be observed.

The pumps may be operated with an inert gas ballast via a connection which is provided for this purpose. The cover plate (7/8) can be removed to gain access to this M 16 x 1.5 threaded port (7/6). Matching connectors are available (see Section 1.3).

In inlet pressure for the gas ballast should be about 1000 mbar (absolute) and sufficient quantities of gas must be available (about $^1/_{10}$ of the pumping speed).

Warning Never operate the pump with a sealed exhaust line. There is the danger of injury.

Before starting any work on the pump, the personnel must be informed about possible dangers first. All safety regulations must be observed.

2.3 Electrical Connections

Warning Before wiring the motor or altering the wiring, ensure that mains supply for the pump is off and that it can not be applied inadvertently.

In order to prevent the pump from running up unexpectedly after a mains power failure, the pump must be integrated in the control system in such a way that the pump can only be switched on again manually. This applies equally to emergency cut-out arrangements.

Electrical connections must be done by a qualified electrician as defined by VDE 0105 in accordance with the VDE 0100 guidelines.
Observe all safety regulations.

TRIVAC-B pumps are available with a single-phase or a three-phase AC motor.

2.3.1 Pump with Single-Phase AC Motor

Pumps equipped with a single-phase AC motor may be connected directly to the mains via the mains cord and the mains plug.

At 230 V use at least a 6 A slow-blow or a 10 A fast-blow fuse.

The direction of rotation need not be checked as it is fixed.

The motor is protected against overloading by a thermal overload switch with automatic resetting.

Warning If the thermal overload protector shuts off the pump, the motor will restart itself as soon as it cools. That's why the mains plug should be disconnected from the mains before starting with any work on the pump.

2.3.2 Pump with Three-Phase AC Motor

TRIVAC-B pumps with a three-phase motor are supplied without accessories for the electrical connection. They must be connected via the appropriate cable, and a suitable motor protection switch. Set the switch in accordance with the rating on the motor nameplate.

Fig. 8 shows the connection for pumps with 230/400 V, 50 Hz motors. Please also observe the motor wiring diagram in the junction box and the information given on the nameplate of the motor.

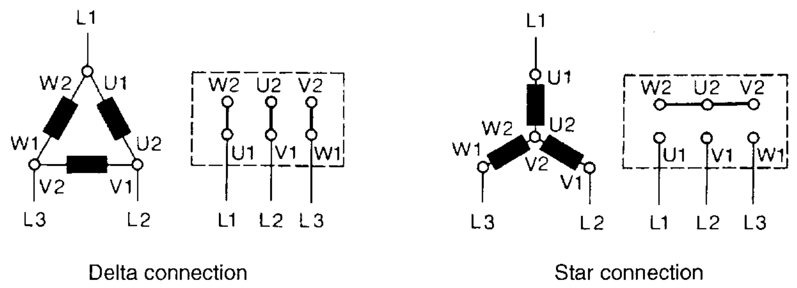


Fig. 8 Connection diagram for TRIVAC-B with 50 Hz 3-phase motor

Caution After connecting the motor and after every time you alter the wiring, check the direction of rotation. To do so, briefly switch on the motor and check whether a suitable cover (e. g. a blank flange) is sucked on at the intake port. If not, interchange two phases of the connection.
Observe the direction arrow on the coupling housing.

2.4 Start-up

Each time before starting up ensure that the oil level is visible in the oil level glass.

For pumps with 3-phase motors, check the direction of rotation before starting the pump

for the first time and after each change in the electrical connection (see Section 2.3.2).

On initial start-up, after prolonged idle periods or after an oil change, the specified ultimate pressure cannot be attained immediately until the oil is degassed. This can be done by running the pump for approx. 30 min. with the intake line closed and the gas ballast valve (7/5) open.

Warning Before starting the pump ensure that the pump and the fitted accessories meet the requirements of your application and that safe operation can be guaranteed.

Avoid exposure of any part of the body to the vacuum. There is the danger of injury. Never operate the pump with an open intake port. Vacuum connections as well as oil-fill and oil-drain openings must never be opened during operation.

Warning The safety regulations which apply to the application in each case must be observed. This applies to installation, operation and during maintenance (service) as well as waste disposal and transportation.
The standard pump is not suited for pumping of hazardous gases or vapours.

Our technical sales department is available for further advice in these matters.

2.4.1 Areas of Application

Warning Before pumping oxygen (or other highly reactive gases) at concentrations exceeding the concentration in the atmosphere
(> 21 % for oxygen) it will be necessary to use a special pump. Such a pump will have to be modified and de-greased, and an inert special lubricant (like PFPE) must be used.

The pump is not suitable for pumping of:

- ignitable and explosive gases or vapours
- oxidants
- pyrophorous gases.

Caution The pumps are not suitable for pumping of liquids or very dusty media. Suitable protective devices must be installed.

Our technical sales department is available for further advice in these matters.

2.5 Operation

TRIVAC-B pumps can pump condensable gases and vapours, provided that the gas ballast valve (7/5) is open and the pump has attained its operating temperature.

2.5.1 Pumping of Non-Condensable Gases

If the process contains mainly permanent gases, the pump may be operated without gas ballast (position 0), provided that the saturation vapour pressure at operating temperature is not exceeded during compression.

If the composition of the gases to be pumped is not known and if condensation in the pump cannot be ruled out, run the pump with the gas ballast valve open in accordance with Section 2.5.2.

2.5.2 Pumping of Condensable Gases and Vapours

With the gas ballast valve open (position I) and at operating temperature, TRIVAC-B pumps can pump pure water vapour up to the water vapour tolerance specified by the technical data. If the vapour pressure increases above the permissible level, the water vapour will condense in the oil of the pump.

When pumping vapours ensure that the gas ballast valve is open and that the pump has been warmed up for approximately 30 minutes with the intake line closed.

Caution Vapour phases may only be pumped up to the permissible limit after the pump has attained its operating temperature.

During pumping, vapours may dissolve in the oil. This changes the oil's properties and thus there is a risk of corrosion in the pump. Therefore, don't switch off the TRIVAC-B immediately after completion of the process. Instead, allow the pump to continue operating with the gas ballast valve open and the intake line closed until the oil is free of condensed vapours. We strongly recommend operating the TRIVAC-B in this mode for about 30 minutes after completion of the process.

In cyclic operation, the TRIVAC-B should not be switched off during the intervals between the individual working phases (power consumption is minimal when the pump is operating at ultimate pressure), but should continue to run with gas ballast valve open and intake port closed (if possible via a valve).

Once all vapours have been pumped off from a process (e.g. during drying), the gas ballast valve can be closed to improve the attainable ultimate pressure.

2.5.3 Operating Temperature

Proper operation of the TRIVAC-B is ensured in the ambient temperature range between 12 °C to 40 °C (55 °F to 104 °F).

At operating temperature, the surface temperature of the TRIVAC-B may lie between 40 °C and over 80 °C (104 °F and 176 °F), depending on the load.

Warning The surface temperature of the TRIVAC-B pumps may rise above 80 °C.

There is the danger of receiving burns.

2.6 Switching Off/Shutdown

Under normal circumstances, all that you need do is to electrically switch off the TRIVAC-B.

No further measures will be required.

When pumping condensable media let the pump continue to operate with the gas ballast valve open and the intake line closed before switching off (see Section 2.5.2).

When pumping aggressive or corrosive media, let the pump continue to operate even during long non-working intervals (e.g. overnight) with the intake line closed and the gas ballast valve open. This avoids corrosion during idle periods.

If the TRIVAC-B is to be shutdown for an extended period after pumping aggressive or corrosive media or if the pump has to be stored, proceed as follows:

Warning When pumping harmful substances, take adequate safety precautions.

Our technical sales department is available for further advice in these matters.

Drain the oil (see Section 3.2).

Add clean oil until the oil-level is at the “min” mark (see Section 3.2) and let the pump operate for some time.

Then drain the oil and add clean oil until the oil level is at the “max.” mark (see Section 3.2).

Seal the connection ports. Special conservation or anti-corrosion oils aren’t necessary.

Caution Please also take note of the information given in Section 3.9 (storage and storage conditions).

2.6.1 Shutdown through Monitoring Components

Warning When the pump has been switched off due to overheating sensed by the motor coil protector, the pump must only be started manually after the pump has cooled down to the ambient temperature and after having removed the cause first.

2.6.2 Failure of the Control System or the Mains Power

Warning In order to prevent the pump from running up unexpectedly after a mains power failure, the pump must be integrated in the control system in such a way that the pump can only be switched on again manually. This applies equally to emergency cut-out arrangements.

3 Maintenance

Warning Disconnect the electrical connections before disassembling the pump. Make absolutely sure that the pump cannot be accidentally started.

If the pump has pumped harmful substances, contrary to what has been stated in Section 2.4, ascertain the nature of hazard and take adequate safety measures.
Observe all safety regulations.

If you send a pump to LEYBOLD for repair please indicate any harmful substances existing in or around the pump. A form is available from LEYBOLD for this purpose.

Caution When disposing of used oil, you must observe the applicable environmental regulations!

Due to the design concept, TRIVAC-B pumps require very little maintenance when operated under normal conditions. The work required is described in the sections below. In addition to this, a maintenance plan is provided in Section 3.11.

Caution All work must be carried out by suitably trained personnel. Maintenance or repairs carried out incorrectly will affect the life and performance of the pump and may cause problems when filing warranty claims.

For the spare part numbers please refer to the enclosed spare parts list.
In case of special versions please always state the special number, model number and the serial number.

LEYBOLD offers practical courses on the maintenance, repair, and testing of TRIVAC-B pumps. Further details are available from LEYBOLD on request.

Caution If the TRIVAC-B is used in ambient air which is much contaminated, make sure that the air circulation and the gas ballast valve are not adversely affected.

When the TRIVAC-B has been pumping corrosive media, we recommend to perform any possibly planned maintenance work immediately in order to prevent corrosion of the pump while at standstill.

3.1 Checking the Oil Level

During operation of the TRIVAC-B the oil level must always remain between marks (9/2) and (9/3) on the oil-level glass. The amount of oil must be checked and topped up as required.

Caution Fill in oil only after the pump has been switched off.

3.1.1 Checking the Condition of N 62 or HE 200 Oil

The ageing process for the standard operating fluid N 62 resp. HE 200 (see Chapter 1.2.1) will depend very much on the area of application for the pump.

a) Visual check
Normally the oil is clear and transparent. If the oil darkens, it should be changed.

b) Chemical check
The neutralisation number of N 62 oil is determined according to DIN 51558. If it exceeds 2, the oil should be changed.

c) Viscosity check
If the viscosity of N 62 at 25 °C exceeds a level of 240 mPas (20% higher than the viscosity of fresh oil) an oil change is recommended.

If gases or liquids dissolved in the oil result in a deterioration of the ultimate pressure, the oil can be degassed by allowing the pump to run for approx. 30 min. with the intake port closed and the gas ballast valve open.

When wanting to check the oil, switch off the pump first and drain out from the warm pump the required amount of oil through the oil drain (9/4) into a beaker or similar.

Caution Please note the safety information given in Chapter 3.2.

3.2 Oil Change

Warning Before pumping oxygen (or other highly reactive gases) at concentrations exceeding the concentration in the atmosphere (> 21 % for oxygen) it will be necessary to use a special pump. Such a pump will have to be modified and de-greased, and an inert special lubricant (like PFPE) must be used.

Hazardous substances may escape from the pump and the oil. Take adequate safety precautions. For example wear gloves, face protection or breathing protection.

Observe all safety regulations.

For proper operation of the pump, it is essential that the pump has an adequate supply of the correct and clean oil at all times.

The oil must be changed when it looks dirty or if it appears chemically or mechanically worn out (see Section 3.1.1).

The oil should be changed after the first 100 operating hours and then at least every 2,000 to 3,000 operating hours or after one year. At high intake pressures and intake temperatures and/or when pumping contaminated gases, the oil will have to be changed more frequently.

Further oil changes should be made before and after long-term storage of the pump.

If the oil becomes contaminated too quickly, install a dust filter and/or oil filter (see Section 1.3). Contact us for more information in this matter.

Caution Only change the oil after the pump has been switched off and while the pump is still warm.

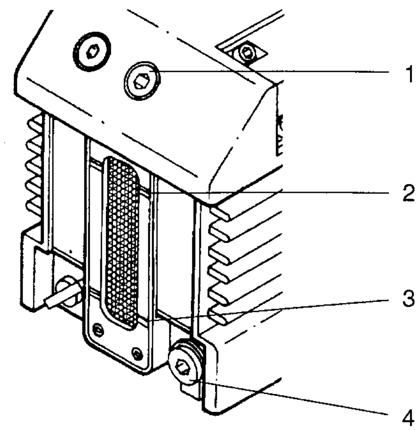
Required tool: Allen key 8 mm.

Remove the oil-drain plug (9/4) and let the used oil drain into a suitable container. When the flow of oil slows down, screw the oil-drain plug back in, briefly switch on the pump (max. 10 s) and then switch it off again. Remove the oil-drain plug once more and drain out the remaining oil.

Screw the oil-drain plug back in (check the gasket and reinstall a new one if necessary).

Remove the oil-fill plug (9/1) and fill in with fresh oil.

Screw the oil-fill plug (9/1) back in.



Key to Fig. 9
1 Oil-fill plug
2 Oil-level mark maximum
3 Oil-level mark minimum
4 Oil-drain plug

Fig. 9 Oil change

Warning If there is the danger that the operating agent may present a hazard in any way due to decomposition of the oil, or because of the media which have been pumped, you must determine the kind of hazard and ensure that all necessary safety precautions are taken.

Caution We can only guarantee that the pump operates as specified by the technical data if the lubricants recommended by us are used.

3.3 Cleaning the Dirt Trap

A wire-mesh sieve is located in the intake port of the pump to act as a dirt trap for coarse particles. It should be kept clean to avoid a reduction of the pumping speed.

For this purpose, remove the dirt trap (2/2) from the intake port and rinse it in a suitable vessel with solvent. Then thoroughly dry it with compressed air. If the dirt trap is defective, replace it with a new one.

Caution The cleaning intervals depend on the application. If the pump is exposed to large amounts of abrasive materials, a dust filter should be fitted into the intake line.

Key to Fig. 10
1 Oil case
2 Spring buckles
3 Demister
4 Frame for demister
5 Hex. socket screws
6 Silencing nozzle
7 Gasket

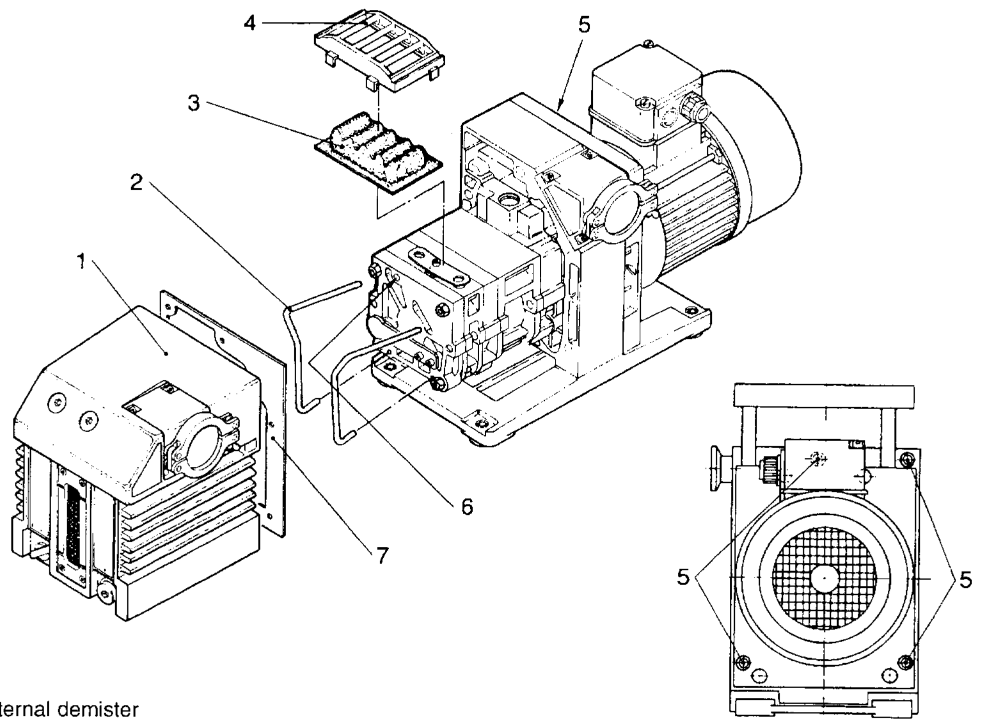


Fig. 10 Removal and fitting of the internal demister

3.4 Removing and Fitting the Internal Demister

Required tools:

Allen keys 5 mm and 8 mm

The internal demister is spring-mounted in a frame. When it is clogged, it rises periodically to reduce the pressure difference created.

The resultant noise at high intake pressures indicates that the internal demister is dirty.

Periodically clean or replace the internal demister; the maintenance interval depends on the application. Use a suitable solvent for cleaning.

Shutdown the pump and drain the oil (see Section 3.2).

Pull the handle upward.

Remove the **four recessed** screws (10/5) on the oil case (10/1). Don't remove the **non-recessed screws**; they hold the motor flange in place.

Pull the oil case forward off the pump.

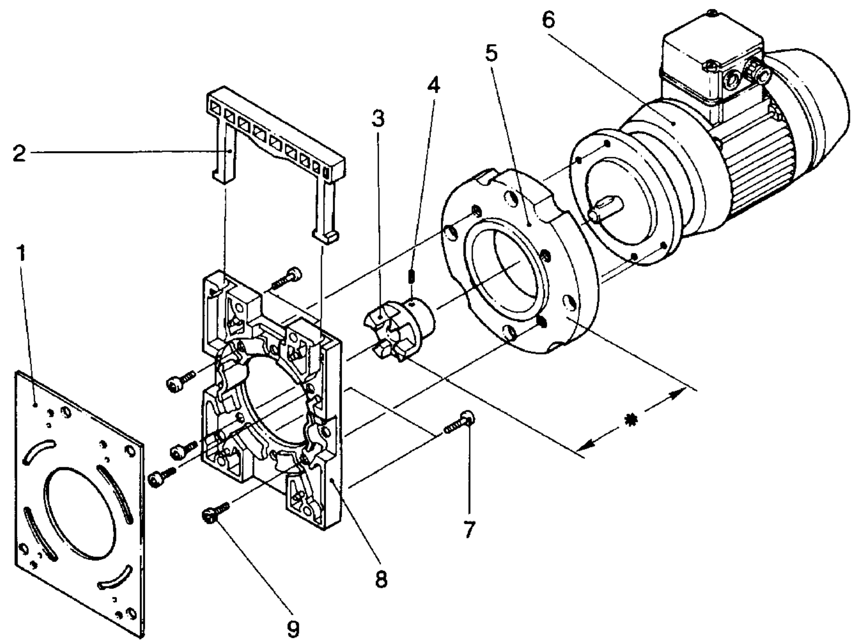
Remove the gasket (10/7).

Press the spring buckles (10/2) sideways away from the frame (10/4). Lift off the frame (10/4) and remove the internal demister (10/3).

Clean all parts and check that they are in perfect condition; if not, replace them with new parts.

Reassemble in the reverse order.

Caution Torque for the screws (10/5) is 5 Nm.



Key to Fig. 11
1 Gasket
2 Handle
3 Coupling
4 Threaded pin
5 Only for USA motors: adapter flange
6 Electric motor
7 Hex. socket screws
8 Intermediate flange
9 Hex. socket screw

Fig. 11 Disassembly and reassembly of the electric motor

3.5 Disassembly and Reassembly of the Electric Motor

Warning Before starting work, always disconnect the motor from the mains.
Disconnect the wires in the junction box of the motor (three-phase models only) or pull the mains plug.

Required tools:

Screwdriver 1.0 x 5.5 mm (for junction box), open-jaw wrenches 7 mm and 19 mm (for junction box), Allan keys 2.5 mm, 3 mm, 5 mm, 6 mm, possibly puller for coupling.

Disconnect the wires in the junction box of the motor (three-phase models only) or pull the mains plug.

Place the pump on its front side.

Unscrew the four non-recessed hex. socket screws (11/7).

Remove the intermediate flange (11/8) together with the electric motor.

Take off the gasket (11/1).

Remove the handle (11/2).

Loosen the threaded pin (11/4) and pull the coupling (11/3) off the motor shaft.

Unscrew the hex. socket screws (11/9).

Remove the electric motor (11/6) (and the adapter flange (11/5) in the case of the USA motors).

Clean all parts and check that they are in perfect condition; if not, replace them with new parts.

Reassemble in the reverse order.

Caution In the case of 60 Hz motors (USA versions) with adapter flange the coupling must not be pushed on to the shaft right up to the stop. On the other hand if it is not pushed on far enough the pump module may be damaged during operation. Push the coupling on in such a way that the distance between the front end of the coupling (11/3) and front side of the adapter flange (11/5) amounts to 41.3 ± 0.8 mm (1 $^5/_8$ ± $^1/_{32}$ inch) (see Fig. 11). The adapter flange (11/5) is screwed to the motor flange with four additional screws.

Key to Fig. 12
1 Coupling element
2 Hexagon socket screw
3 Spring washer
4 Coupling (one half)
5 Key
6 Compression disc
7 O-ring
8 Bushing
9 Shaft seal
10 Centering disk
11 Hexagon socket screws

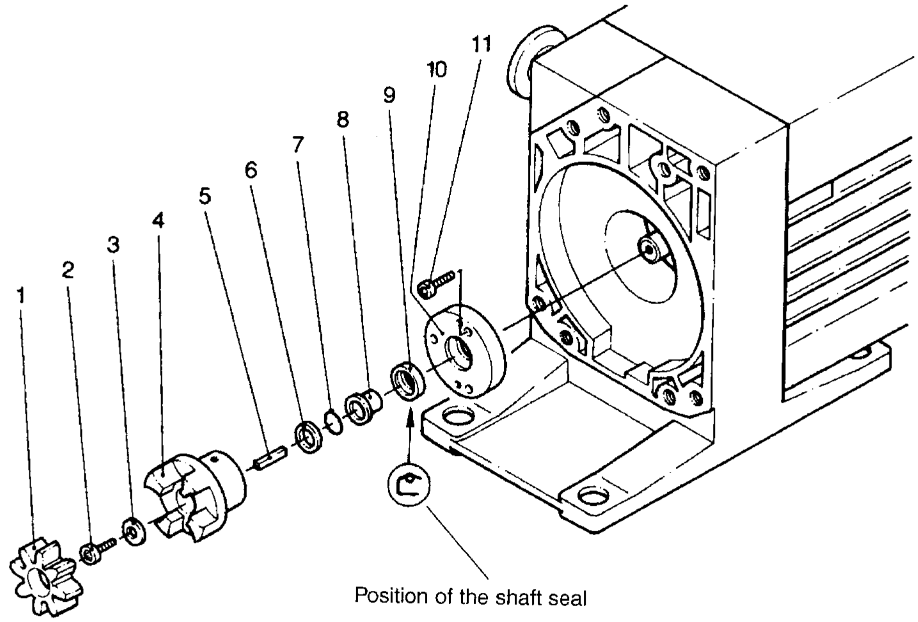


Fig. 12 Exchanging the outer shaft seal

3.6 Replacing the Outer Shaft Seal

Required tools:

Allen keys 3 mm, 5 mm, 8 mm, flat-nose pliers, plastic hammer, shaft seal driver, possibly puller for coupling.

The TRIVAC 4/8 B has two shaft seals; the outer one is subject to greater wear. Oil marks under the coupling housing are signs of a damaged outer shaft seal.

The outer shaft seal can be replaced without removing or disassembling the pump module.

Shutdown the pump.

Drain the oil (see Section 3.2) or place the pump on its front side.

Unscrew the four **non-recessed** hex. socket screws (11/7) and remove the motor (11/6) together with the intermediate flange (11/8).

Remove the gasket (11/1).

Pull off the coupling element(12/1).

Remove the hex. socket screw (12/2) and the spring washer (12/3).

Remove the coupling half (12/4).

Remove the key (12/5).

Pull off the compression disc (12/6) and the O-ring (12/7).

Unscrew the hex. socket screws (12/11) and pull off the centering disk (12/10) together with the bushing (12/8).

If the centering disk is stuck, screw the capscrews (12/11) into the jackscrew holes in the centering disk.

Pull the bushing out from the centering disc and force the shaft seal (12/9) out of the centering disk.

Caution We recommend the use of a new shaft seal, an O-ring and bushing for reassembly. Before insertion, moisten the new shaft seal slightly with a little vacuum pump oil.

Using a suitable plastic or aluminium cylinder (shaft seal driver) and a plastic hammer, force the shaft seal (12/9) carefully and without bending it into the centering disk (for position of shaft seal, see Fig. 12).

If you do not have a shaft seal driver, place the shaft seal on the opening in centering disk and carefully force it in with light blows of the plastic hammer. The shaft seal must not be bent.

Carefully push the bushing (12/8) into the shaft seal.

Push the centering disk (12/10) with the shaft seal and bushing onto the shaft and up against the end plate; fasten it with the hex. socket screws (12/11).

Push the O-ring (12/7) and the compression disc (12/6) onto the shaft.

Insert the key (12/5).

Mount the pump-half of the coupling (12/4) on the shaft.

Install the spring washer (12/3) and tighten the hex. screw (12/2).

Insert the coupling element (12/1) into the coupling and mount the motor (see Section 3.5).

Key to Fig. 13
1 Hex. nuts
2 Pump module
3 Washer
4 Gasket
5 Coupling element
6 Tie rods

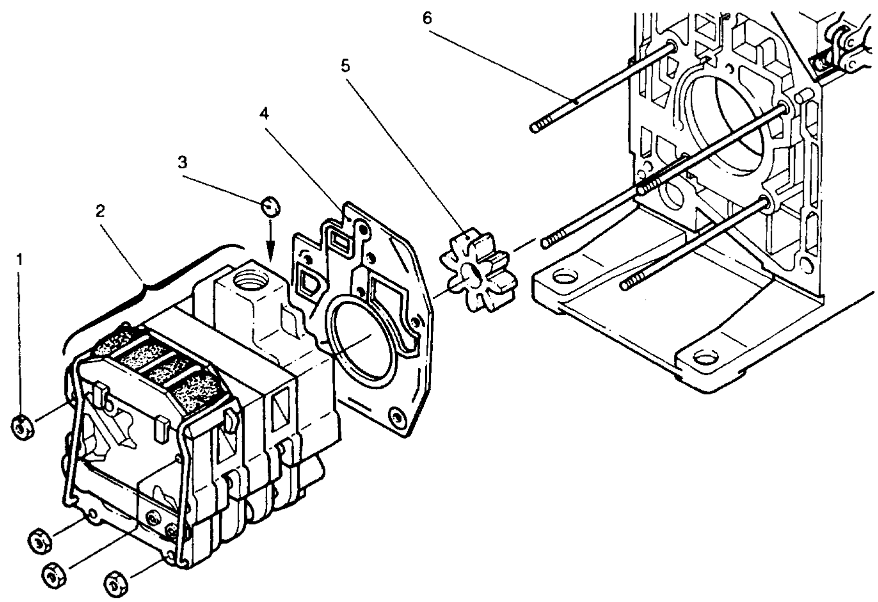


Fig. 13 Removing and remounting the pump module

3.7 Removing and Remounting the Pump Module

Required tools:

Allen keys 3 mm, 5 mm, 8 mm, box wrench 10 mm, possibly pliers.

3.7.1 Removing the Pump Module

Drain the oil and remove the oil case (see Section 3.4).

Unscrew the hex. nuts (13/1).

Pull the entire pump module (13/2) forward off the tie rods (13/6).

Caution When doing so, ensure that the individual pin-fitted parts are not loosened. Further disassembly of the pump module should only be carried out by a trained service engineer.

Remove the gasket (13/4).

Take the coupling element (13/5) off the coupling.

Caution After removing the protective shipping materials, handle the new pump module with care.

Before installing a new pump module, remove the four tie rods from the new module and insert them in the old one for protection during shipment.

3.7.2 Remounting the Pump Module

When installing a new pump module, it is also advisable to use a new gasket (13/4).

Check the coupling element (13/5) for damage; if necessary, install a new one.

Use the tie rods supplied with the new pump module only if the old ones are damaged. To do so, unscrew the old tie rods with lock nuts, and screw in the new ones. With the aid of the lock nuts, tighten the tie rods. Then remove the lock nuts.

Before mounting the pump module, make sure that sealing disc (13/3) fits correctly in its bore.

Push the gasket (13/4) onto the tie rods (13/6). Push the coupling element (13/5) onto

one coupling half.

Push the entire pump module (new or repaired) onto the tie rods.

Caution Screw on the hex. nuts (13/1) and carefully cross-tighten them (torque 7.5 Nm).

Mount the oil case together with the gasket (see Section 3.4).

Fill in oil.

3.8 Leybold Service

If a pump is returned to Leybold, indicate whether the pump free of substances damaging to health or whether it is contaminated.

If it is contaminated also indicate the nature of the hazard. For this you must use a form which has been prepared by us which we will provide upon request.

A copy of this form is reproduced at the end of these Operating Instructions: “Declaration of Contamination of Vacuum Instruments and Components”.

Please attach this form to the pump or enclose it with the pump.

This “Declaration of Contamination” is required to meet German Law and to protect our personnel.

Leybold must return any pumps without a “Declaration of Contamination” to the sender’s address.

Warning The pump must be packed in such a way, that it will not be damaged during shipping and so that any contaminants are not released from the package.

3.8.1 Waste Disposal of Used Pump Materials

The corresponding environmental and safety regulations apply. This applies equally to used filters and filter elements (oil filter, exhaust filter and dust filter).

Warning

- In the case of hazardous substances determine the kind of hazard first and observe the applicable safety regulations. If the potential hazard still persists, the pump must be decontaminated before starting with any maintenance work. For professional decontamination we recommend our Leybold service.
- Never exchange the oil or the filters while the pump is still warm. Let the pump cool down to uncritical temperatures first. You must wear suitable protective clothing.

3.9 Storing the Pump

Caution Before putting a pump into operation once more it should be stored in a dry place preferably at room temperature (20 °C). Before the pump is shelved it must be properly disconnected from the vacuum system, purged with dry nitrogen and the oil should be changed too.

The inlets and outlets of the pump must be sealed with the shipping seals which are provided upon delivery.
The gas ballast switch must be set to the “0” position and if the pump is to be shelved for a longer period of time it should be sealed in a PE bag containing some desiccant (silica gel).

When a pump is put into operation after it has been shelved for over one year, standard maintenance should be run on the pump and the oil should also be exchanged (see Operating Instructions). We recommend that you contact the Leybold service.

3.10 Troubleshooting

Fault	Possible cause	Remedy	Repair*
Pump does not start.	Wiring is malfunctioning. Motor protection switch incorrectly set (3-phase motors only). Operating voltage does not match motor. Motor is malfunctioning. Oil temperature is below 12 °C. Oil is too viscous. Exhaust filter/exhaust line is clogged. Pump is seized up (sign: pump is jammed).	Check and repair wiring. Set motor protection switch properly. Replace the motor. Replace the motor. Heat the pump and pump oil or use different oil. Change the oil. Replace the filter or clean the exhaust line. Repair the pump.	– 2.3 3.5 3.5 2.5.3/3.2 3.2 – Service
Pump does not reach ultimate pressure.	Measuring technique or gauge is unsuitable. External leak[1]. Anti-suckback valve is malfunctioning. Exhaust valve is malfunctioning. Oil is unsuitable. Intake line is dirty. Pump is too small.	Use correct measuring technique and gauge. Measure the pressure directly at pump's intake port. Repair the pump. Repair the valve. Repair the valve. Change the oil (degas it, if necessary). Clean the intake line. Check the process data; replace the pump, if necessary.	– Service Service Service 3.2 – –
Pumping speed is too low.	Dirt trap in the intake port is clogged. Exhaust filter is clogged. Connecting lines are too narrow or too long.	Clean the dirt trap; Precaution: install a dust filter in intake line. Install a new filter element. Use adequately wide and short connecting lines.	3.3 – 2.2
After switching off pump under vacuum, pressure in the system rises too fast.	System has a leak. Anti-suckback valve is malfunctioning.	Check the system. Repair the valve.	– Service
Pump gets hotter than usually observed.	Cooling air supply is obstructed. Ambient temperature is too high. Process gas is too hot. Oil level is too low. Oil is unsuitable. Oil cycle is obstructed. Exhaust filter/exhaust line is obstructed. Exhaust valve is malfunctioning. Pump module is worn out. Deviating mains voltage.	Set pump up correctly. Set pump up correctly. Change the process. Add oil. Change the oil. Clean or repair the oil lines and channels. Replace the exhaust filter, clean the exhaust line. Repair the valve. Replace the pump module. Check the motor voltage and the available mains voltage.	2.1 2.1/2.5.3 – 3.1 3.2 Service – Service 3.7
Oil in the intake line or in vacuum vessel.	Oil comes from the vacuum system. Anti-suckback valve is obstructed. Sealing surfaces of anti-suckback valve are damaged or dirty. Oil level is too high.	Check the vacuum system. Clean or repair the valve. Clean or repair the intake port and anti-suckback valve. Drain the excess oil.	– Service Service 3.1
Oil is turbid.	Condensation.	Degas the oil or change the oil and clean the pump. Precaution: open the gas ballast valve or insert a condensate trap.	2.5.2/3.2
Pump is excessively noisy.	Oil level is much too low (oil is no longer visible). Silencing nozzle is clogged. Intake pressure is too high. Internal demister is clogged. Coupling element is worn. Vanes or bushings are damaged.	Add oil. Clean the silencing nozzle or replace it. Lower the intake pressure. Clean or replace demister. Install new coupling element. Repair pump.	3.1/3.2 Fig. 10 – 3.4 3.5/3.6 Service

* Repair information: refer to the Section in the Operation Instruction stated here.
1) Bubble test: The warm pump with degassed oil is running without gas ballast and the intake blanked off. The exhaust line is lead into a vessel with water. If a an evenly spaced line of bubbles appears, then the pump has an external leak.

Key to the maintenance plan - see 3.11
VE = Maintenance before switching on the system
VP = Maintenance before starting production
t = Daily maintenance
6m = Six monthly maintenance
a = Annual maintenance
n-a = Maintenance every n years.

We recommend that you service the pump every two years covering the following:
- Cleaning
- Checking of the individual components
- Exchange of all seals
- Functional check.

This check should be run by the Leybold service.

3.11 Maintenance Plan (Recommendation)

No.	Rotary vane pumps TRIVAC D 4 B TRIVAC D 8 B	Measurement/test quantity Operating/auxiliary materials	Interval						Remarks
			VE	VP	t	6m	a	n-a	Refer also to the Operating Instructions – Chapter: individual components.
1	Operate the pump for at least 0.8 hours with gas ballast.				x				Condensed water is thus removed from the oil.
2	Check the oil level, change the oil if required.	Oil: N 62 or special alternative oils	x		x				Refill: only after the pump has been switched off.
3	Check the quality of the oil, change the oil if required.	visually	x		x				**Visually:** normally light and transparent, oil change is required when discolorations increase.
		chemically				x			**Chemically:** to DIN 51558 when the neutralisation number exceeds 2; then an oil change will be required.
		mechanically				x			**Mechanically:** when dynamic viscosity at 25 °C exceeds 240 mPas; then an oil change will be required. Disposal of waste oil: see Chapter 3.8.1 and 5.2
4	Clean the dirt trap in the intake port, change it as required.	Suitable cleaning agent and compressed air.				x			❑ Clean dirt trap with a cleaning agent and blow it out with compressed air under a suction hood. ❑ Replace the defective dirt trap. Use a cleaning agent which complies with the national / international specifications. **Observe the safety regulations when using cleaning agents.**
5	Clean the internal demister, change it as required.	Suitable cleaning agent.					x		Already clean before the maintenance interval has elapsed when the noise level increases. ❑ Clean the internal demister using a cleaning agent. ❑ Replace the defective internal demister. ❑ Dispose of the defective internal demister as special waste. Cleaning agent according to national / international specifications. **Observe the safety regulations when using cleaning agents.**
6	Check the edges of the teeth on the coupling element for any damages, change the coupling element as required.						x		
7	Change the oil - and clean the oil level glass.	Oil: N 62 or special and alternative oils. See Chapter 1.6.1. Suitable cleaning agent and compressed air.					x		Oil change: • First oil change after 100 operating hours. • Pump switched off and cold. Change the oil when the pump is cold in order to avoid releasing absorbed gases. ❑ Clean the oil level glass with a cleaning agent and blow it out with compressed air under a suction hood. Cleaning agent according to national / international specifications. **Observe the safety regulations when using cleaning agents.** **Quantity of oil:** see Operating Instructions, Chapter 1.6. **Waste disposal of oil:** see Operating Instructions, Chapter 3.8.1.
8	Check the fan of the pump and the motor as well as the cooling fins on the motor for deposits and clean as required.	Brush and industrial vacuum cleaner.					x		Already clean before the maintenance interval has elapsed when the pump or the motor gets too warm. **Caution:** switch off the pump and ensure that it can not run up inadvertently (disconnect from the mains).

EEC Declaration of Conformity

LEYBOLD

We – LEYBOLD Vakuum GmbH – herewith declare that the products defined below meet the basic requirements regarding safety and health of the relevant EC directives by design, type and versions which are brought into circulation by us.

In case of any product changes made without our approval, this declaration will be void.

Designation of the products: Rotary vane pump - dual stage

Types: TRIVAC B
D 4 B / D 8 B

Cat. Nos.:

112 45; 112 46; 112 55; 112 56

113 03; 113 04; 113 06; 113 08; 113 09;

113 13; 113 14;

113 16; 113 18; 113 21

The products conform to the following directives:

- EC Directive on Machinery (98/37/EG)
- EC Directive on Low-Voltages (73/23)+(93/68/EWG)
- EC EMC Directive (89/336/EWG)
  (91/263/EWG) + (92/31/EWG) + (93/68/EWG)

Applied harmonised standards:

- DIN EN 292 Part 1 11.91
- DIN EN 292 Part 2 06.95
- DIN EN 1012 Part 2 07.96
- DIN EN 60 204 Part 1 11.98

Applied national standards and technical specifications:

- DIN 31 001 April 1983

Cologne, June 20, 2001

K. Kilian, Business Area Manager LPV
Division Industrial

Cologne, June 20, 2001

Dr. Bahnen, Head of R&D LPV
Division Industrial

EEC Manufacturer's Declaration

in the sense of the Directive on Machinery 89/392/EWG, Annex IIb

LEYBOLD

We – Leybold Vacuum GmbH – herewith declare that operation of the incomplete machine defined below, is not permissible until it has been determined that the machine into which this incomplete machine is to be installed, meets the regulations of the EEC Directive on Machinery.

Designation of the products: Rotary vane pump
- dual stage

Types: TRIVAC B
D 4 B without motor
D 8 B without motor

Cat. Nos.: 113 07
113 17

Applied harmonised standards:

- DIN EN 292 Part 1 11.91
- DIN EN 292 Part 2 06.95
- DIN EN 1012 Part 2 07.96
- DIN EN 60 204 Part 111.98

Applied national standards and technical specifications:

- DIN 31 001 April 1983
- DIN ISO 1940 Dec. 1993

Cologne, June 20, 2001

K. Kilian, Business Area Manager LPV
Division Industrial

Cologne, June 20, 2001

Dr. Bahnen, Head of R&D LPV
Division Industrial

LEYBOLD

VDMA

Declaration of Contamination of Compressors, Vacuum Pumps and Components

The repair and / or servicing of compressors, vacuum pumps and components will be carried out only if a correctly completed declaration has been submitted. Non-completion will result in delay. The manufacturer can refuse to accept any equipment without a declaration. A separate declaration has to be completed for every single component.

This declaration may be completed and signed only by authorised and qualified staff.

Customer/Dep./Institute: ____________________

Address: ____________________

____

Person to contact: ____________________

Phone: ____________ **Fax:** ____________

Order number of customer: ____________________

Reason for returning the item/s

____

____

____

____

____

A. Description of the equipment (machine or component)

Type: ____________________

Catalogue number: ____________________

Serial number: ____________________

Type of oil used: ____________________

Ancillary equipment

____

____

____

B. Condition of the equipment (machine or component)

		Yes	No	Not known
1.	Has the equipment been used	☐	☐	☐
2.	Drained (product/service fluid)	☐	☐	☐
3.	All openings sealed airtight	☐		
4.	Purged:	☐	☐	☐

Cleaning agent: ____________________

Method of cleaning: ____________________

C. Description of processed substances (Please fill in absolutely)

1. What substances have come into contact with the equipment:
   Trade name and/or chemical term of service fluids and substances processed, properties of the substances according to safety data sheet (toxic, inflammable, corrosive, radioactive)

	Trade name:	Chemical name:	Properties:
a)			
b)			
c)			
d)			

2. Are these substances harmful? Yes ☐ No ☐ Not known ☐
3. Dangerous decomposition products when thermally loaded Yes ☐ No ☐ Not known ☐

Which: ____________________

Components contaminated by micro biological, explosive or radioactive products will not be accepted without written evidence of decontamination.

D. Legally binding declaration

I/we hereby declare that the information supplied on this form is accurate and sufficient to judge any contamination level.

Name of authorised person (block letters): ____________________

date	signature of authorised person	firm stamp

Copies: Page 1 (white) to manufacturer or representative – Page 2 (yellow) attach to consigement packaging securely – Page 3 (blue) copy for file of sender

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Vakuum-Lösungen

Applikations-
Unterstützung

Service

LEYBOLD

LEYBOLD VAKUUM

ET 01.201/14

TRIVAC® B

S 4 B, D 4 B

S 8 B, D 8 B

Drehschieber-Vakuumpumpe

Rotary Vane Vacuum Pump

Pompe rotative à vide
à palettes

Gültig ab Kat.-Nr. / Fabrikations-Nr.
Valid from Cat.-No. / Serial-No.
Valable à partir du No. de Cat. /
No. de Fabrication

102 45/46/55/56	2020 0000001
103 01/02/03/04/05	2020 0000001
103 06/07/08/11/12	2020 0000001
103 13/14/15/16/17	2020 0000001
103 21	2020 0000001
112 45/46/55/56	2020
0000001	
113 01/02/03/04/05	2020 0000001
113 06/07/08/09/11	2020 0000001
113 12/13/14/15/16	2020 0000001
113 17/18/19/21	2020

Ersatzteilliste

Spare Parts List

Liste des pièces de rechange

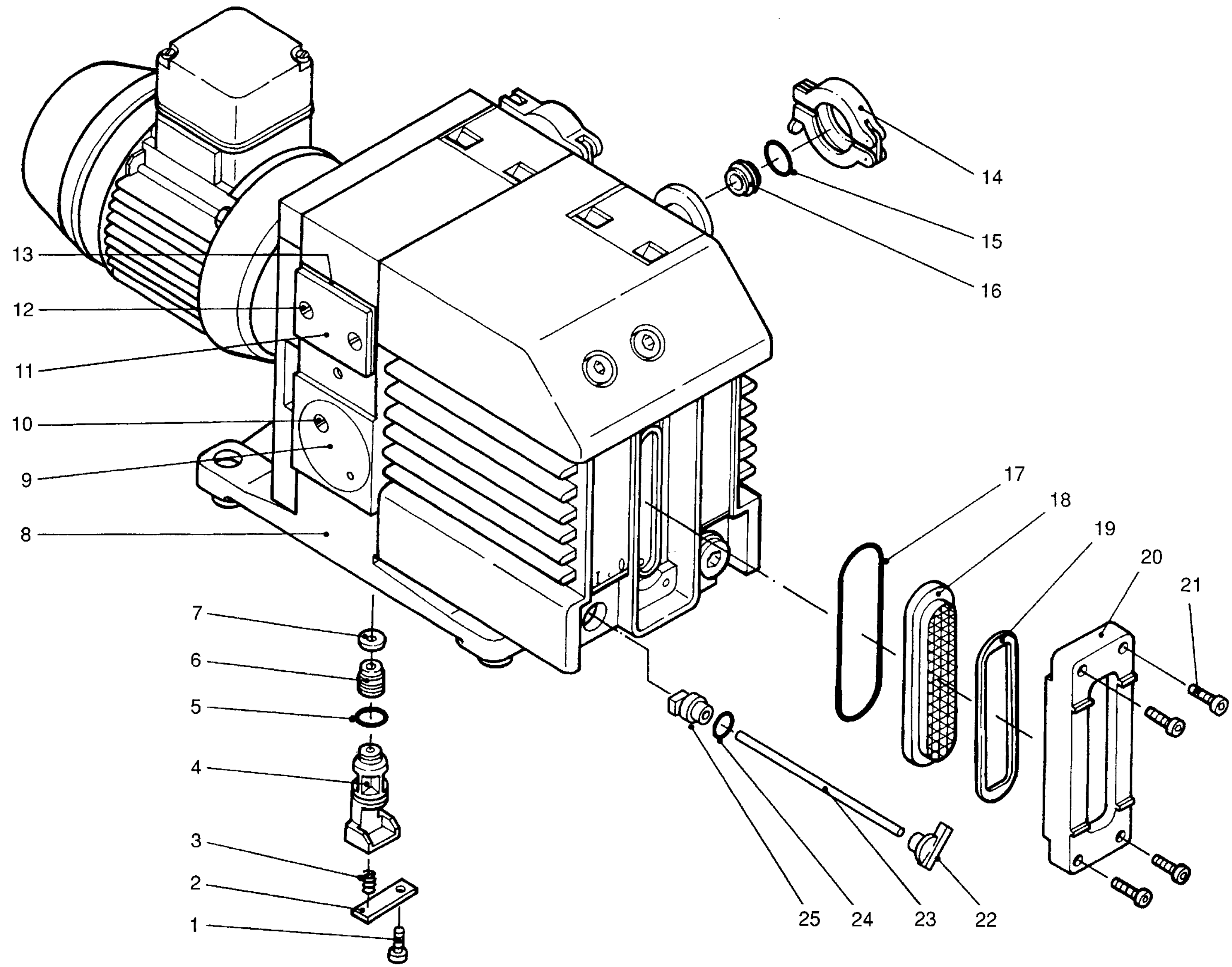

Abb./Fig. 1 TRIVAC 4/8 B mit Gasballasteinrichtung / with gasballastvalve / avec robinet de lest d'air

Siehe Abb.1 / See fig.1 / Voir fig.1 TRIVAC 4/8 B

Pos.	Stückzahl / Quantity / Nombre de pièces S4B	D4B	S8B	D8B	Benennung	Description	Désignation	Abmessungen / Dimensions (mm)	Werkstoff/Material/Matériel	Bestell-Nr. / Ref. No. / Réf.	Bemerkungen / Notes / Remarques
1	1	1	1	1	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 6 x 12	DIN 912	201 03 101	
2	1	1	1	1	Halteblech	Supporting plate	Plaque de retenue	35 x 120 x 2	St	451 74 040	
3	1	1	1	1	Druckfeder	Spring	Ressort	1 x 5 x 34,5	St	221 61 041	
4	1	1	1	1	Kolben	Piston	Piston	ø 21,5 x 57	PA	321 06 151	
5	1	1	1	1	O-Ring	O-ring	Joint torique	16 x 2,5	FPM	239 70 147[1])	1) im
6	1	1	1	1	Dichtelement	Seal	Joint	ø 16 x 12,5	FPM	348 61 029[1])	Dichtungssatz ent-
7	1				Scheibe Gasballast	Disc	Disque lest d'air	ø 15,5 x 1,1 x 0,5	St	200 09 175	halten (Seite 8) /
7		1	1	1	Scheibe Gasballast	Disc	Disque lest d'air	ø 15,5 x 3 x 0,5	St	221 02 048	included in set of
8	1	1	1	1	Kupplungsgehäuse	Coupling housing	Carter d'accouplement	211 x 228 x 142	Al-Leg.	331 68 004	seals (page 8) /
9	1	1	1	1	Blende	Shutter	Diaphragme	ø 54 x 3	Al	221 02 253	compris dans le
10	1	1	1	1	Schneidschraube	Tapping screw	Vis autotarau deuse	FM 4 x 12	DIN 7513	201 03 034	jeu de joints (pg 8)
11	1	1	1	1	Deckel	Cover	Couvercle	4 x 40 x 53	Al-Leg.	200 10 019	
12	2	2	2	2	Senkschraube	Countersunk screw	Vis noyée	M 6 x 16	DIN 7991	201 03 015	
13	1	1	1	1	Dichtung	Gasket	Joint	53 x 40 x 0,5	AFM	200 10 732[1])	
14	2	2	2	2	Spannring	Clamping ring	Collier de fermeture	DN 10/16	Al	230 60 101	
15	2	2	2	2	O-Ring	O-ring	Joint torique	18 x 5	FPM	239 70 176[1])	
16	1	1	1	1	Zentrierring	Centering ring	Anneau de centrage	DN 16 KF	Al	231 94 205	
17	1	1	1	1	O-Ring	O-ring	Joint torique	70 x 5	FPM	239 70 509[1])	
18	1	1	1	1	Ölauge	Oil level glass	Niveau d'huile	111 x 35 x 14	Glas	350 01 179	
19	1	1	1	1	Dichtung Ölauge	Gasket	Joint	108 x 33 x 1	AFM	200 12 257[1])	
20	1	1	1	1	Rahmen	Frame	Châssis	43 x 132 x 14	Al	200 10 017	
21	4	4	4	4	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 4 x 18	DIN 912	200 09 162	
22	1	1	1	1	Knebel für Gasballast	Gasballast lever	Levier lest d'air	30 x 36 x 18	PA	281 53 014	
23	1	1	1		Welle	Shaft	Arbre	130 lg	St	401 57 327	
23				1	Welle	Shaft	Arbre	155 lg	St	401 57 328	
24	1	1	1	1	O-Ring	O-ring	Joint torique	12 x 1,5	FPM	239 70 108	
25	1	1	1	1	Exzenter	Cam	Exzentrique	ø 16 x 29	PA	281 53 015	

Bei Ersatzteilbestellungen bitte unbedingt die Katalog- und Fabrikations-Nummer angeben !

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Lorsque vous commandez des pièces de rechange, veuillez toujours indiquer le numéro de catalogue et de fabrication !

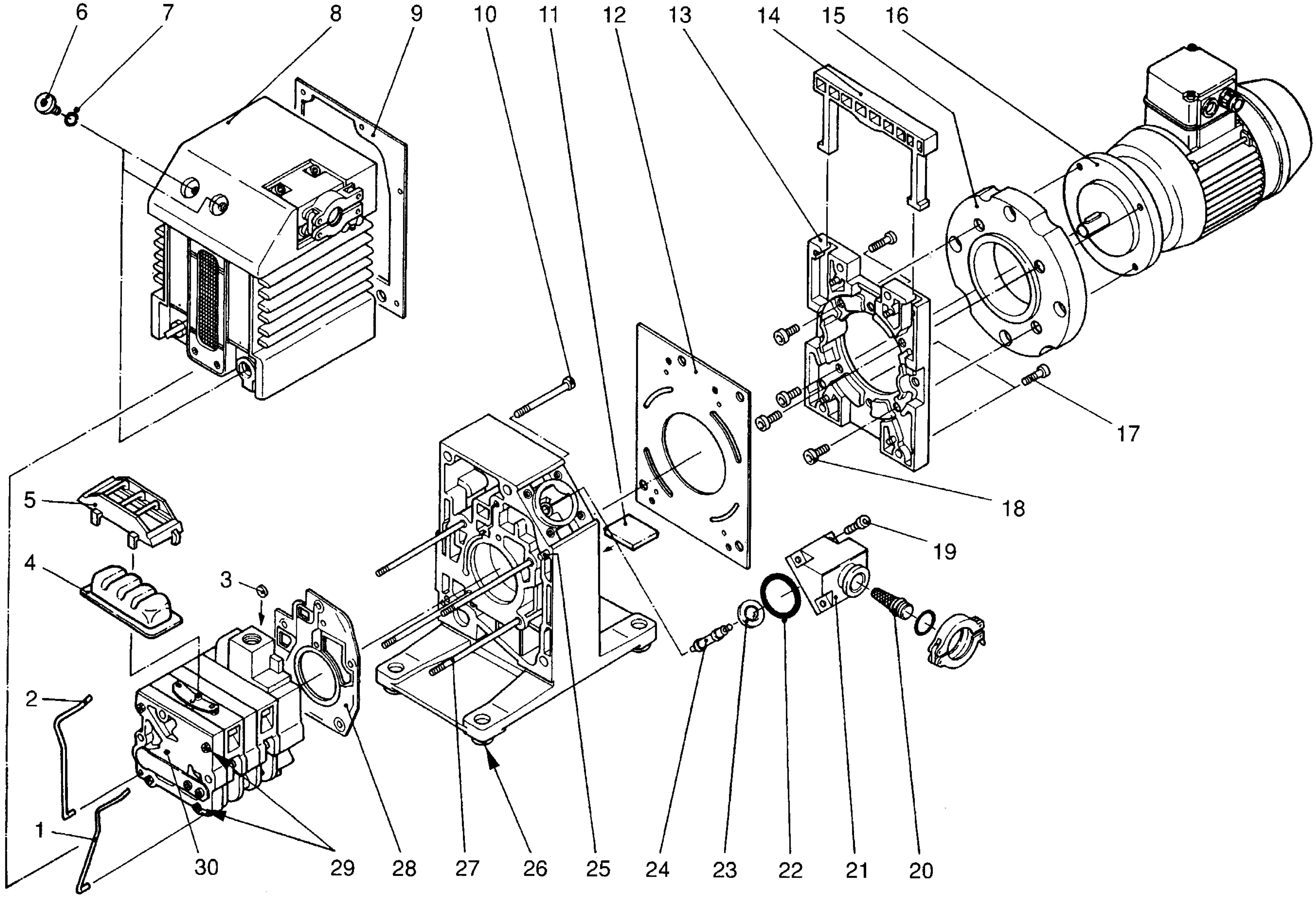

Abb./Fig. 2 TRIVAC D 4/8 B; S 4/8 B ähnlich/similar/similaire

Siehe Abb.2 / See fig.2 / Voir fig.2 TRIVAC 4/8 B

Pos.	Stückzahl / Quantity Nombre de pièces S4B	D4B	S8B	D8B	Benennung	Description	Désignation	Abmessungen / Dimensions (mm)	Werkstoff/Material/Matériel	Bestell-Nr. Ref. No. Réf.	Bemerkungen Notes Remarques
1	1	1	1	1	Klammer	Clamp	Griffe	rechts/right/droit		200 10 768	
2	1	1	1	1	Klammer	Clamp	Griffe	links/left/gauche		200 10 769	
3	1	1	1	1	Scheibe	Disc	Disque	ø 10 x 2	1.4301	221 02 036	
4	1	1			Formfilter	Internal demister	Filtre	92 x 38 x 18	SYPATR	390 26 010[1])	[1]) im
4			1	1	Formfilter	Internal demister	Filtre	92 x 63 x 18	SYPATR	390 26 011[1])	Dichtungssatz ent-
5	1	1			Rahmen	Frame	Châssis	102 x 39 x 16	Al	371 82 139	halten (Seite 8) /
5			1	1	Rahmen	Frame	Châssis	102 x 64 x 16	Al	371 82 140	included in set of
6	3	3	3	3	Verschlußschraube	Plug screw	Bouchon de fermeture	M 16 x 1,5	DIN 908	201 27 105	seals (page 8) /
7	3	3	3	3	Dichtring	Gasket ring	Joint	15,1 x 22 x 2	FPM	239 55 165	compris dans le
8	1	1	1		Ölkasten	Oil casing	Carter d'huile	142 x 190 x 145	Al-Leg.	200 09 338	jeu de joints (pg 8)
8				1	Ölkasten	Oil casing	Carter d'huile	142 x 190 x 170	Al-Leg.	200 09 344	
9	1	1	1	1	Dichtung Ölkasten-Kuppl.	Gasket	Joint	143 x 191 x 0,5	AFM	200 10 733[1])	
10	6	6	6	6	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 6 x 60	DIN 912	201 03 109	
11	1	1	1	1	Filz	Felt	Feutre	40 x 35 x 12		151 08 035	
12	1	1	1	1	Dichtung Kuppl./Zwischenfl.	Gasket	Joint	140 x 189 x 1	Lowoflex	200 10 731[1])	
13	1	1	1	1	Zwischenflansch	Motor connect flange	Contrebride moteur	140 x 174 x 18,5	Al-Leg.	361 46 001	
14	1	1	1	1	Tragegriff	Handle	Poignée	140 x 76 x 16	PA	281 53 011	
15*)	1	1	1	1	Adapter	Adapter	Adapteur	ø 168 x 24	Al	200 09 650*)	*) USA-
16	1	1	1	1	Motor	Motor	Moteur			Page 9	Ausführung /
17	4	4	4	4	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 6 x 20	DIN 912	201 03 103	USA design /
18	4	4	4	4	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 8 x 16	DIN 912	201 03 012	Construction p.
19	8	8	8	8	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 6 x 12	DIN 912	201 03 101	USA
20	1	1	1	1	Schmutzfänger	Dirt trab	Piège à impurétes	DN 16 KF	St	411 70 122	
21	2	2	2	2	Stutzen	Connecting port	Raccord d'admission	DN 16	Al-Leg.	431 71 253	
22	2	2	2	2	O-Ring	O-ring	Joint torique	38 x 2	FPM	239 70 163[1])	
23	1	1	1	1	Ventilteller	Valve plate	Platine soupape	ø 24 x 9	FPM/St	401 59 003[1])	
24	1		1		Kolben	Piston	Piston	ø 7,5 x 50	St	321 06 153	
24		1		1	Kolben	Piston	Piston	ø 7,5 x 50		200 09 609	
25	2	2	2	2	Kerbstift	Grooved pin	Goupille cannelée	4 x 16	DIN 1472	241 03 001	
26	4	4	4	4	Fuß	Foot	Pied	ø 25 x 18	NBR	348 61 037	
27	4				Zuganker	Tie rod	Tirant	M 6 x 86	St60	101 20 002	
27		4			Zuganker	Tie rod	Tirant	M 6 x 128	St60	101 20 003	
27			4		Zuganker	Tie rod	Tirant	M 6 x 111	St60	101 20 004	
27				4	Zuganker	Tie rod	Tirant	M 6 x 153	St60	101 20 005	
28	1	1	1	1	Dichtung Innenteil-Kuppl.	Gasket	Joint	104 x 130 x 0,5	AFM	200 10 730[1])	
29	4	4	4	4	Mutter	Nut	Ecrou	M 6	DIN 934	211 03 009	
30	**1**				**Innenteil kompl.**	**Pumping module compl.**	**Corps de pompe compl.**	**incl. Pos. 1,2,3,4,5,27,29**		**200 10 988**	
30		**1**			**Innenteil kompl.**	**Pumping module compl.**	**Corps de pompe compl.**	**incl. Pos. 1,2,3,4,5,27,29**		**200 10 989**	
30			**1**		**Innenteil kompl.**	**Pumping module compl.**	**Corps de pompe compl.**	**incl. Pos. 1,2,3,4,5,27,29**		**200 10 990**	
30				**1**	**Innenteil kompl.**	**Pumping module compl.**	**Corps de pompe compl.**	**incl. Pos. 1,2,3,4,5,27,29**		**200 10 991**	

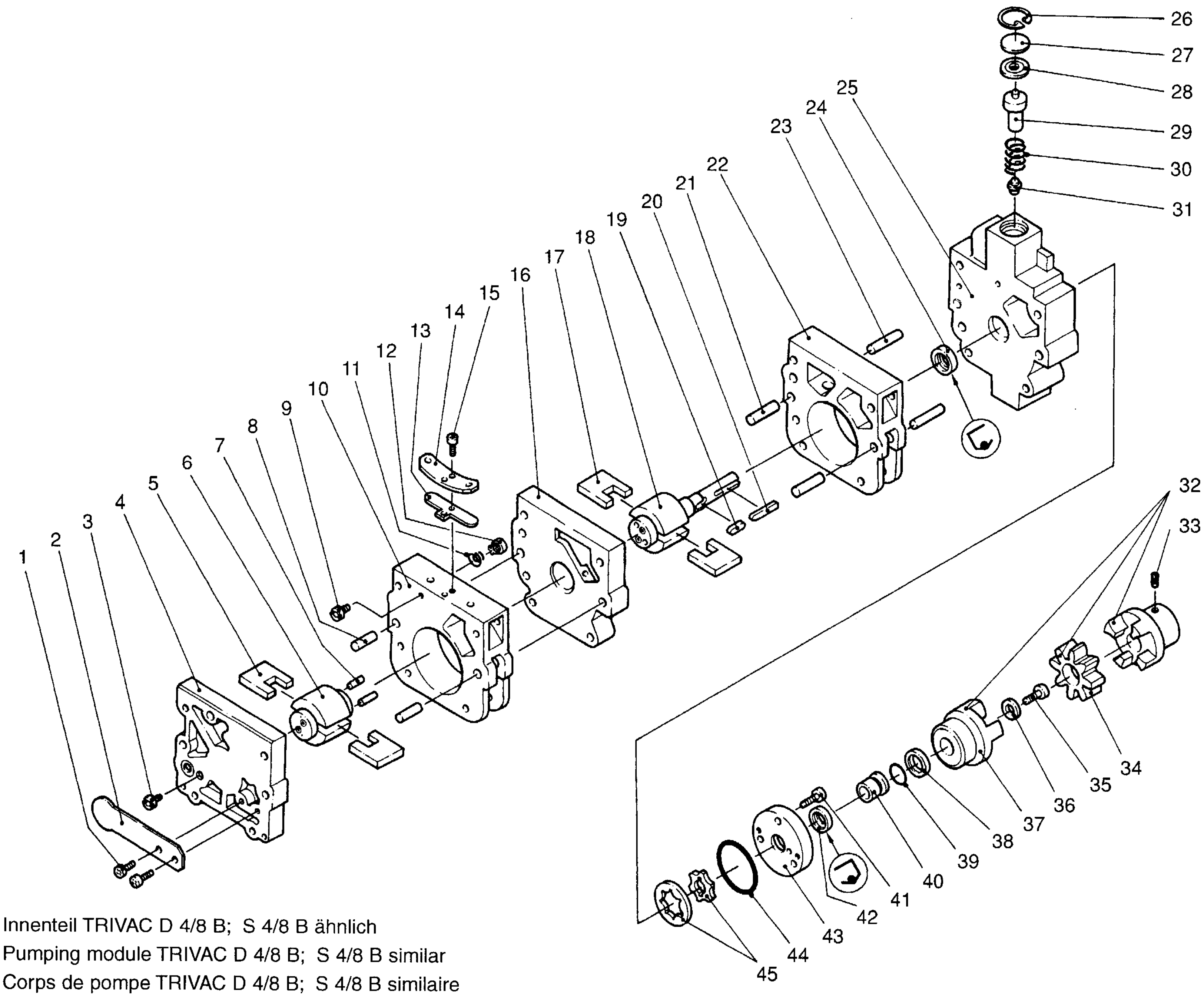

Abb. 3 Innenteil TRIVAC D 4/8 B; S 4/8 B ähnlich
Fig. 3 Pumping module TRIVAC D 4/8 B; S 4/8 B similar
Fig. 3 Corps de pompe TRIVAC D 4/8 B; S 4/8 B similaire

Siehe Abb.3 / See fig.3 / Voir fig.3 TRIVAC 4/8 B

Pos.	Stückzahl / Quantity Nombre de pièces S4B	D4B	S8B	D8B	Benennung	Description	Désignation	Abmessungen / Dimensions (mm)	Werkstoff/Material/Matériel	Bestell-Nr. Ref. No. Réf.	Bemerkungen Notes Remarques
1	2	2	2	2	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 5 x 10	DIN 912	201 03 215	
2	1	1	1	1	Überdruckventil	Pressure valve	Soupape de pression	0,4 x 26 x 93	St	401 75 023	
3	1				Düse-Öleinspritzung	Oil-Nozzle	Gicleur d'huile	ø 0,9	Al	200 09 243	
3		1		1	Düse-Öleinspritzung	Oil-Nozzle	Gicleur d'huile	ø 0,8	Al	200 09 244	
3			1		Düse-Öleinspritzung	Oil-Nozzle	Gicleur d'huile	ø 1,0	Al	393 50 006	
4	1	1	1	1	Lagerdeckel	Rear end plate	Flasque arrière	92 x 102 x 14	GG	351 11 010	
5	2				VV-Schieber	Vane	Palette	25 x 28 x 4	Inkutex	200 10 654	
5		2		2	VV-Schieber	Vane	Palette	25 x 28 x 4	Inkutex	200 39 220	
5			2		VV-Schieber	Vane	Palette	50 x 28 x 4	Inkutex	200 10 658	
6	1				VV-Anker	Rotor forestage	Rotor primaire	ø 45 x 97	GG	321 66 160	
6		1		1	VV-Anker	Rotor forestage	Rotor primaire	ø 45 x 41	GG	321 66 166	
6			1		VV-Anker	Rotor forestage	Rotor primaire	ø 45 x 122	GG	321 66 161	
7		2		2	Zylinderstift	Cylindrical pin	Goupille cylindrique	ø 6_{m6} x 24	DIN 6325	241 03 011	
8	2	2	2	2	Zylinderstift	Cylindrical pin	Goupille cylindrique	ø 8_{k4} x 24	DIN 7979	241 03 016	
9	1			1	Düse GD	Nozzle GD	Gicleur GD	ø 0,25	Al	393 50 013	
9		1	1		Düse GD	Nozzle GD	Gicleur GD	ø 0,2	Al	393 50 019	
10	1				Pumpenring	Pump cylinder	Cylindre	92 x 102 x 25	GG	231 92 008	
10		1		1	VV-Ring	Pump cylinder forestage	Cylindre primaire	92 x 102 x 25	GG	231 92 021	
10			1		Pumpenring	Pump cylinder	Cylindre	92 x 102 x 50	GG	231 92 009	
11	1	1	1	1	Druckfeder	Spring	Ressort	ø 0,7x10,2x15,4	St	221 61 031	
12	1	1	1	1	Rückschlagventil	Non-return valve	Clapet de retenue	ø 12 x 7	FPM	348 61 028	
13	1	1		1	Blattventil	Valve plate	Platine soupape	51 x 14,5 x 0,2	St	401 75 014	
13			1		Blattventil	Valve plate	Platine soupape	30 x 30 x 0,2	St	401 75 015	
14	1	1		1	Ventilfänger	Valve stop	Butée de soupape	52 x 15 x 15	St	451 74 043	
14			1		Ventilfänger	Valve stop	Butée de soupape	31 x 30,5 x 1,5	St	451 74 044	
15	1	1	2	1	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 5 x 8	DIN 912	201 03 214	
16		1		1	Zwischenlager	Center bearing	Palier intermédiaire	92 x 102 x 17,2	GG	261 51 137	
17		2			HV-Schieber	Vane	Palette	25 x 28 x 4	Inkutex	200 39 220	
17				2	HV-Schieber	Vane	Palette	50 x 28 x 4	Inkutex	200 10 658	
18		1			HV-Anker	Rotor HV-stage	Rotor basse pression	ø 45 x 97	GG	321 66 160	
18				1	HV-Anker	Rotor HV-stage	Rotor basse pression	ø 45 x 122	GG	321 66 161	
19	1	1	1	1	Paßfeder	Key	Clavette	3,2 x 3,2 x 6	DIN 6885	221 16 022	1) im
20	1	1	1	1	Paßfeder	Key	Clavette	3,2 x 3,2 x 22	DIN 6885	221 16 023	Dichtungssatz ent-
21		2		2	Zylinderstift	Cylindrical pin	Goupille cylindrique	ø 8_{k4} x 32	DIN 7979	241 03 009	halten (Seite 8) /
22		1			HV-Ring	Pump cylinder HV-stage	Cylindre vide poussé	92 x 102 x 25	GG	231 92 014	included in set of
22				1	HV-Ring	Pump cylinder HV-stage	Cylindre vide poussé	92 x 102 x 50	GG	231 92 015	seals (page 8) /
23	2	2	2	2	Zylinderstift	Cylindrical pin	Goupille cylindrique	ø 8_{k4} x 24	DIN 7979	241 03 016	compris dans le
24	1	1	1	1	Radial-Dichtring	Radial shaft seal	Joint radial	BA 15 x 24 x 7	FPM	239 53 006[1])	jeu de joints (pg 8)
25	1	1	1	1	Lagerstück	Front bearing	Flasque côte d'accouplement	104x144x28,7	GG	200 09 544	

Bei Ersatzteilbestellungen bitte unbedingt die Katalog- und Fabrikations-Nummer angeben !

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Siehe Abb.3 / See fig.3 / Voir fig.3 TRIVAC 4/8 B

Pos.	Stückzahl / Quantity Nombre de pièces S4B	D4B	S8B	D8B	Benennung	Description	Désignation	Abmessungen / Dimensions (mm)	Werkstoff/Material/Matériel	Bestell-Nr. Ref. No. Réf.	Bemerkungen Notes Remarques
26	1	1	1	1	Sicherungsring	Retainer ring	Circlip	24 x 1,2	DIN 472	231 04 009	
27	1	1	1	1	Scheibe	Disc	Disque	ø 23,5 x 1	St	221 02 035	
28	1	1	1	1	Dichtung	Gasket	Joint	ø 23,8 x 0,5	AFM	200 10 734[1])	[1]) im
29	1	1	1	1	Steuerkolben	Control piston	Piston de réglage	ø 20 x 31,5	Al	321 06 152	Dichtungssatz ent-
30	1	1	1	1	Druckfeder	Split spring	Ressort de pression	ø 18 x 1,5 x 29	St	221 61 040	halten /
31	1	1	1	1	Dichtnippel	Plug seal	Joint soupape	ø 8 x 6	FPM	239 73 146[1])	included in set of
32	1	1	1	1	Kupplung kompl.	Coupling compl.	Accouplement compl.	ø 55 x 66	Rotex 24	200 09 104	seals /
32*)	1	1	1	1	Kupplung kompl.	Coupling compl.	Accouplement compl.	ø 55 x 66	Rotex 24	200 09 649*)	compris dans le
33	1	1	1	1	Stiftschraube	Threaded stud	Goujon	M 5 x 12	DIN 916	201 23 105	jeu de joints
34	1	1	1	1	Zahnkranz	Thoothed ring	Jante dentée	Rotex 24		200 09 110	
35	1	1	1	1	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 4 x 12	DIN 912	201 03 037	*) USA-
36	1	1	1	1	Spannscheibe	Clamping disc	Disque de serrage	ø 20 x 3,5	St	200 09 102	Ausführung /
37	1	1	1	1	Kupplungshälfte (Pumpe)	Coupling half(pump)	Accouplement (pompe)	ø 55 x 46	Rotex 24	200 09 112	USA design
38	1	1	1	1	Preßscheibe	Pressed disc	Disque de pression	ø 18 x 12 x 3	St	200 09 113	
39	1	1	1	1	O-Ring	O-ring	Joint torique	12 x 1,5	FPM	239 70 108[1])	
40	1	1	1	1	Buchse	Socket	Douille de prise	12 x 15/17 x 1	St	200 09 111[1])	
41	3	3	3	3	Zylinderschraube	Cylinder screw	Vis à tête cylindrique	M 4 x 18	DIN 912	201 03 206	
42	1	1	1	1	Radial-Dichtring	Radial shaft seal	Joint radial	BA 15 x 24 x 7	FPM	239 53 006[1])	
43	1	1	1	1	Zentrierscheibe	Centering disc	Disque de centrage	ø 62 x 11	GG	401 57 312	
44	1	1	1	1	O-Ring	O-ring	Joint torique	40 x 1,5	FPM	239 70 015[1])	
45	1	1	1	1	Gerotor	Gerotor	Gerotor	Typ 8030		321 66 157	
	1	**1**	**1**	**1**	**Dichtungssatz [a])**	**Set of seals [a])**	**Jeu de joints [a])**			**197 20**	
					[a]) enthält alle mit [1]) gekennzeichneten Teile	[a]) contains all parts marked [1])	[a]) renferme toutes les pièces marquées par [1])				

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Motorabhängige Daten / Motor related data / Données se référant au moteur

S 4 B	**D 4 B**	**S 8 B**	**D 8 B**	Motor-Anschluß-spannung, -Frequenz Motor connection voltage, frequency Connexion tension moteur, fréquence	Motor-Leistung Motor-power Puissance du motor	Nennstrom Rated. current Courant. nominal	Drehzahl Speed Vitesse de rotation	**Bestell-Nr. Motor** **Order no. motor** **No. de commande du moteur**
Kat.-Nr. Cat. No. No. de Cat.	Kat.-Nr. Cat. No. No. de Cat.	Kat.-Nr. Cat. No. No. de Cat.	Kat.-Nr. Cat. No. No. de Cat.					
102 45	112 45	102 55	112 55	1~ , 230 V, 50 Hz	0,37 kW	2,9 A	1400	**380 66 008**
102 46	112 46	102 56	112 56	3~ , 230/400 V, 50 Hz 250/440 V, 60 Hz	0,37 kW	1,95/1,12 A 1,73/1,0 A	1970 1680	**380 66 006**
103 01	113 01	103 11	113 11	1~ , 220 V, 50/60 Hz	0,37 kW	3 A	1400/ 1660	**200 10 401**
103 02	113 02	103 12	113 12	1~ , 240 V, 50/60 Hz	0,37 kW	2,7 A	1380/ 1680	**200 10 402**
103 03	113 03	103 13	113 13	1~ , 115 V, 60 Hz	0,37 kW	5,6 A	1700	**200 10 403**
103 04	113 04 113 08	103 14	113 14 113 18	1~ , 100 V, 50 Hz 110 V, 60 Hz	0,37 kW	8,7/6,1 A	1400/ 1700	**200 10 404**
103 05	113 05	103 15	113 15	3~ , 400 V, 50 Hz	0,37 kW	1,12 A	1370	**200 10 405**
103 06	113 06	103 16	113 16	3~ , 230/400 V, 50 Hz	0,37 kW	1,92/1,11 A	1395	**200 10 406**
103 08	113 09	103 21	113 21	1~ , 230 V, 50/60 Hz	0,37 kW	2,9 A	1500/ 1800	**200 39 867**
103 07	113 07	103 17	113 17	ohne Motor without motor sans moteur	——	——	——	——

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Quantum Design

Physical Property Measurement System

Horizontal Rotator Option User's Manual

Part Number 1384-100B

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Technical support (858) 481-4400
(800) 289-6996
Fax (858) 481-7410

Second edition of manual completed June 2000.

Trademarks

U.S. Patents

4.791.788 Method for Obtaining Improved Temperature Regulation When Using Liquid Helium Cooling
4.848.093 Apparatus and Method for Regulating Temperature in a Cryogenic Test Chamber
5.311.125 Magnetic Property Characterization System Employing a Single Sensing Coil Arrangement to Measure AC Susceptibility and DC Moment of a Sample (patent licensed from Lakeshore)
5.647.228 Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber
5.798.641 Torque Magnetometer Utilizing Integrated Piezoresistive Levers

Foreign Patents

U.K. 9713380.5 Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber

C O N T E N T S

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Contents and Conventions

P.1 Introduction

This preface contains the following information:

- Section P.2 discusses the overall scope of the manual.
- Section P.3 briefly summarizes the contents of the manual.
- Section P.4 illustrates and describes conventions that appear in the manual.

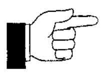
P.2 Scope of the Manual

This manual contains important information regarding the care, handling, and use of the Horizontal Rotator option for the Physical Property Measurement System (PPMS).

P.3 Contents of the Manual

- Chapter 1 presents an overview of the Horizontal Rotator option and discusses the Horizontal Rotator probe.
- Chapter 2 explains how to install the Horizontal Rotator hardware.
- Chapter 3 discusses the operation of the rotator motor and how the rotator affects measurements.
- Appendix A lists the PPMS firmware commands that may be used with the Horizontal Rotator.
- Appendix B contains the interconnection tables.

P.4 Conventions in the Manual

File menu	**Bold** text distinguishes the names of menus, options, buttons, and panels appearing on the PC monitor or on the Model 6000 PPMS Controller LCD screen.
File➤Open	The ➤ symbol indicates that you select multiple, nested software options.
STATUS	**Bold** text and all CAPITAL letters distinguish the names of keys located on the front panel of the Model 6000 PPMS Controller.
`.dat`	The `Courier` font distinguishes characters you enter from the PC keyboard or from the Model 6000 PPMS Controller front panel. The `Courier` font also distinguishes code and the names of files and directories.
<Enter>	Angle brackets < > distinguish the names of keys located on the PC keyboard.
<Alt+Enter>	A plus sign + connecting the names of two or more keys distinguishes keys you press simultaneously.
	A pointing hand introduces a supplementary note.
	An exclamation point inside an inverted triangle introduces a cautionary note.
	A lightning bolt inside an inverted triangle introduces a warning.

C H A P T E R 1

Introduction

1.1 Introduction

This chapter contains the following information:

- Section 1.2 presents an overview of the PPMS Horizontal Rotator option.
- Section 1.3 discusses operation of the Horizontal Rotator probe.

1.2 Overview of the Horizontal Rotator Option

The Quantum Design Horizontal Rotator option for the Physical Property Measurement System (PPMS) allows sample rotations around an axis that is perpendicular to the magnetic field of a longitudinal PPMS magnet. The Horizontal Rotator probe fits into the PPMS sample chamber with all wiring connections accomplished via the keyed connector at the bottom of the sample chamber. The rotator may safely be exposed to all temperatures accessible in the PPMS.

The range of rotator rotation is −10° to 370°. For Horizontal Rotators with serial numbers 011 or greater, 0° and 360° denote the face-up orientation. For Horizontal Rotators with serial numbers 001 to 010, 0° and 360° denote the face-down orientation, and 180° denotes the face-up orientation. An anti-backlash spring helps keep the same gear faces in contact at all times. For the standard rotator motor, the motorized steps are in .0532° increments, and the maximum rate of rotation is 10° per second. For the high-resolution motor, the motorized steps are in 0.00449° increments, and the maximum rate of rotation is about 50° per minute. Jewel bearings on the moving parts lengthen the life span of the rotator.

Table 1-1. Hardware for Horizontal Rotator Option

HARDWARE	PART NUMBER	ILLUSTRATION
Horizontal Rotator Probe	4084-304	Figure 1-2
Resistance Bridge Sample Holder Board	3084-371	Figure 2-1
Support Plate with Motor	4084-302	Figure 2-6
Rotator Support Tool	4084-391	Figure 2-2
Sample Removal Tool	4084-307	Figure 2-3
Horizontal Rotator Kit for ACT Option	4084-308	

The Horizontal Rotator option may be used with the PPMS AC Transport Measurement System (ACT) option or the PPMS Resistivity option. For detailed information about using the rotator with either of these options, refer to the *Physical Property Measurement System: AC Transport Option User's Manual* or the *Physical Property Measurement System: Resistivity Option User's Manual.*

1.2.1 Manual and Automatic Operation

The Horizontal Rotator may be operated manually or used with an automatic motor drive. The vernier dial on the top of the Horizontal Rotator probe may be turned manually, or the motor connected to the support plate can mate with the top of the rotator to control sample orientation. The **Instrument➤ Motion** menu option in PPMS MultiVu allows immediate access to motor control and configuration. Sequence commands can automate motor control through the use of PPMS sequences. Section 3.2.2 discusses immediate-mode operation. Section 3.2.3 discusses sequence mode operation. Appendix A lists the firmware commands that affect the Horizontal Rotator. The *Physical Property Measurement System: Firmware Manual* explains in more detail how to control the motor directly from the front panel of the Model 6000 PPMS Controller.

The manually operated rotator consists of the Horizontal Rotator probe and the support plate assembly without a motor.

1.2.2 Electrical Connection to the Model 6000

The motor cable (part number 4084-303) connects the rotator motor to the "P10–Motor" port located on the rear panel of the Model 6000 PPMS Controller. The connections for the "P10–Motor" port are hard wired from the Model 6000 motherboard, providing six signals that consist of four phase lines plus one index signal and one limit signal. The four phase lines provide power to the stepper motor. The index switch at the motor is used as the −10° reference position. The limit signal is permanently deactivated (shorted to ground) and is not used with the motorized Horizontal Rotator option.

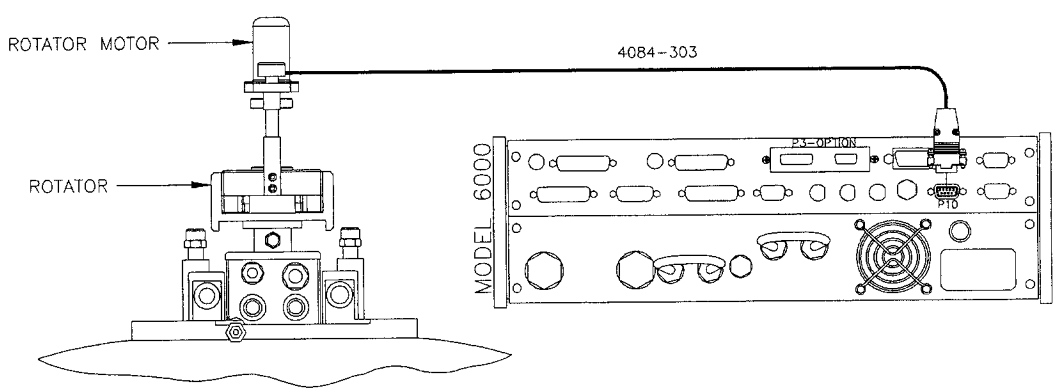


Figure 1-1. Connection Diagram for Horizontal Rotator

1.2.3 Maintenance

The rotator O-rings should be kept clean and lubricated to ensure long life for the PPMS. The O-rings on the top end of the Horizontal Rotator probe (see figure 1-2) should be lubricated with Apiezon M Grease. The O-rings on the bottom of the rotator support plate (see figure 2-6) should be lubricated with silicone vacuum grease. Both greases can be obtained from Quantum Design. Gears, bearings, and other moving parts on the rotator should not come in contact with grease.

Heat sink compound is applied to the top of the rotator thermometer to help keep it in close thermal contact with the sample holder board. Fresh thermal compound should be applied when there is no visible amount of compound left on the thermometer. This thermal compound can also be obtained from Quantum Design.

Table 1-2. Part Numbers for Horizontal Rotator Parts and Accessories

DESCRIPTION	PART NUMBER	ILLUSTRATION
O-ring for Horizontal Rotator Probe	VON-218	Figure 1-2
O-ring for Support Plate	VON2-326	Figure 2-6
Apiezon M Grease (for VON-218)	HM11	
Silicone Vacuum Grease (for VON2-326)	AGV1	
Thermal Compound for Rotator Thermometer	AGT1	
Rotator Support Tool	4084-391	Figure 2-2
Sample Removal Tool	4084-307	Figure 2-3
Resistance Bridge Sample Holder Board	3084-371	Figure 2-1
Universal Sample Holder Board	3084-341	Figure 2-5
AC Transport Sample Holder Board	3084-370	
Horizontal Rotator Kit for ACT Option • Includes ACT/Horizontal Rotator Probe Cable • Includes ACT Sample Holder Board	4084-308 3084-517 3084-370	

Prices for parts listed in table 1-2 can be obtained by contacting Quantum Design's Customer Service Department. Some parts may also be obtained through other vendors.

1.3 Horizontal Rotator Probe

Caution! The Horizontal Rotator probe is delicate and must be handled with care to avoid denting or bending the stainless steel tube on the probe's exterior. Use caution when working near the intricate components in the rotator transfer case so that you do not damage gears or wiring. Be extremely careful when placing the probe on a flat surface, such as a table, because the probe may easily roll off.

The Horizontal Rotator probe is used to insert the sample into the PPMS sample chamber. A sample holder board is attached to the rotator platform circuit board on the rotator transfer case, and electrical connections to the sample are made through the keyed interface at the bottom of the Horizontal Rotator probe. Refer to figure 1-2.

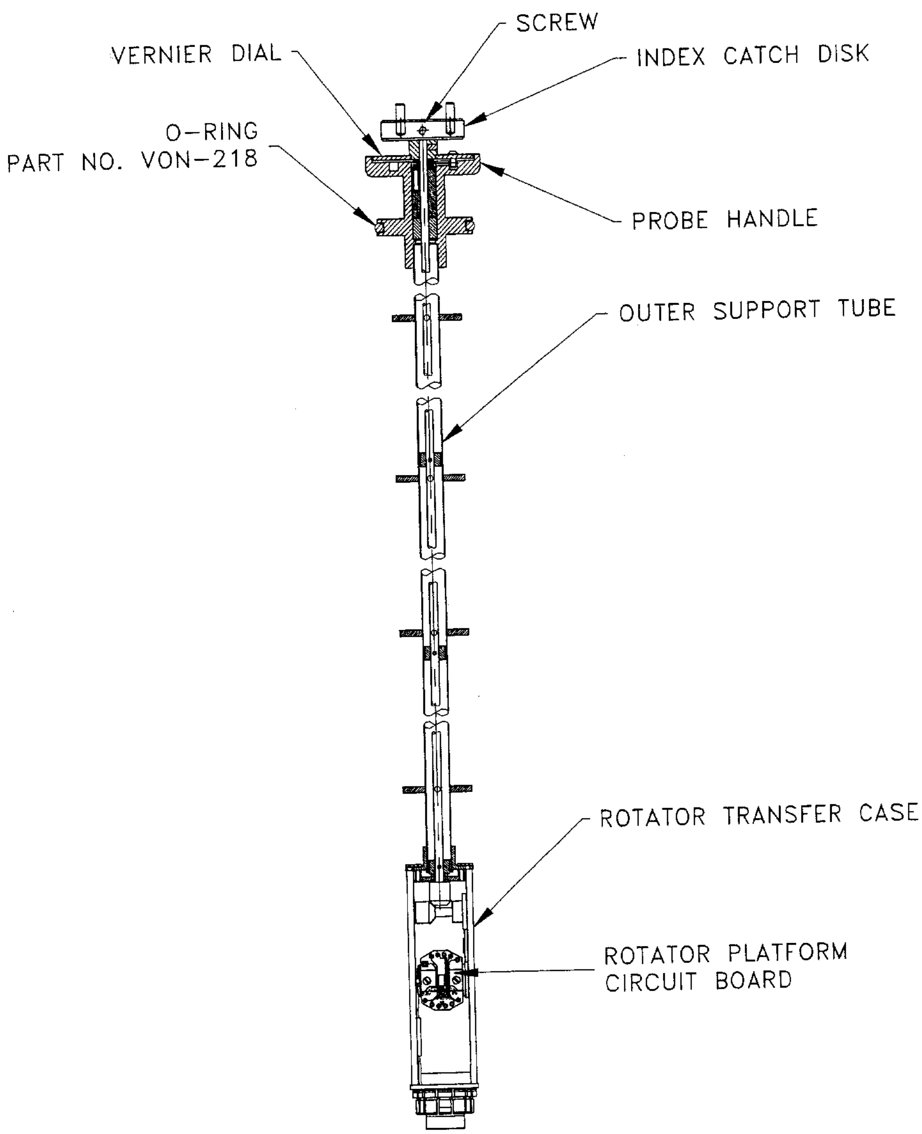


Figure 1-2. Horizontal Rotator Probe

Caution! When it is first removed from the PPMS sample chamber, the Horizontal Rotator probe is usually very cold, and ice typically forms on it, temporarily locking gears and bearings. This is normal. Do not force rotator motion when the rotator is in this condition. The rotator thaws within 1 or 2 minutes, and you may gently work the index catch disk to verify rotation.

Caution! Do not store the Horizontal Rotator probe so that it hangs upside down, and do not rotate the rotator upside down. When the rotator is upside down, the metal pin that prevents the rotator from moving beyond −10° or 370° falls out. This problem can normally be fixed by turning the probe right-side up and rotating it back and forth a few times.

When not in use, the Horizontal Rotator probe should be stored in a vertical position in a hanging rack.

The O-rings on the top end of the Horizontal Rotator probe should periodically be lubricated with grease. Refer to section 1.2.3.

1.3.1 Current Leads

Four copper alloy current leads are wired to the rotator platform circuit board. These leads are connected to contact pads 7, 8, 11, and 12 as labeled on the resistance bridge sample holder board. The remainders of the leads are phosphor-bronze and should only be used for voltage detection.

Caution! The current leads on the rotator (7, 8, 11, and 12) are fine-gauge copper alloy. They are rated for a maximum .500A current. It is possible to output up to 2A current by using the ACT option with the rotator. Depending on temperature and other conditions, this may overheat and melt the rotator wiring. To avoid this situation, limit your output current to .500A while using ACT with the rotator. At room temperature the resistance of the rotator current leads is roughly 0.5 Ω.

Note: Quantum Design doesn't guarantee the rotator wiring for any current above .500A. However, it is possible to perform experiments with greater current by limiting measurement duration and introducing a cooling period between measurements. Call Quantum Design customer service for details.

1.3.2 Rotator Thermometer

The rotator thermometer is wired to contact pads 3 through 6. User bridge board channel 1 reads the rotator thermometer *unless* the ACT option is in use. When the ACT option is in use, system bridge board channel 4 reads the rotator thermometer.

When the rotator is being used, the settings for user bridge board channel 1 should not be changed from their normal settings for the rotator. These settings are 1000 μA current limit, 100 μW power limit, and 10 mV voltage limit. Exceeding these limits can damage the thermometer. Because this thermometer is used by the Model 6000 as the user thermometer that controls system temperature, you must avoid wiring samples in parallel with the rotator thermometer. Doing so eliminates the ability to accurately read the rotator thermometer and causes erroneous sample measurements.

Heat sink compound is applied to the top of the rotator thermometer. Refer to section 1.2.3.

1.3.3 Changing the Orientation of the Sample Holder Board

To change the angular orientation of the sample holder board that is mounted on the rotator platform circuit board, you use only the index catch disk at the top of the Horizontal Rotator probe. Do not force rotation of the sample holder board itself. The index catch disk is intentionally left loose enough to slip when the rotator has reached its physical limits. This is to prevent damage to the delicate components of the rotator should the motor attempt to move the rotator beyond its physical limits. If the index catch disk is too loose, you may tighten the set screw within this disk by using a 1/16-inch ball driver or Allen wrench. Do not disable this safety disengagement mechanism by gluing or otherwise permanently attaching the index catch disk.

C H A P T E R 2

Installation

2.1 Introduction

This chapter contains the following information:

- Section 2.2 summarizes the rotator hardware installation procedures.
- Section 2.3 explains how to mount a sample on a sample holder board.
- Section 2.4 explains how to attach a sample holder board to the rotator probe.
- Section 2.5 explains how to install the rotator hardware into the PPMS.
- Section 2.6 explains how to download the rotator configuration files.
- Section 2.7 explains how to ensure proper position calibration.
- Section 2.8 explains how to remove the rotator hardware from the PPMS.

2.2 Overview of Horizontal Rotator Installation

You must complete the following procedures before you may take measurements with the Horizontal Rotator.

1. Mount the sample on a sample holder board (section 2.3).
2. Attach the sample holder board to the Horizontal Rotator probe (section 2.4).
3. Install the Horizontal Rotator hardware in the PPMS (section 2.5).
4. Download the appropriate rotator configuration file (section 2.6).
5. Engage the motor and check for proper position calibration (section 2.7).

If you want to simply attach a different sample to the Horizontal Rotator probe without completely removing the rotator hardware from the PPMS, you may omit steps 4 and 5 above *unless* you perceive problems with rotator operation, in which case these should be your first two lines of action.

Before taking measurements, you should refer to section 3.4, "Measurement Considerations."

2.3 Mounting the Sample on the Sample Holder Board

The sample is mounted on a sample holder board (see figure 2-1), which is then attached to the rotator platform circuit board on the Horizontal Rotator probe. The sample should be smaller than 8 × 9 mm so that the sample holder board can be mounted on the rotator platform. The sample holder board makes thermal contact with a thermometer on the rotator platform, allowing close monitoring of the sample temperature when the sample is installed in the PPMS sample chamber. Electrical connections to the mounted sample are made through contact pads on the sample holder board.

To mount a sample on a sample holder board, you (1) secure the sample to the sample holder board and then (2) wire the sample to the sample holder board.

2.3.1 Step 1: Secure the Sample

You may use a variety of techniques, including tapes, glues, greases, and epoxies, to secure samples to the sample holder board. The method you use to secure a sample must be able to withstand the entire temperature range to which the sample will be subjected.

2.3.2 Step 2: Wire the Sample

Electrical contact to the sample is made by using the labeled contact pads on the sample holder board. You typically solder leads to these pads. You may wire samples permanently to the sample holder board and then install the sample holder board on the rotator when you are ready to use the sample.

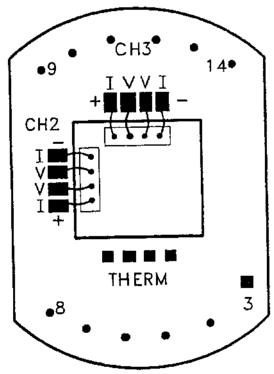


Figure 2-1. Resistance bridge sample holder board with two samples mounted for four-wire resistance measurements.

When the PPMS probe head is connected to the user bridge board, you should wire the samples, which are mounted on the resistance bridge sample holder board, to user bridge board channels 2 and 3 (figure 2-1). The contact pad functions when the probe head is connected to the user bridge board—that is, the contact pad functions for the resistance bridge sample holder board—are identified below in table 2-1.

When the ACT option is activated and the probe head is connected to the Model 7100 AC Transport Controller, the contact pads function differently than they do when the probe head is connected to the user bridge board. Refer to the *Physical Property Measurement System: AC Transport Option User's Manual* for the Horizontal Rotator–ACT wiring arrangement and for detailed information about using the rotator with the ACT option.

Caution! Avoid using contact pads 3 through 6 and thus wiring samples in parallel with the rotator thermometer. Wiring samples in parallel with the rotator thermometer invalidates the thermometer readings and causes the PPMS temperature control to malfunction. Refer to section 1.3.2.

Contact pads for the rotator thermometer channel are provided only for the extreme case that you require simultaneous measurements on three channels and want to disconnect the rotator thermometer. Such a course of action is not recommended, and may void the warranty. Contact your Quantum Design service representative before you consider disconnecting the rotator thermometer.

Table 2-1. Standard interconnection table for Horizontal Rotator option. Table shows interconnections between Resistivity option, Horizontal Rotator sample holder board, and thermometer.

RESISTANCE BRIDGE BOARD FUNCTION	P1 PORT ON MODEL 6000	GRAY LEMO CONNECTOR ON PROBE HEAD	RESISTANCE BRIDGE SAMPLE HOLDER	THERMOMETER
Channel 1, I+	5	3	3	I+
Channel 1, I–	18	4	4	I–
Channel 1, V+	6	5	5	V+
Channel 1, V–	19	6	6	V–
Channel 2, I+	7	7	7	
Channel 2, I–	20	8	8	
Channel 2, V+	8	9	9	
Channel 2, V–	21	10	10	
Channel 3, I+	9	11	11	
Channel 3, I–	22	12	12	
Channel 3, V+	10	13	13	
Channel 3, V–	23	14	14	

2.4 Attaching the Sample Holder Board to the Rotator

After the sample is mounted on the sample holder board, you may attach the sample holder board to the rotator platform circuit board that is on the Horizontal Rotator probe. The rotator platform circuit board is located on the rotator transfer case, which is near the bottom end of the Horizontal Rotator probe. Refer to figures 1-2 and 2-5.

The rotator support tool (figure 2-2) and the sample removal tool (figure 2-3) help you avoid damaging rotator hardware when you install and remove the sample holder board. Always use these two hardware components during sample holder board installation and removal.

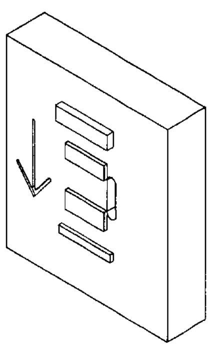


Figure 2-2. Rotator Support Tool

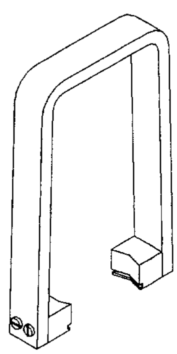


Figure 2-3. Sample Removal Tool

Complete the following steps to attach the sample holder board to the rotator:

1. Set the vernier dial on the Horizontal Rotator probe to 90°.
2. Lay the Horizontal Rotator probe on a flat surface, such as a table, with the chuck key facing upward and the rotator support tool beneath the rotator transfer case. The arrow on the support tool must point toward the handle of the rotator probe (figure 2-4.) This orientation allows the rotator support tool to support the transfer case and prevent the rotator from rolling.

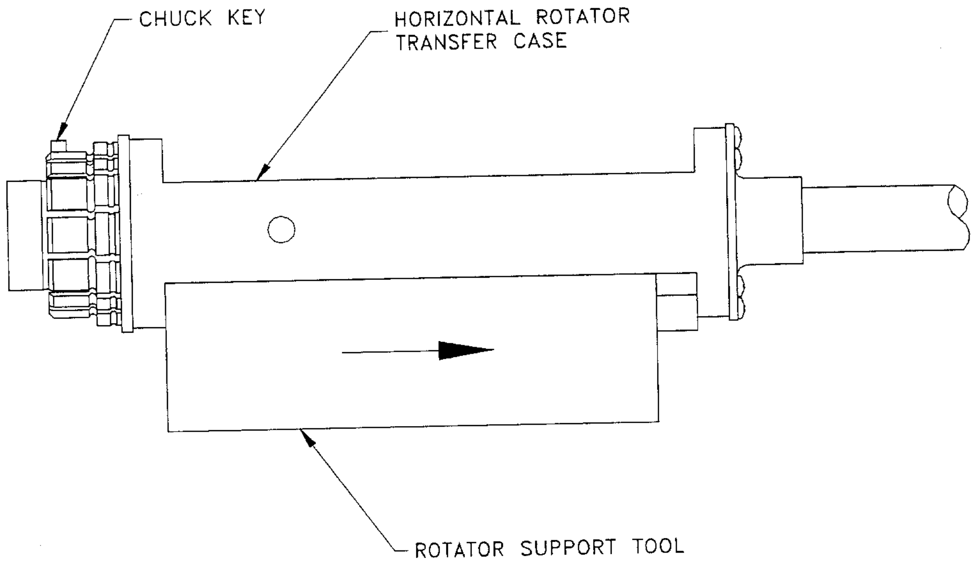


Figure 2-4. Correct Orientation of Rotator Transfer Case on Rotator Support Tool

3. Grasp the sample holder board with the sample removal tool (figure 2-3), and carefully align the pins on the sample holder board with the sockets on the rotator platform circuit board. Refer to figure 2-5 below. Pin #3 is slightly offset from the rest of the pins, so only one orientation of the board is possible. If you force the sample holder board into place with the wrong orientation, you may damage the thin pins on the board.

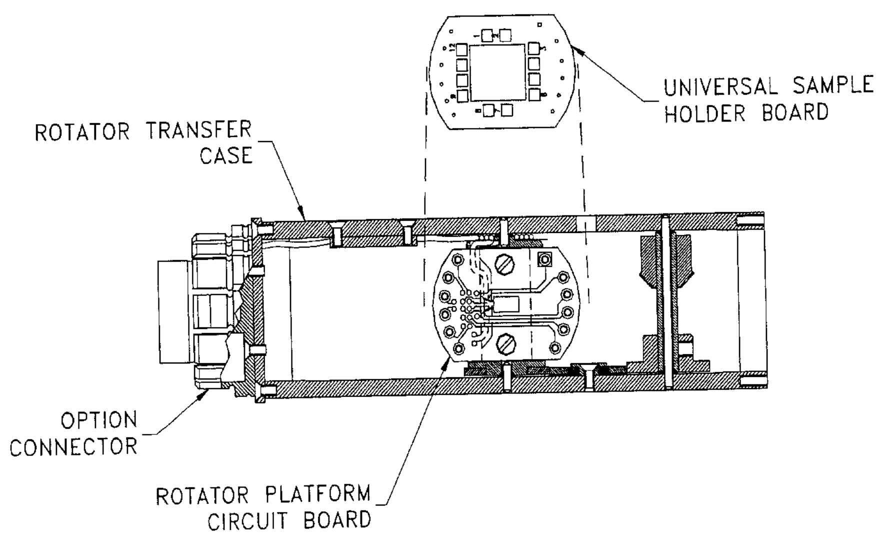


Figure 2-5. Placing the Sample Holder Board on the Rotator Platform Circuit Board

Caution! Use the sample removal tool like a set of tweezers to grasp the sample holder board when you insert the sample holder board on or remove it from the rotator platform. The sample removal tool ensures that even pressure is applied to the sample holder board, therefore keeping the thin pins on the bottom of the sample holder board from bending. Using your fingers to press the sample holder board onto the rotator may bend the pins and damage the electrical connections to the sample.

4. Continue to grasp the sample holder board with the sample removal tool, and then use the sample removal tool to push down the sample holder board completely so that it is immediately on top of the rotator platform circuit board. If the sample holder board is not pushed in with even pressure applied across the board, it may go in crooked and damage the pins. The sample holder board should contact the rotator thermometer with a little thermal compound on top of the thermometer. Once the sample holder board is properly attached, the rotator probe is ready to be installed in the PPMS.

To remove the sample from the rotator probe, follow essentially the same procedure above, being sure you *gently* pull the sample holder board out of place by using the sample removal tool.

Refer to section 1.3.3 to change the angular orientation of a sample holder board that is attached to the rotator probe.

2.5 Installing the Horizontal Rotator Hardware

The following procedure explains how you install the Horizontal Rotator support plate and Horizontal Rotator probe in the PPMS. Section 2.3 explains how you mount a sample on a sample holder board, and section 2.4 explains how you attach the sample holder board to the Horizontal Rotator probe.

Caution! Before you open the sample chamber to the atmosphere, always verify that it is at or above room temperature. If you open the sample chamber while it is below room temperature, condensation and cryopumping of air constituents may occur. This can ultimately cause sample tube deformation and loss of temperature control.

1. Set the PPMS temperature to 298 K, and wait for the temperature to stabilize.
2. Vent the sample chamber continuously.
3. Open the sample chamber and remove any sample puck or PPMS option currently installed in the chamber. Refer to the *Physical Property Measurement System: Hardware Manual* or to the appropriate option manual.
4. Verify that the user bridge cable (part number 3084-003) or the ACT/Horizontal Rotator probe cable (part number 3084-517) is connected (*a*) to the gray, color-coded port on the PPMS probe head and (*b*) to other ports as appropriate.

   For specific information about the user bridge cable, refer to the *Physical Property Measurement System: Resistivity Option User's Manual.* For specific information about the ACT/Horizontal Rotator probe cable, refer to the *Physical Property Measurement System: AC Transport Option User's Manual.*
5. Place the rotator support plate (figure 2-6) over the PPMS probe head with the centering clip towards the rear of the probe—that is, towards the cable connections.
6. Keep the centering clip up, and firmly squeeze the two flange clamps (figure 2-6) together until they click into place, locking the support plate onto the flange on top of the probe head. You may *temporarily* remove one or both relief valves from the PPMS helium fill ports to afford easier access for the flange clamps.

7. Flip the centering clip down to lock the two flange clamps against the probe head.

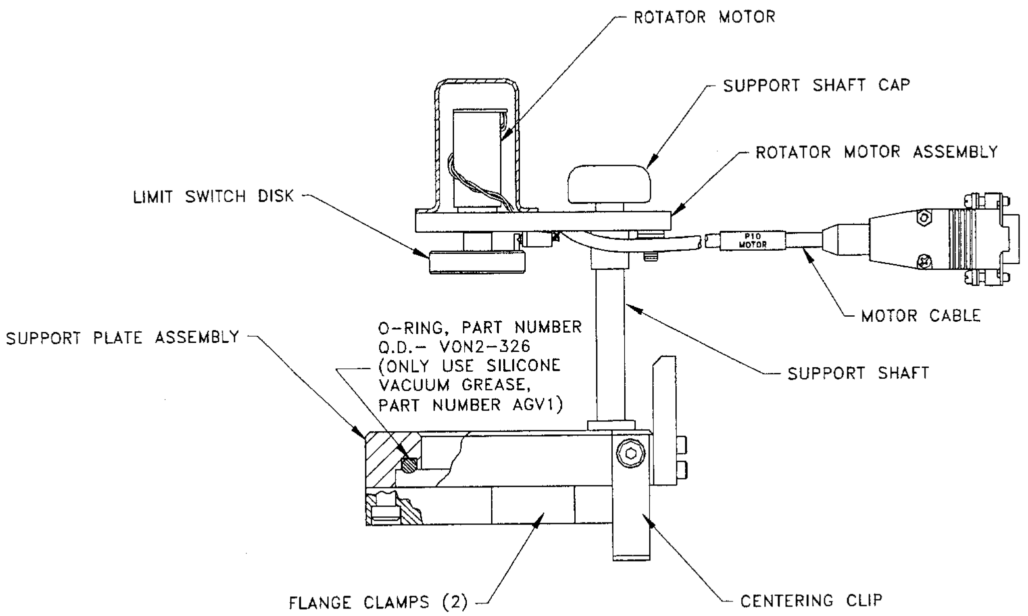


Figure 2-6. Horizontal Rotator Support Plate and Motor

8. Insert the DB-9 connector on the motor cable (part number 4084-303) into the "P10–Motor" port on the rear panel of the Model 6000 PPMS Controller. Tighten the connector screws to hold the DB-9 connector in place.
9. Lift up the rotator motor and swing it to one side of the sample chamber to allow entry into the chamber.
10. Slowly and carefully lower the Horizontal Rotator probe into the sample chamber through the support plate until it just rests at the bottom of the chamber. Guide the rotator probe straight into the sample chamber and do not force it or allow it to bend.

    Caution! The Horizontal Rotator probe is delicate and must be handled with care to avoid denting or bending the stainless steel tube on the probe's exterior. Be extremely careful when placing the probe on a flat surface, such as a table, because the probe may easily roll off.

11. Gently rotate the entire Horizontal Rotator probe so that the white mark on the vernier dial faces the front of the PPMS probe. You should feel the keyed connector at the base of the rotator probe drop into place. Firmly push down on the probe to seat it in the connector on the bottom of the sample chamber. It should drop about 0.2 inch (0.5 cm) deeper, sealing the sample chamber, when properly seated. The support plate that you clamped onto the top of the PPMS sample chamber holds the rotator probe in place while sealing the sample chamber.
12. Purge and seal the sample chamber. Installation of the rotator hardware is now complete.

    Note: Before you use the Horizontal Rotator, you must download the appropriate rotator configuration file as described in section 2.6. You may also want to ensure proper position calibration as explained in section 2.7.

2.6 Downloading the Rotator Configuration Files

After the rotator hardware is first installed or whenever it is reinstalled following use of any other PPMS measurement option, the rotator configuration files supplied with the Horizontal Rotator must be downloaded. Downloading the rotator configuration files ensures that the Model 6000 PPMS Controller uses the proper motor configuration and thermometer calibration.

The Horizontal Rotator configuration file contains the step size information for the rotator motor, the calibration information for the rotator thermometer, and the commands to control the PPMS temperature from the thermometer readings made on the bridge channel. You select the appropriate configuration file for the type of rotator system you are using. The name of each rotator configuration file includes the rotator's serial number. In table 2-2, "###" represents the rotator's serial number.

Table 2-2. Types of Rotator Configuration Files

CONFIGURATION FILE	CABLE FOR BRIDGE BOARD	BRIDGE BOARD READING THERMOMETER CALIBRATION
`HR###.CFG`	User Bridge Board Cable	User Bridge Board Channel 1
`HRACT###.CFG`	ACT/Horizontal Rotator Probe Cable	System Bridge Board Channel 4

Complete the following steps to download the rotator configuration files:

1. Insert the disk included with the Horizontal Rotator option into the PC, and select the `A:` drive.
2. Select the **PPMS 32-bit Tools** icon on the PC desktop, and then run the Romcfg32 utility.
3. Select **Send to PPMS | Send Config** in the main menu.
4. Select the `A:` drive, which is the drive where the rotator configuration files are located.
5. Locate the rotator configuration file for your system.
   - If your system has a standard configuration with the rotator connected to the Model 6000 user bridge board, the appropriate file is `HR###.CFG`, where `###` represents the serial number of the rotator. Refer to table 2-2.
   - If your system uses the special four-way ACT/Horizontal Rotator probe cable, the appropriate file is `HRACT###.CFG`, where `###` represents the serial number of the rotator. Refer to table 2-2.
6. Select the appropriate file, and then click **OK**. After the configuration files are downloaded, the rotator is configured and ready to be used.

For ease of use, you may create a directory called `c:/h_rotat` on the PPMS computer hard drive and copy the configuration files to this directory. Archive the floppy disks for emergency use.

To verify that the configuration file has been read properly, you may check the Model 6000 **STATUS** screen. If the configuration has downloaded properly and the hardware is correctly installed, the **STATUS** screen should display the **User** temperature above the **System** temperature. The user thermometer should initially be a few degrees different than the system thermometer. Configuring the Horizontal Rotator by transmitting the configuration files to the Model 6000 ROM also turns on UserTemp so that the rotator thermometer is used for temperature control.

Note: When you remove the Horizontal Rotator probe from the sample chamber, you should turn off the UserTemp thermometer so that the Model 6000
no longer interprets resistance readings on user bridge board channel 1 as temperature readings to be used in system temperature control. Turning off UserTemp is a simple process that is explained below in step 9 of section 2.8.

2.7 Ensuring Proper Position Calibration

To ensure that the position reported by the software matches the actual sample orientation, perform the following steps after you install the Horizontal Rotator probe in the PPMS and download the configuration file.

1. Disengage the motor from the rotator.
2. Use the **Set Position** sequence command to move the motor to the index position and define that position as $-10°$. Refer to section 3.2.3.
3. Use the **Set Position** sequence command to move the motor to the 0° position. Refer to section 3.2.3.
4. Manually rotate the rotator to the 0° orientation and engage the motor. The rotator probe may require some additional adjustment to achieve proper mating of the limit switch disk on the motor and the index catch disk on the rotator probe. It is acceptable at this point if the vernier dial does not read 0°. However, verify that the index catch disk and the limit switch disk mate concentrically. If these two disks are not concentric, they are not mated properly, but are 180° out of phase.
5. Finalize the position calibration and check for rotation again by using the software to set the rotator to $-10°$. The motor may move a bit past the limit of rotator motion if the calibration is not already correct. This is intended. After the motor stops moving, set the position to 370° and again wait for the motor to stop moving. After it stops, position calibration is complete. The rotator is ready to begin measurements. For measurement considerations, refer to section 3.4.

2.8 Removing the Horizontal Rotator Hardware

Caution! Before you open the sample chamber to the atmosphere, always verify that it is at or above room temperature. If you open the sample chamber while it is below room temperature, condensation and cryopumping of air constituents may occur. This can ultimately cause sample tube deformation and loss of temperature control.

1. Set the PPMS temperature to 298 K, and wait for the temperature to stabilize.
2. Vent the sample chamber continuously.
3. Disengage the rotator motor from the Horizontal Rotator probe, and pull the rotator probe straight up, guiding it gently out of the sample chamber.

   Caution! The Horizontal Rotator probe is delicate and must be handled with care to avoid denting or bending the stainless steel tube on the probe's exterior. Be extremely careful when placing the probe on a flat surface, such as a table, because the probe may easily roll off.

   Caution! When it is first removed from the PPMS sample chamber, the Horizontal Rotator probe is usually very cold, and ice typically forms on it, temporarily locking gears and bearings. This is normal. Do not force rotator motion when the rotator is in this condition. The rotator thaws within 1 or 2 minutes, and you may gently work the index catch disk to verify rotation.

   Note: If you want to attach a different sample to the rotator, do so now. Refer to section 2.4. Then complete steps 8 through 11 in section 2.5 to reinstall the Horizontal Rotator probe in the sample chamber. Do not leave the PPMS sample chamber open to atmosphere for extended periods of time. If you want to completely remove the rotator hardware from the PPMS, complete steps 4 through 9 below.

4. Place the rotator probe in a safe place, preferably hanging vertically.
5. Flip the centering clip on the support plate upwards and release the two flange clamps on the support plate by swinging them out, thus disengaging the support plate from the flange on the PPMS probe head. Refer to figure 2-6.
6. Set the motor aside. You may disconnect it from the "P10–Motor" port on the Model 6000 PPMS Controller, if you like.
7. Install another option or sample puck and blank flange with O-ring.
8. Purge and seal the system.
9. Do the following to set the temperature control back to the system thermometer so that the PPMS does not interpret readings on bridge channel 1 as user thermometer readings:

   (*a*) Open **Monitor QD-6000** in the **PPMS 32-bit Tools** folder, or select **Utilities➤Send GPIB Commands** in the PPMS MultiVu interface.

   (*b*) Type `USERTEMP 0`.

   (*c*) Press <Enter> to execute this command.

You are now ready to use the PPMS for other experiments.

CHAPTER 3

Rotator Motor Operation

3.1 Introduction

This chapter contains the following information:

- Section 3.2 explains how to control the operation of the rotator motor.
- Section 3.3 explains how to set the position configuration parameters.
- Section 3.4 discusses factors to consider when taking measurements.

3.2 Controlling the Rotator Motor

Software commands enable both automated and immediate control of the rotator motor. Commands accessed through the **Instrument➤Motion** option in PPMS MultiVu enable immediate control of any motor connected to the "P10–Motor" port on the Model 6000 PPMS Controller. The **Set Position** and **Scan Position** sequence commands enable automatic motor control from within a PPMS sequence.

The positions to which the sample can move depend on the position configuration parameters and the type of positioner moving the sample. The position configuration parameters for the rotator motor are set by the downloaded rotator configuration file and should never need to be modified unless the speed of the motor must be adjusted or the type of motor being used is changed. Refer to section 3.3.

3.2.1 Status Information

Status information consisting of the index position and the motor's current and maximum position is displayed at the top of the **Motion Control** dialog box (see figure 3-1 on the following page), which you open by selecting **Instrument➤Motion**. If the motor is configured properly, the index position is identified as −10° and the maximum position is identified as 370°. The lines above and below the position control slide bar also roughly represent the motor's current position.

The position reported as the motor's current position and displayed in the **Now at** field in the **Motion Control** dialog box is determined by the number of pulses sent to the motor since its position was last defined; there is no direct feedback from which to obtain the exact sample position. To be certain the reported position matches the true sample orientation, you do the following : (*a*) set the position to −10°, (*b*) wait for the software to report it has reached −10°, and then (*c*) set the position to 370°. After the software reports it has reached 370°, the rotator should be at its upper physical limit (370°).

3.2.2 Movement Control Commands in Immediate Mode

All immediate-mode movement control commands are accessed through the **Instrument➤Motion** menu option in PPMS MultiVu. Selecting **Instrument➤Motion** opens the **Motion Control** dialog box (figure 3-1).

Table 3-1. Immediate-Mode Movement Control Commands

COMMAND	DEFINITION	ACTIVATING
Move To	Motor moves to specified position.	• Enter value in Move To text box, then select corresponding Set button. • Drag slide bar button, then select Move To Set button. • Click on slide bar arrows, then select Move To Set button.
Redefine Current Position	System redefines motor's current position as specified position.	Enter value in Redefine Current Position text box, then select corresponding Set button. Motor does *not* move.
Go to Index	Motor moves to index position.	Select Go to Index button.

As soon as you select a **Set** button or the **Go to Index** button in the **Motion Control** dialog box, the motor begins to move. The system monitors the motor's movement. Status information in the **Motion Control** dialog box identifies each new motor position.

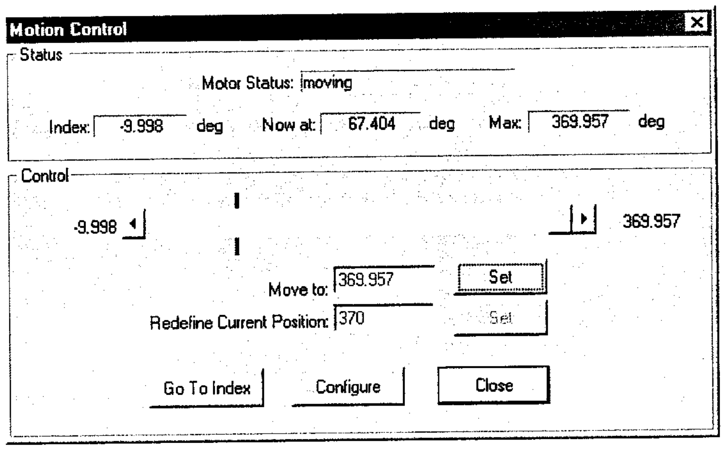


Figure 3-1. **Motion Control** Dialog Box

3.2.3 Movement Control Commands in Sequence Mode

The **Set Position** and **Scan Position** sequence commands move the motor within a PPMS sequence. **Set Position** moves the motor to single specified position. **Scan Position**, which is a scan command, moves the motor to a series of positions that are within a specified position range. The *Physical Property Measurement System: PPMS MultiVu Application User's Manual* discusses the operation of scan commands in detail.

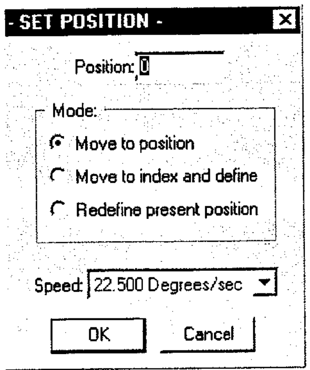


Figure 3-2. **Set Position** Dialog Box
(See Table 3-2)

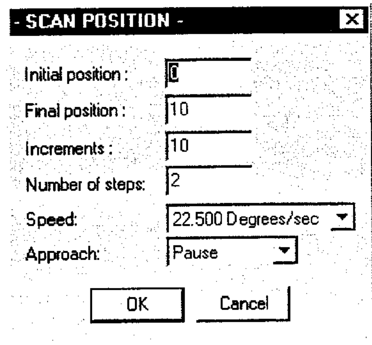


Figure 3-3. **Scan Position** Dialog Box
(See Table 3-3)

Table 3-2. **Set Position** Sequence Command Movement Modes

MOVEMENT MODE	DEFINITION
Move to Position	Motor moves to specified position. Default movement mode.
Move to Index and Define	Motor moves to index switch and system redefines index position with number specified in Position text box in Set Position command. This mode should be used *only* to redefine index position. With Horizontal Rotator, index position is usually set to $-10°$.
Redefine Present Position	System redefines motor's present position according to user's specifications.

Table 3-3. Parameters for **Scan Position** Sequence Command

PARAMETER	DEFINITION
Initial Position	First set point in position range.
Final Position	Last set point in position range.
Increments	Number of units between set points.
Number of Steps	Number of set points.
Speed	Rate at which position changes.
Approach	Mode of approaching set points. Pause mode stops motor at each set point. Sweep mode ramps motor at requested speed to final set point and stops at only final set point.

When the Horizontal Rotator is being used to change the sample's orientation, **Measurement** sequence commands and the **Bridge Setup** sequence command are often also included in the sequence along with the **Set Position** or **Scan Position** command. For information about the PPMS measurement option sequence commands, refer to the appropriate option manual. For information about the **Bridge Setup** command, refer to the *Physical Property Measurement System: PPMS MultiVu Application User's Manual.*

The *Physical Property Measurement System: PPMS MultiVu Application User's Manual* discusses sequence operation and all standard system sequence commands in detail. The *Physical Property Measurement System: Commands Manual* also contains information about PPMS sequences.

3.3 Setting the Position Configuration Parameters

Note: The position configuration parameters are automatically set by the downloaded rotator configuration file and should never need to be modified unless the speed of the motor must be adjusted or the type of motor being used in the system is changed. Generally, the position configuration parameters are set once during system setup.

The positions to which the sample can move depend on the position configuration parameters and the type of positioner moving the sample. The position configuration parameters are defined in the **Position Configuration** dialog box, which you open by selecting **Instrument➤Motion➤Configure**.

Complete the following steps to verify or change the motor configuration:

1. Select **Instrument➤Motion➤Configure**. The **Position Configuration** dialog box opens. The dialog box lists the values of the position configuration parameters that control how the stepper motor moves the sample.

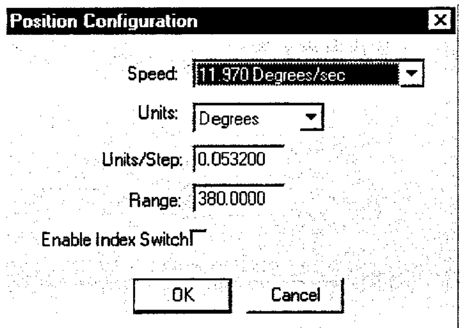


Figure 3-4. **Position Configuration** dialog box displaying correct settings for standard resolution Horizontal Rotator option. When using high-resolution motor, proper number of user units (degrees) in motor steps is 0.00449.

2. Select the speed at which the stepper motor moves the sample.
3. Select the units the system uses to report the sample position. The appropriate selection depends on the configuration of the sample positioner. The allowed values are steps, degrees, radians, millimeters, centimeters, mils, inches, or user defined.
4. Specify the unit distance the sample moves for each step of motion. Units-per-step may be any numeric value.
5. Specify the range of the sample's movement. The range is the maximum distance over which the motor is allowed to move.
6. Enable the index switch, if necessary. If you enable the index switch, the positioner cannot move the sample below the index position. If the index switch is not enabled, it remains a limit, but the sample can move below the index position. By default, the index switch is not enabled. If your system uses a Quantum Design rotator motor, the index switch should *not* be enabled.
7. Select **OK** to enable your selections.

3.4 Measurement Considerations

Most measurement considerations to take into account when designing experiments and writing sequences with the Horizontal Rotator option center around the issue of backlash and the tortional spring found on the rotator. The thermal characteristics and electrical limits of the hardware should also be kept in mind.

The Horizontal Rotator comprises a significant thermal load for the PPMS. The rotator thermometer closely monitors the temperature of the sample(s) on the rotator. However, introducing such a load into the PPMS sample chamber noticeably reduces the speed of the temperature control in the PPMS, especially at higher temperatures (See Section 1.3.1 about Current Leads). Sequences involving temperature changes may take longer than similar sequences run without a rotator installed in the PPMS.

The meshing of the rotator gears is also temperature dependent. Typical behavior is less than 2° of backlash at room temperature (due almost entirely to backlash in the motor), up to 8° of backlash at 150 K, and roughly 6° of backlash at 10 K. While the tortional spring on the rotator is effective at removing backlash at room temperature, its functionality reduces with temperature. Furthermore, if not used conscientiously, the spring can actually cause misleading rotator behavior if the rotator platform circuit board begins to alternately stick and slip during consecutive measurements with small angular changes.

To avoid backlash issues altogether, measurements should always be taken after approaching the sample orientation from the same direction. Since the spring can allow alternate sticking/slipping behavior while it is being unwound, measurements should generally be performed as the spring is being wound tighter. This occurs as the angular orientation is being decreased. To achieve the smoothest rotation and most reproducible results, measurements should always be taken on *decreasing* angles.

Even with taking such precautions, the correlation of rotator platform orientation to vernier dial reading varies with temperature, up to ±3°. To fully characterize your rotator at a designated temperature, you may wish to use a Hall sensor, which can be obtained from Quantum Design.

A P P E N D I X   A

PPMS Firmware Commands

A.1 Introduction

This appendix contains the following information:

- Section A.2 displays the PPMS firmware command tree.
- Section A.3 discusses the firmware commands generally used with the Horizontal Rotator.

A.2 PPMS Firmware Command Tree

The following command tree depicts the Model 6000 PPMS Controller firmware commands that are relevant to the Horizontal Rotator option.

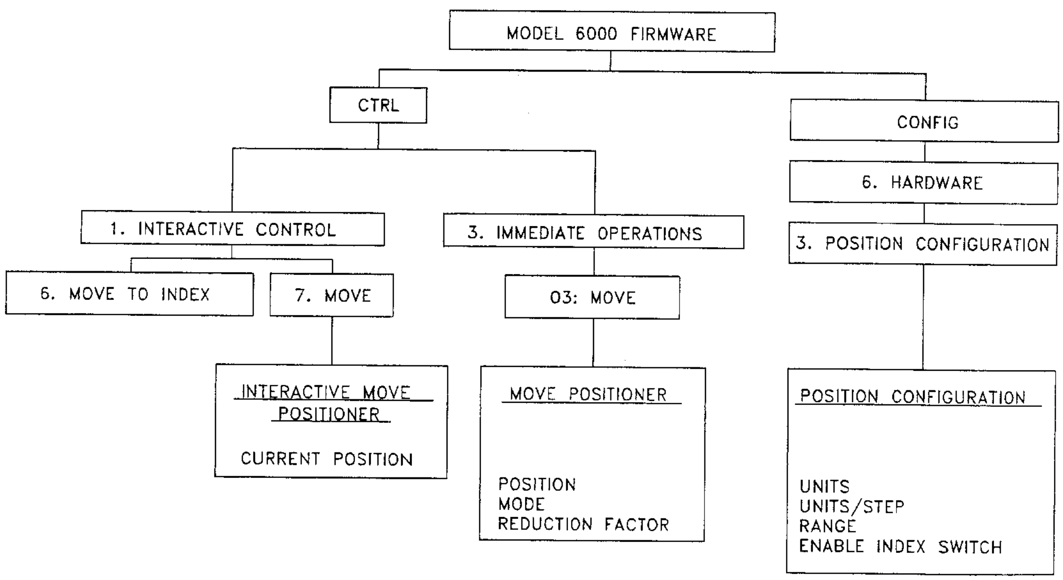


Figure A-1. Model 6000 Firmware Command Tree

A.3 Function of PPMS Firmware Commands

A.3.1 PPMS Firmware Setup Commands

Configuration of the firmware for proper hardware motion control ensures that the PPMS is set up so that measurements may be made properly. Configuration files that are used for the Horizontal Rotator are written into nonvolatile RAM when downloaded to the Model 6000. Alternately, the position configuration can be set from the Model 6000 front panel, as described in the next section.

A.3.1.1 MODEL 6000 POSITION CONFIGURATION COMMANDS

To set the position configuration parameters to their correct values for use with the Horizontal Rotator motor, you access the **Position Configuration** screen in the Model 6000 by selecting **CONFIG➤6. Hardware➤3. Position Configuration**. Set the following parameters within the **Position Configuration** screen in order to configure the motion control variables. Then press **ALT+ENTER** to execute your changes.

Table A-1. **Position Configuration** Parameters for Motion Control Variables

PARAMETER	VALUE
Units	Degrees
Units/Step	0.053200 for standard motor 0.00449 for high-resolution motor
Range	380
Enable Index Switch	No

A.3.2 PPMS Firmware Immediate Operation Command

The Model 6000 **Move** command immediately activates the Horizontal Rotator by controlling the motion of the motor as described in table A-2. To activate the **Move** command, select **CTRL➤ 3. Immediate Operations➤03 Move** or press **Enter** while the cursor points to **Position** on the Model 6000 **STATUS** screen. Press **ALT+ENTER** to execute any parameters you select.

Table A-2. Options in **Move Positioner** Screen

SELECT	IN ORDER TO
Position	Specify the position to which the motor moves.
Mode	Set the positioner mode to Normal, Move to Index, or Define Current Position. See table A-3.
Reduction Factor	Select the speed reduction factor.

Table A-3 defines the modes that are available in the **Move Positioner** screen. The screen displays the current angle.

Table A-3. **Move Positioner** Screen Modes

MODE	FUNCTION
Normal	Moves the stepper motor to the specified position.
Move to Index	Moves the motor until the index switch is opened, and then defines the motor position according to the specified value.
Define Current Position	Redefines the motor's current position as the specified position value.

A.3.3 PPMS Firmware Interactive Control Commands

The **Move to Index** and **Move** commands are in the **Interactive Control** menu. You activate **Move to Index** by selecting **CTRL➤1. Interactive Control➤6. Move to Index**. You activate **Move** by selecting **CTRL➤1. Interactive Control➤7. Move**.

Move to Index moves the stepper motor in the direction of decreasing angles until the index switch is opened. Then it defines the motor position to be *zero*. For this reason, the interactive **Move to Index** command should not be used to position the rotator motor. The index position when using the rotator is always −10°. The functionality of this command may be changed at a later date so that future versions of the PPMS firmware allow use of this command with the rotator.

The interactive **Move** command moves the motor in single steps as you press the **INCR** or **DECR** keys. Press **ALT+INCR** or **ALT+DECR** to change the position 15 steps at a time. The interactive **Move** screen also displays **limit** and **index** when the limit and index switches are opened.

A P P E N D I X B

Interconnection Tables

B.1 Introduction

This appendix contains the following information:

- Section B.2 shows the standard interconnections for the Horizontal Rotator.
- Section B.3 shows the interconnections for the ACT/Horizontal Rotator cable.
- Section B.4 shows the interconnections for the motor.

B.2 Standard Interconnection Table

Table B-1. Standard interconnection table for Horizontal Rotator option. Table shows interconnections between Resistivity option, Horizontal Rotator sample holder board, and thermometer.

RESISTANCE BRIDGE BOARD FUNCTION	P1 PORT ON MODEL 6000	GRAY LEMO CONNECTOR ON PROBE HEAD	RESISTANCE BRIDGE SAMPLE HOLDER	THERMOMETER
Channel 1, I+	5	3	3	I+
Channel 1, I–	18	4	4	I–
Channel 1, V+	6	5	5	V+
Channel 1, V–	19	6	6	V–
Channel 2, I+	7	7	7	
Channel 2, I–	20	8	8	
Channel 2, V+	8	9	9	
Channel 2, V–	21	10	10	
Channel 3, I+	9	11	11	
Channel 3, I–	22	12	12	
Channel 3, V+	10	13	13	
Channel 3, V–	23	14	14	

B.3 Interconnection Tables for the ACT/Horizontal Rotator Probe Cable

The following tables show the standard interconnections between the Model 7100 AC Transport Controller, the ACT sample holder board for the rotator, system bridge board, and thermometer.

Table B-2. Pin Mapping for P2–System Bridge Port on Model 6000

SAMPLE HOLDER BOARD	GRAY LEMO CONNECTOR ON PROBE HEAD	FOUR-PIN LEMO CONNECTOR AT P2 PORT ON MODEL 6000	FUNCTION
3	3	1	Bridge Channel 4 I+ (Rotator Thermometer)
4	4	2	Bridge Channel 4 I– (Rotator Thermometer)
5	5	3	Bridge Channel 4 V+ (Rotator Thermometer)
6	6	4	Bridge Channel 4 V– (Rotator Thermometer)

Table B-3. Pin Mapping for P1–Sample Current Out Port on Model 7100

SAMPLE HOLDER BOARD	GRAY LEMO CONNECTOR ON PROBE HEAD	P1 PORT ON MODEL 7100	FUNCTION
7*	7	1–4	ACT Ch1/Ch2 I+
8*	8	6–9	ACT Ch1/Ch2 I–

* Denoted leads on the Horizontal Rotator are a copper alloy, while the remainder of the leads on the Rotator are phosphor-bronze.

Table B-4. Pin Mapping for P5–Sample Voltage In Port on Model 7100

SAMPLE HOLDER BOARD	GRAY LEMO CONNECTOR ON PROBE HEAD	P5 PORT ON MODEL 7100	FUNCTION
9	9	5 & 7	Channel 2 Va/b+
10	10	6 & 8	Channel 2 V–
11*	11	3	Channel 1 Vb+
12*	12	4	Channel 1 V–
13	13	2	Channel 1 V–
14	14	1	Channel 1 Va+

* Denoted leads on the Horizontal Rotator are a copper alloy, while the remainder of the leads on the Rotator are phosphor-bronze.

B.4 Motor Interconnection Table

Table B-5. Motor interconnection table. Table shows interconnections between motor and P10–Motor port on Model 6000.

DB-9 CONNECTOR	NAME	MOTOR CABLE	DESCRIPTION
9	Index	Black	Index switch
5	Limit Ground	Green*	
4	Limit	Yellow*	Limit wire
2	Phase 1	Red	Coil number 1
7	Phase 2	Violet	
1	Phase 3	Brown	Coil number 2
6	Phase 4	Blue	

* The limit signal wire is shorted to ground on the motor's index switch, as can be seen by examining the underside of the motor assembly.

References

Quantum Design. 2000. *Physical Property Measurement System: AC Transport Option User's Manual.*

———. 1995. *Physical Property Measurement System: Commands Manual.*

———. 1996. *Physical Property Measurement System: Firmware Manual.*

———. 2000. *Physical Property Measurement System: Hardware Manual.*

———. 2000. *Physical Property Measurement System: PPMS MultiVu Application User's Manual.*

———. 1999. *Physical Property Measurement System: Resistivity Option User's Manual.*

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Quantum Design

Physical Property Measurement System

Helium-3 Refrigerator System User's Manual

Part Number 1092-100, D-1

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Trademarks

U.S. Patents
4,791,788 Method for Obtaining Improved Temperature Regulation When Using Liquid Helium Cooling
4,848,093 Apparatus and Method for Regulating Temperature in a Cryogenic Test Chamber
5,311,125 Magnetic Property Characterization System Employing a Single Sensing Coil Arrangement to Measure AC Susceptibility and DC Moment of a Sample (patent licensed from Lakeshore)
5,647,228 Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber
5,798,641 Torque Magnetometer Utilizing Integrated Piezoresistive Levers

Foreign Patents
U.K. 9713380.5 Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber

C O N T E N T S

Table of Contents

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P R E F A C E

Contents and Conventions

P.1 Introduction

This preface contains the following information:

- Section P.2 discusses the overall scope of the manual.
- Section P.3 briefly summarizes the contents of the manual.
- Section P.4 illustrates and describes conventions that appear in the manual.

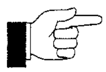
P.2 Scope of the Manual

This manual discusses the Physical Property Measurement System (PPMS) Helium-3 Refrigerator System option. This manual explains how to install the Helium-3 system, discusses the hardware and software that are unique to the Helium-3 system, and explains basic operation and maintenance procedures for the Helium-3 system.

P.3 Contents of the Manual

- Chapter 1 introduces the Helium-3 system and discusses the theory of operation for the Helium-3 system.
- Chapter 2 discusses the hardware used with the Helium-3 system.
- Chapter 3 discusses the Helium-3 system software.
- Chapter 4 describes the basic operation of the Helium-3 system.
- Chapter 5 contains a troubleshooting guide and explains how to perform common maintenance procedures.
- Appendix A explains how to install the Helium-3 system.
- Appendix B illustrates Helium-3 system connections and contains pinout tables.

P.4 Conventions in the Manual

File menu	Bold text distinguishes the names of menus, options, buttons, and panels appearing on the PC monitor or on the Model 6000 PPMS Controller LCD screen.
File >> **Open**	The >> symbol indicates that you select multiple, nested software options.
STATUS	Bold text and all capital letters distinguish the names of keys located on the front panel of the Model 6000 PPMS Controller.
`.dat`	The Courier font distinguishes characters you enter from the PC keyboard or from the Model 6000 PPMS Controller front panel. The Courier font also distinguishes code and the names of files and directories.
<Enter>	Angle brackets distinguish the names of keys located on the PC keyboard.
<Alt+Enter>	A plus sign connecting the names of two or more keys distinguishes keys you press simultaneously.
	A pointing hand introduces a supplementary note.
Caution!	Introduces a cautionary note.
Warning!	Introduces a warning.

C H A P T E R 1

Theory of Operation

1.1 Introduction

This chapter contains the following information:

- Section 1.2 presents an overview of the Helium-3 system.
- Section 1.3 discusses the theory of operation for the Helium-3 system.
- Section 1.4 discusses the Helium-3 temperature control.

1.2 Overview of the Helium-3 System

The Quantum Design Helium-3 Refrigerator System option (Model P825) extends the minimum temperature of the Physical Property Measurement System (PPMS) below 0.4 K. The Helium-3 system is integrated seamlessly into the base PPMS platform, and its operation is designed to be completely transparent to the PPMS measurement application software.

The Helium-3 Refrigerator system is entirely self-contained. The Helium-3 insert, pumping lines, electrical cables, and diaphragm pump are incorporated into a small cart that can be rolled to any location when the system is not in use. The efficient design of the gas-handling system requires less than 1 liter of replacement gas per year under heavy usage. This is made possible by using a gas-handling system that is sealed and uses oil-free pumps for gas circulation.

The Helium-3 system is compatible with the PPMS Resistivity, AC Transport, and Heat Capacity options. Once the samples are mounted on the Helium-3 insert and installed in the PPMS sample chamber, the temperature control is handled automatically down to below 0.4 K without the need to learn new measurement control software.

NOTE

For first-time installation instructions for the Helium-3 system, please refer to Appendix A.

1.2.1 System Requirements

The following components are required to operate the Quantum Design Helium-3 Refrigerator System:

- ☑ PPMS Resistivity option with enhanced user bridge board
- ☑ PPMS Continuous Low-Temperature Control (CLTC) option
- ☑ PPMS High-Vacuum option

The High-Vacuum option is an integral component of the PPMS Heat Capacity option.

1.2.2 System Hardware

The Helium-3 system hardware consists primarily of the insert assembly, the diaphragm pump/gas-handling assembly, and a cart that holds both assemblies. A special controller card in the Model 6000 PPMS Controller provides the necessary control signals. Also, sample-mounting hardware for the Resistivity, AC Transport, and Heat Capacity options allows these options to be used with the Helium-3 system.

Chapter 2 discusses the Helium-3 hardware in detail.

1.2.3 System Software

The software provided with the Helium-3 system consists of a main temperature control module, diagnostics utilities, and maintenance utilities. The Helium-3 Control Console application must be running on the PC in order to enable temperature control with the Helium-3 insert.

Chapter 3 discusses the Helium-3 software architecture in detail.

1.3 Theory of Operation

A helium-3 refrigerator cools to below 0.4 K by pumping on a pot of liquid ^{3}He. This isotope of helium condenses at slightly above 3 K at 1 atmosphere. Evaporative cooling to below 0.4 K can be achieved if the pressure above the liquid is maintained in the millitorr range and there is sufficient thermal isolation from the warmer surroundings.

With the PPMS Helium-3 system, the cooling power for condensing ^{3}He is provided by the cold walls of the PPMS sample chamber. A variable-speed turbo pump mounted at the top of the Helium-3 insert and backed by a small diaphragm pump provides the low pressure needed for cooling. Thermal isolation is provided by sealing the insert of the probe into the PPMS sample chamber, which is maintained at high vacuum by using the PPMS High-Vacuum system.

To provide continuous cooling below 0.5 K, the pot is continuously refilled using a very small capillary, or impedance, that feeds liquid ^{3}He at a few hundred torr from the 2-K condenser to the colder pot that is pumped to a few millitorr.

The 2-K liquid flowing into the pot from the impedance constitutes a small heat leak into the pot. Hence the system is not able to achieve the lowest possible temperature while filling the pot. To achieve the base temperature of the instrument, the gas-handling system has been designed to shut off the flow of recondensing gas to the impedance once sufficient liquid has collected in the pot. In this "one-shot" mode, a base temperature of well below 0.4 K can be achieved for over an hour before the pot must be refilled. A ^{3}He reservoir tank provides the necessary volume of gas in the system to completely fill the pot with liquid when the one-shot mode is needed.

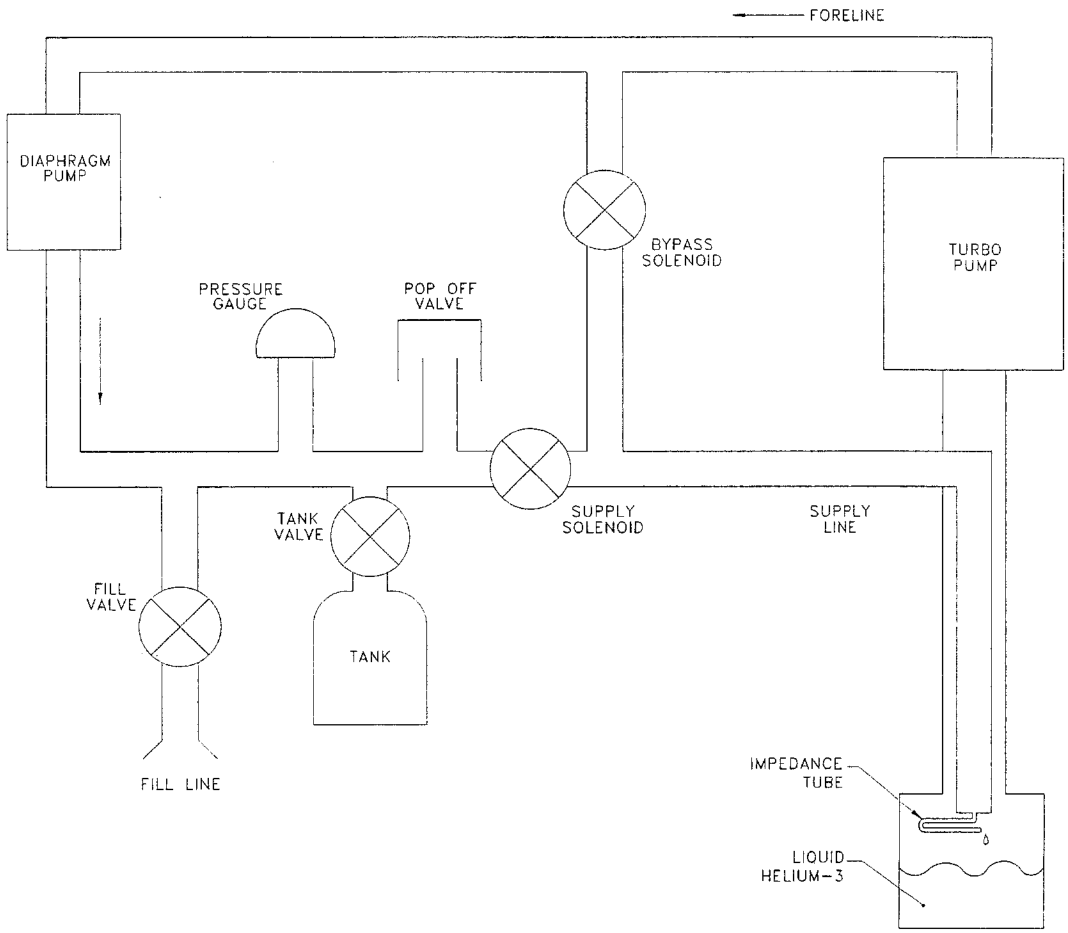


Figure 1-1. Helium-3 System Schematic

User samples are mounted on special sample mounts that plug into a sample holder connected to the pot. The thermal contact between the sample holder and pot is somewhat weak so that the temperature of the holder can be raised using a heater on the holder and an integrated thermometer for control. The standard PPMS temperature control algorithms provide temperature control at higher temperatures.

1.4 Temperature Control

The Helium-3 insert has been designed specifically for cooling samples below 2 K by pumping on a bath of liquid ^3He. However, since it can be inconvenient to remount samples for measurement at higher temperatures, the Helium-3 system has been designed to provide temperature control from the lowest temperature continuously up to 350 K. To cover such a wide temperature range, several operating modes are used. Table 1-1 lists each of the operating modes and corresponding temperature ranges. The transitions between the operating modes are completely automated though the use of the control software. Automatic initiation of the PPMS High-Vacuum system is also performed when it is needed for proper operation at pumped ^3He temperatures.

Table 1-1. Operating Modes

SAMPLE TEMP	PPMS TEMP	COOLING SOURCE	HEATING SOURCE	CHAMBER STATE	DESCRIPTION
20.00–350.00 K	20.00–350.00 K	PPMS Sample Chamber	PPMS Sample Chamber	Vented or High Vacuum	High Temp
4.00–20.00 K	4.00–20.00 K	PPMS Sample Chamber	PPMS Sample Chamber	High Vacuum	Low Temp Sys Heater
2.50–4.00 K	1.80 K	PPMS Sample Chamber	Helium-3 Stage Heater	High Vacuum	No Cooling, Helium-3 Heater
0.45–2.50 K	1.80 K	Pumped ^3He	Helium-3 Stage Heater	High Vacuum	Circulating Mode
0.35–0.45 K	1.80 K	Pumped ^3He	Helium-3 Stage Heater	High Vacuum	One-Shot Mode

1.4.1 High-Temperature Standard Mode (20–350 K)

In this temperature range, temperature control is very similar to the standard PPMS sample chamber temperature control. Both cooling and heating are provided through the PPMS sample chamber with feedback from the thermometer located on the Helium-3 sample platform. The sample chamber may be in any state (vented, purged, high vacuum, and so on).

When the sample chamber is at high vacuum, thermal contact between the sample chamber walls and the Helium-3 insert is relatively poor. This can result in a much slower thermal response while con-trolling temperature. The system software automatically adjusts the time-constants in the temperature control routines when the chamber is switched between the high-vacuum state and another state. To achieve the most rapid cool-down, it is recommended that cool-down be initiated with the sample chamber vented or purged. The only exception to this would be during heat capacity measurements where high vacuum is needed for the measurement itself.

Between 20 and 285 K, the system is susceptible to developing plugs from gas contaminants in the Helium-3 space. To address this problem, the diaphragm and turbo pumps are run with the bypass solenoid open and supply solenoid closed to remove most of the gas from the probe. Once the probe is below 20 K, the threat of plugging is reduced by the cold-trapping of the contaminants.

1.4.2 Low-Temperature Standard Mode (4–20 K)

Below 20 K, the sample chamber must be maintained at high vacuum even when high vacuum is not needed for the specific measurement. It is necessary to initiate high vacuum at 20 K to avoid condensing helium or saturating the charcoal at the bottom of the probe. If the sample chamber is inadvertently vented while below 20 K, the control software issues a warning and then attempts to reactivate the High-Vacuum system by sending the temperature back up to 20 K.

Like high-temperature standard mode, low-temperature standard mode uses the PPMS sample chamber for both heating and cooling. The only real difference between the two modes is the requirement that the chamber be maintained at high vacuum.

1.4.3 No-Cooling Mode (2.5–4 K)

From 2.5 to 4 K, it is important to avoid condensing ^{3}He in the pot. This is because the heat that is released and absorbed by the ^{3}He condensing and evaporating makes temperature control very sluggish. To address this issue, the diaphragm and turbo pumps are run with the bypass solenoid open and the supply solenoid closed so that all ^{3}He is pumped away from the cold end of the probe. To control temperature, the PPMS sample chamber is maintained below 2 K and the heater located on the Helium-3 sample stage is used to raise the temperature up to the set point.

When entering this state from lower temperatures, the pot is first evacuated to ensure that all condensed ^{3}He is removed.

1.4.4 Circulating Mode (0.5–2.5 K)

Once below about 2.5 K, cooling is provided by circulating ^{3}He. In this mode, the supply solenoid is open and the bypass solenoid is closed. Evaporative cooling takes place in the pot by pumping with the turbo pump. The pot is continuously refilled through the impedance. The turbo pump speed is adjusted depending on the temperature set point and the heat load.

At temperatures below about 1 K, liquid ^{3}He collects in the pot. The control software determines the level of liquid by monitoring the gas pressure at the tank. Once the pressure is low enough, indicating a full pot, and if the temperature set point is too low to be achieved in the circulating state, the system starts the one-shot mode as described in Section 1.4.5. Generally the pressure must be below about 150 torr to enter one-shot mode.

1.4.5 One-Shot Mode (0.35–0.5 K)

While in the circulating state, the base temperature is limited to about 0.45 K by the heat load created by the 2-K liquid flowing into the pot from the impedance. To achieve the ultimate base temperature, the system can be operated in a one-shot mode, where the supply of ^{3}He to the impedance is cut off. Without the warm liquid flowing into the pot, the system can attain temperatures below 0.4 K. In this mode, the supply solenoid is closed and the bypass solenoid is open.

Operation in one-shot mode is limited to about 90 minutes before the pot must be refilled, as the pot is not refilled continuously. To determine when the pot must be refilled, the control software monitors the pressure in the tank. When the pressure increases to a specific value, the system automatically switches back into circulating mode to allow liquid ^3He to collect in the pot. The precise value of this crossover pressure is set when the system is charged with ^3He gas. It is remeasured whenever the cyrocleaning procedure is performed (see Section 5.3.1). The system automatically switches back into one-shot mode once the pressure falls to the appropriate value, indicating adequate liquid in the pot.

1.4.6 Standby Mode

When you first start the control software, the Helium-3 temperature control engine automatically enters standby mode. In this state, both valves are open and the circulating pumps are off. The system remains in standby mode until a new temperature set point is specified from the PPMS MultiVu appli-cation or from the Model 6000 PPMS Controller. At this point, the control software initiates a system test and then selects one of the operating modes described above.

1.4.7 Probe-out Mode

Whenever the Helium-3 insert is removed while the control software is still running, the system enters the probe-out mode. In this mode, the standard PPMS temperature control engine takes over and the temperature of the sample chamber is controlled as if the Helium-3 option were not present. When the system is in probe-out mode, the control software automatically takes over once the Helium-3 insert is installed in the sample chamber again. A micro-switch located near the head of the insert is used to indicate the probe-out condition.

CHAPTER 2

Hardware

2.1 Introduction

This chapter contains the following information:

- Section 2.2 discusses the Helium-3 insert assembly.
- Section 2.3 discusses the diaphragm pump and gas-handling assembly.
- Section 2.4 discusses the liquid nitrogen cold trap assembly
- Section 2.5 discusses the Model 6000 PPMS Controller
- Section 2.6 discusses option-specific Helium-3 hardware.
- Section 2.7 discusses other accessories included with the Helium-3 system.

2.2 Helium-3 Insert Assembly

The Helium-3 insert assembly (Figure 2-1) functions as the sample holder. Samples are mounted on measurement-specific sample mounts that are plugged into the end of the insert assembly. The whole assembly is then plugged into the PPMS sample chamber.

2.2.1 Thermal Contact

To provide the necessary thermal isolation between the ^{3}He pot and the surrounding environment, the PPMS sample chamber is maintained at low pressure by using the PPMS High-Vacuum option. The vacuum seal is provided at the top flange of the sample chamber by an O-ring under the turbo pump assembly. The system automatically handles the evacuation of the sample chamber when necessary. When the system is operated below about 4 K, evacuation of the sample space is facilitated by cryopump-grade charcoal attached inside the sample housing at the bottom of the insert assembly.

The refrigerator probe shaft of the insert assembly is made of a very thin, stainless steel tube to reduce the static heat load on the PPMS due to the thermal conductance of the shaft. Contact fingers on the outside of the insert assembly ensure that the temperature profile of the insert matches that of the PPMS sample chamber. This provides precooling of the returning ^{3}He gas, as well as minimizing the differential thermal contraction of the insert relative to the sample chamber.

To provide the necessary cooling power for condensing ^{3}He gas, additional contact fingers are located around the sample mount housing.

Thermal isolation of the pot is necessary for proper operation at liquid ^{3}He temperatures. However, at higher temperatures, better thermal contact is needed for faster temperature control. To satisfy both requirements, a special graphite-loaded polymer is sandwiched between the cooling pot and the insert housing. Since the sample is in thermal contact with the pot, polymer provides an additional thermal path to the sample chamber walls. The material has the property of being thermally resistive at low temperatures and relatively thermally conducting at higher temperatures.

2.2.2 Turbo Pump

To provide a sufficiently low pressure for evaporative cooling, a turbo pump is mounted directly on top of the insert assembly. A relatively small pumping line for backing the turbo pump runs from the insert assembly to the diaphragm pump/gas-handling system. Variable speed operation of the turbo pump accommodates variations in the ^{3}He gas flow rate. These variations result from different evaporation rates under different thermal loads on the pot.

When heat capacity measurements are running at low temperatures, mechanical vibrations can produce unwanted heating of the Heat Capacity sample mount. To reduce this effect with the Helium-3 system, the natural mechanical resonances of the turbo pump are mapped out when the instrument is calibrated at the factory. The turbo pump is then operated at only those speeds that exhibit minimal vibrations. Furthermore, a vibration attenuation mechanism is integrated into the top of the insert assembly. This mechanism consists of a stainless steel bellows connecting the turbo pump to the probe shaft. A black rubber support surrounds the bellows and provides damping and structural support.

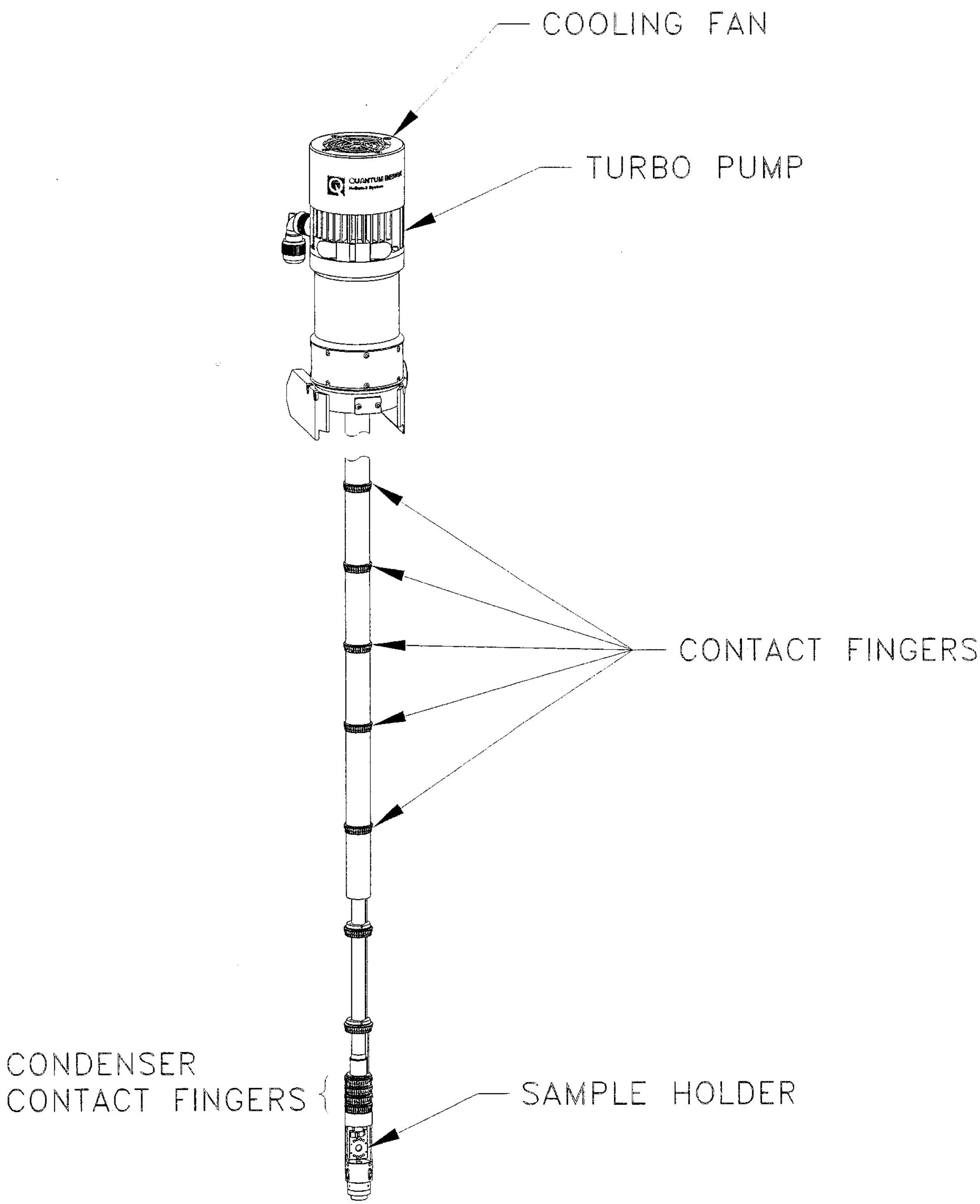


Figure 2-1. Helium-3 Insert Assembly

2.2.3 Helium-3 Pot and Sample Holder

The ^{3}He gas enters the insert through the connector on the back side of the probe head. A helical tube runs down the inside of the main shaft of the insert and precools the gas as it enters the condenser. Condensed liquid then flows into the pot at the lowest point in the circulation path. Cooling occurs when the liquid in the pot is pumped. The ^{3}He exits the pot by evaporation and returns to the turbo pump, where it leaves the insert assembly through the back of the turbo pump.

A short thermal standoff attaches the sample holder to the pot. The thermal link is designed to provide adequate cooling power with the added capability to perform rapid temperature control by raising the temperature of the holder above the temperature of the pot through the use of a small heater. A calibrated thermometer is located in the sample holder. User samples are mounted to the sample holder through the use of measurement-specific sample mounts that plug into the eight-socket connector on the sample holder assembly.

Two sample holders are available to provide different orientations. The vertical sample holder is oriented so that the magnetic field of a longitudinal magnet is in the plane of the holder, while the horizontal sample holder is oriented so that the magnetic field of a longitudinal magnet is perpendicular to the sample holder. The two holders accept the same option-specific sample mounts (see Section 2.6). For systems with a transverse magnet, the vertical sample holder is designed to be loosened, rotated, and retightened to provide different orientations with respect to the field (see Section 4.4).

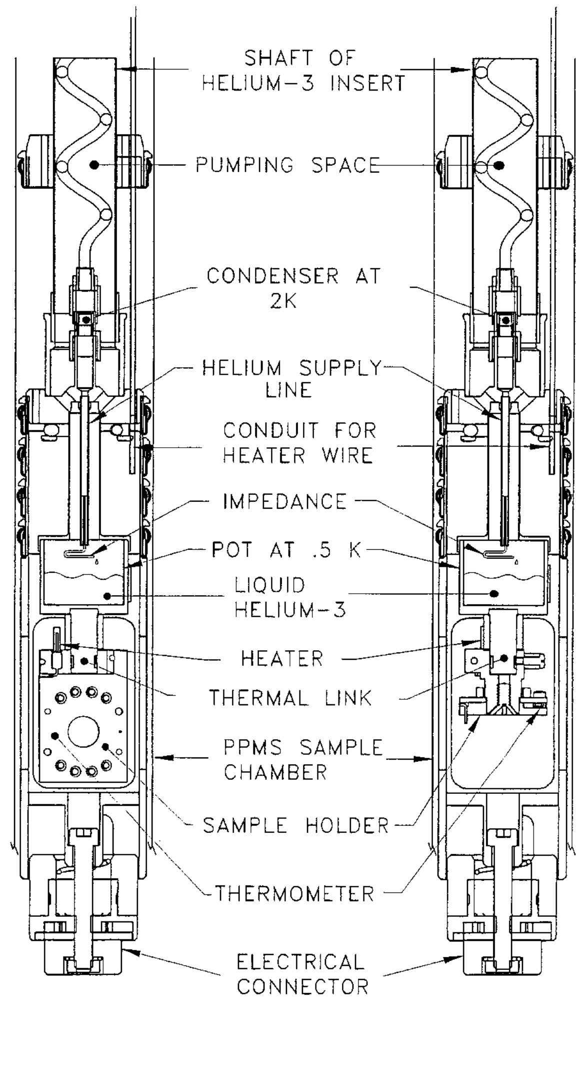


Figure 2-2. Cut-away view of two Helium-3 insert assemblies installed in PPMS sample chambers.

- Helium-3 insert with a vertical sample holder is on the left.
- Helium-3 insert with a horizontal sample holder is on the right.

2.2.4 Electrical Connections to Sample

The sample-holder thermometer and the eight sample measurement wires are contacted through the spring-loaded connector located at the bottom-most point on the insert. This connector, which is designed to engage the 12-pin connector at the bottom of the PPMS sample chamber, is spring-loaded to accommodate slight variations in the vertical position of the probe. The proper orientation for the connector is set by the alignment brackets located on the sides of the turbo pump.

The standard PPMS sample chamber wiring is used to bring the signals out of the dewar via the gray Lemo-type connector. The heater used to raise the temperature of the sample holder is wired-up through a separate connector located on the back side of the insert head.

To perform temperature control, the thermometer channel is read by using either channel 3 or 4 of the user bridge board. When performing resistance measurements with the bridge board, the standard user bridge cable (part number 3084-003) is used, and it places the thermometer signal on channel 3. When performing heat capacity measurements, the standard heat capacity cable (part number 3085-100) is used, and it places the thermometer signal on channel 4. When performing AC Transport measure-ments, a special ACT/Helium-3 cable (part number 3084-518) is used, and it also places the thermometer signal on channel 4. For more information about the signal wiring any of these options use with the Helium-3 system, please refer to the appropriate option manual.

2.3 Diaphragm Pump and Gas-Handling Assembly

The Helium-3 insert assembly is connected to the gas-handling system by two small gas lines and various electrical cables. The gas-handling system is normally located in the cart that is designed to hold the Helium-3 insert when the insert is not in use. The basic components of the gas-handling system are the diaphragm pump, tank, gas manifold, and turbo pump controller.

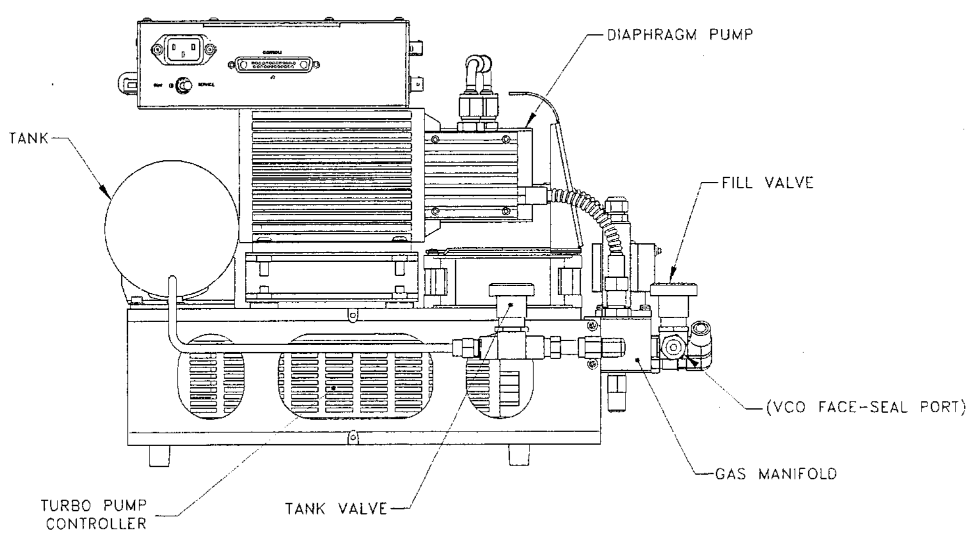


Figure 2-3. Diaphragm Pump and Tank Assembly

2.3.1 Diaphragm Pump and Tank Assembly

The diaphragm pump maintains the outlet pressure from the turbo pump at a few torr. This is necessary for proper operation of the turbo pump. The diaphragm pump is hermetically sealed and uses no lubricants that might otherwise contaminate the gas system. During normal operation, the outlet of the diaphragm pump exhausts the ^{3}He gas back to the insert assembly.

The tank is also attached to the outlet of the diaphragm pump to provide a volume for the gas to expand into as the system condenses various amounts of liquid into the pot. The tank also serves as storage for the ^{3}He gas during maintenance operations. For this purpose, a manual valve is located on the tank to seal off the tank from the rest of the system.

2.3.2 Gas Manifold

While the system operates in a standard circulating mode, the gas flows in a closed loop through the impedance at the bottom of the probe and through the pumps, past the tank, and back into the insert. Another mode of operation shuts off the flow of helium to the impedance to achieve lower temperatures in a one-shot mode. To switch back and forth between these two modes of operation, two solenoid valves, located on the manifold block, are used.

A gauge, which measures the pressure of the gas in the tank, is also located on the manifold block. This gauge allows the temperature control software to infer the level of liquid in the pot as well as diagnose certain fault conditions.

An access port and manual "FILL" valve are also located on the manifold block. The VCO-type, face-seal port is used for adding additional ^{3}He gas to the system and for pumping out contaminants during a routine cryocleaning operation. A special cryocleaning hose is provided to allow the system to be pumped out by using the PPMS sample chamber as a pumping station.

2.3.3 Turbo-Pump Controller

The turbo-pump controller module is located on the lower level of the assembly. Special firmware is designed specifically to operate the turbo pump at different speeds. The controller module also provides the necessary power to run the diaphragm pump.

Communication to the turbo-pump controller is achieved through a serial port that connects to the back of the computer.

2.3.4 Cart and Step Stool

The Helium-3 system is incorporated into a cart. When in operation, the diaphragm pump assembly is located inside the cart. A holder mechanism integrated into the cart is used for storing the Helium-3 insert when the insert is not in use. The holder is also convenient for mounting samples onto the end of the insert. The cart can be easily rolled out of the way when it is not used.

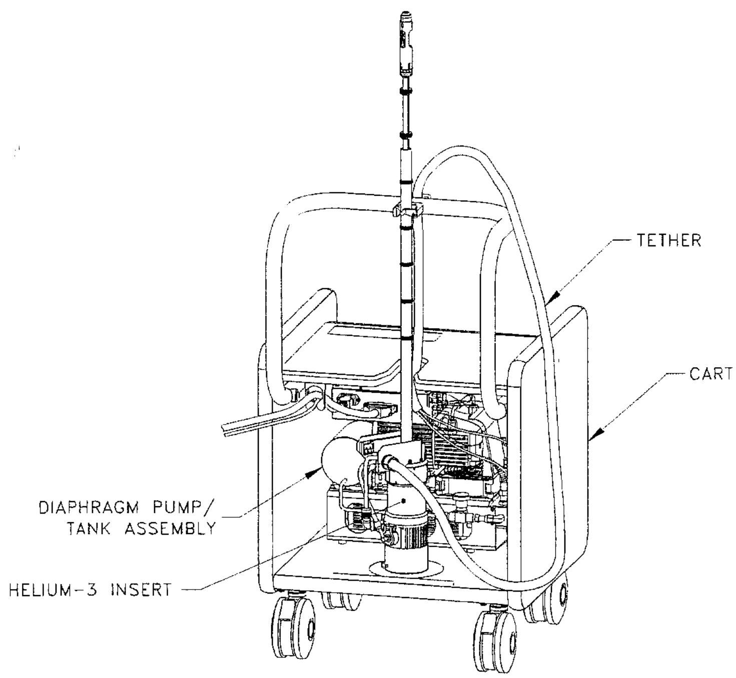


Figure 2-4. Helium-3 Cart Assembly

A step stool is also provided with the Helium-3 system. It is strongly recommended that the stool be used during insertion and removal of the Helium-3 insert from the PPMS sample chamber. The shaft of the probe on the insert is extremely fragile, and the turbo pump is quite heavy by comparison. This combination makes the insert particularly susceptible to damage during handling. Although there is nothing special about the stool, it is included with the system to emphasize the need to handle the insert with care.

2.4 Liquid Nitrogen Cold-Trap Assembly

The Liquid Nitrogen Cold Trap removes contaminants from the ^{3}He gas. As described in Section 5.3.1, "Cryocleaning the Helium-3 Gas Using LN32 Cold Trap," a wizard leads you through the cryocleaning process. Note that when the system is heavily used, you should perform the cryocleaning procedure every two weeks or so.

2.4.1 Cold Trap

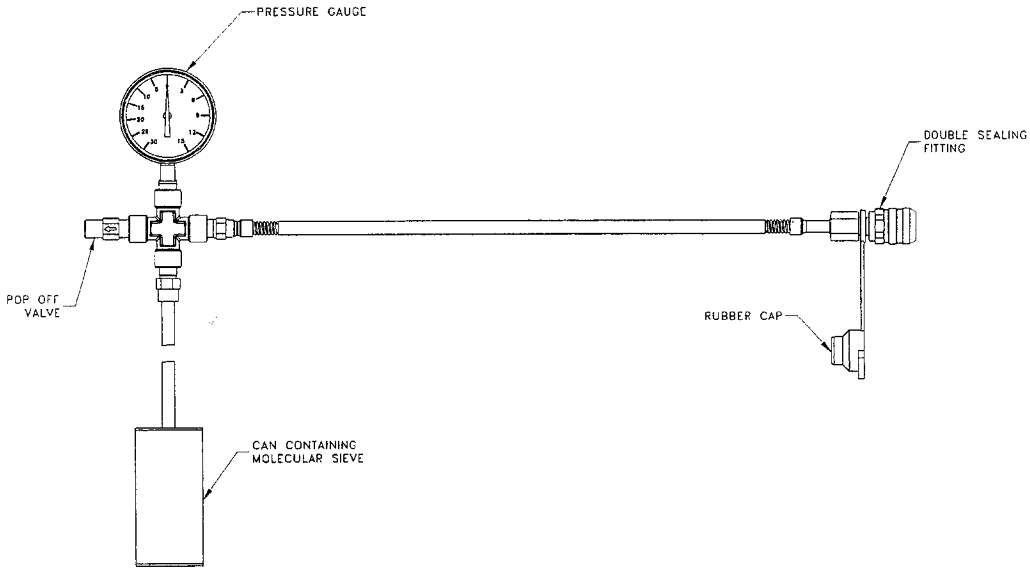


Figure 2-5. Cold Trap

The cold trap contains molecular sieve material in the can portion at the bottom of the assembly. When cooled to liquid nitrogen temperature, the molecular sieve readily absorbs any gas or vapor other than helium. This removes contaminants from the ^{3}He gas.

A pressure gauge determines residual gas in the assembly. If the gauge reads to the right of zero, the pressure inside the cold trap is greater than ambient pressure. In this case, remove the gas from the cold trap using the procedure “Regenerating the Cold Trap” (Section 5.3.2). When the cold trap is at liquid nitrogen temperature and no helium gas has been introduced to the trap, the pressure gauge should read 30 in Hg (to the left), indicating a hard vacuum. If this is not the case, the cold trap probably has a leak.

The double sealing fitting on the cold trap connects and disconnects the trap to the Helium-3 gas manifold without letting in atmospheric gases as the fitting is completely sealed when not connected to its mate. When the fitting is not in use, place the rubber cap on it to protect it from dirt. Each time you connect the cold trap to the Helium-3 gas manifold, apply a thin film of Apiezon M-grease to the surface of the fitting and its mate on the gas manifold. The grease will lubricate the O-rings in the connectors and prevent leaks.

To prevent a dangerous overpressure condition, a pop-off valve is attached to the cold trap.

2.4.2 Trap Regeneration Fitting

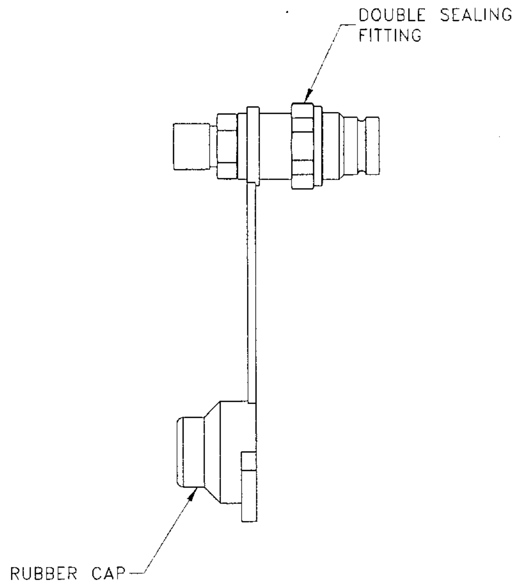


Figure 2-6. The Trap Regeneration Fitting

The trap regeneration fitting allows you to pump out the cold trap if the gas pressure gets above atmospheric pressure in the trap. The fitting adapts from the double sealing fitting on the cold trap assembly to the cryocleaning hose, which is shown in Figure 5-1. The cryocleaning hose then attaches to the top plate of the PPMS to allow pump-out of the cold trap using the PPMS high vacuum system. This procedure is described in more detail in "Regenerating the Cold Trap" (Section 5.3.2). Place the rubber cap on the double sealing fitting when not in use to protect the fitting from dirt.

2.4.3 Liquid Nitrogen Dewar Flask

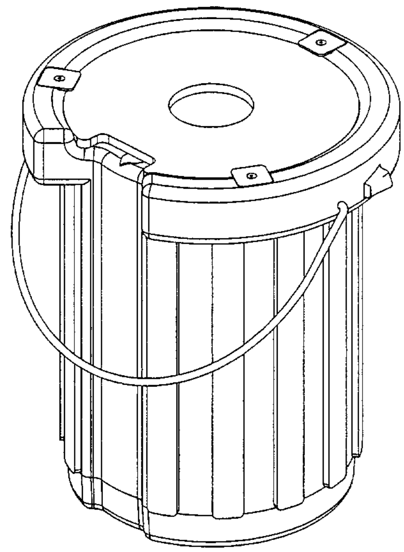


Figure 2-7. Liquid Nitrogen Dewar Flask

The dewar flask is a well-insulated container for liquid nitrogen. The hole in the top of the dewar flask allows the cold trap into the liquid nitrogen.

2.5 Model 6000 PPMS Controller

The expansion circuit board (part number 3076-015) located in the Model 6000 PPMS Controller provides the necessary control signals for the system. This special circuit board drives the two solenoid valves, controls the pressure gauge, and also has a precision current source for driving the sample heater on the sample holder.

Using a resistive temperature sensor below 1 K requires readout electronics that use very little measuring power. The enhanced user bridge board (part number 3076-050) uses a precision balanced current drive to achieve the required sensitivity with minimal self-heating in the temperature sensor.

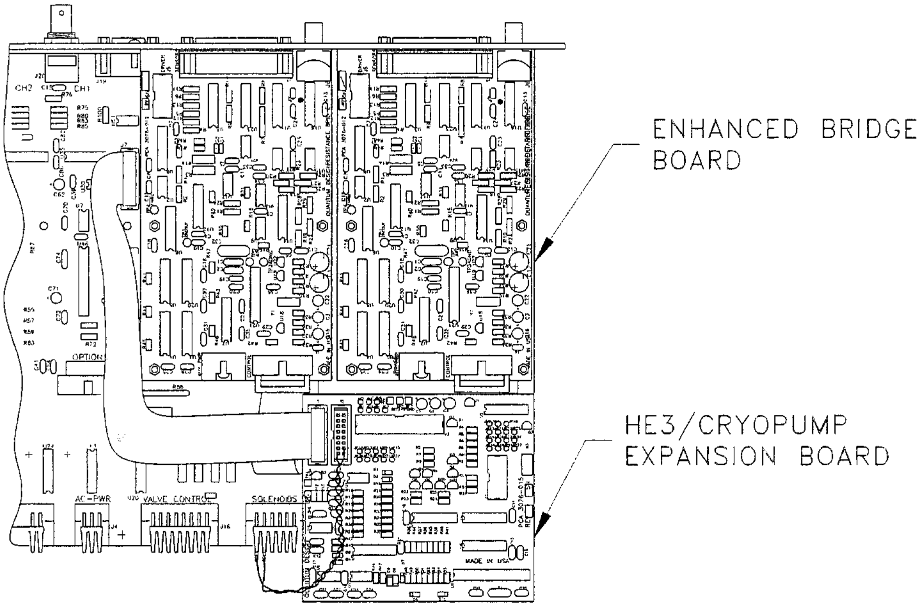


Figure 2-8. Expansion Circuit Board and Enhanced User Bridge Board in Model 6000

2.6 Option-Specific Hardware

2.6.1 Resistivity Measurements

Special eight-pin sample mounts provided with the Helium-3 system are designed for mounting samples for transport measurements that can be performed with the Resistivity option or the AC Transport option.

When the Helium-3 insert is installed and the standard user bridge cable is connected, resistance measurements can be performed on channels 1 and 2 on the bridge board. Refer to the *Physical Property Measurement System: Resistivity Option User's Manual* for information about wiring samples for four-wire resistance measurements to the eight-pin sample mounts and for information about taking resistance measurements when the Helium-3 insert is installed.

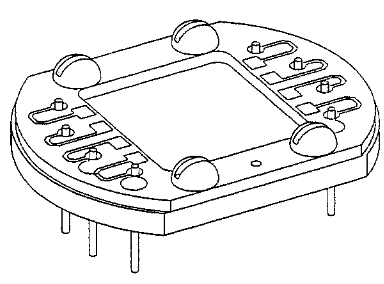


Figure 2-9. Sample Mount for Resistivity and ACT Measurements

2.6.2 AC Transport Measurements

Special eight-pin sample mounts (see Figure 2-9) provided with the Helium-3 system are designed for mounting samples for transport measurements that can be performed with the Resistivity option or the AC Transport option.

The ACT/Helium-3 probe cable (part number 3084-518) must be connected to take ACT measure-ments when the Helium-3 insert is installed. This cable splits off the ACT signals from the Helium-3 thermometer. The thermometer signal is plugged into channel 4 of the bridge board.

Refer to the Physical Property Measurement System: AC Transport Option User's Manual for information about wiring samples for ACT measurements to the eight-pin sample mounts and for information about taking ACT measurements when the Helium-3 insert is installed.

2.6.3 Heat Capacity Measurements

Special Heat Capacity sample mounts have been developed for use with the Helium-3 system. These sample mounts have been designed to fit into the smaller space that is available, and the thermometer is designed to operate to below 0.4 K. Also, thinner wires are used for the platform support to provide longer sample thermalization times.

A special adapter is provided to allow the Heat Capacity sample mounts to be used with the standard sample-mounting station provided with the PPMS Heat Capacity system. A special calibration fixture is used for performing the automated calibration procedure on a new Heat Capacity sample mount. A platform stabilizer plug prevents vibration of heat capacity platforms during measurements in a magnetic field.

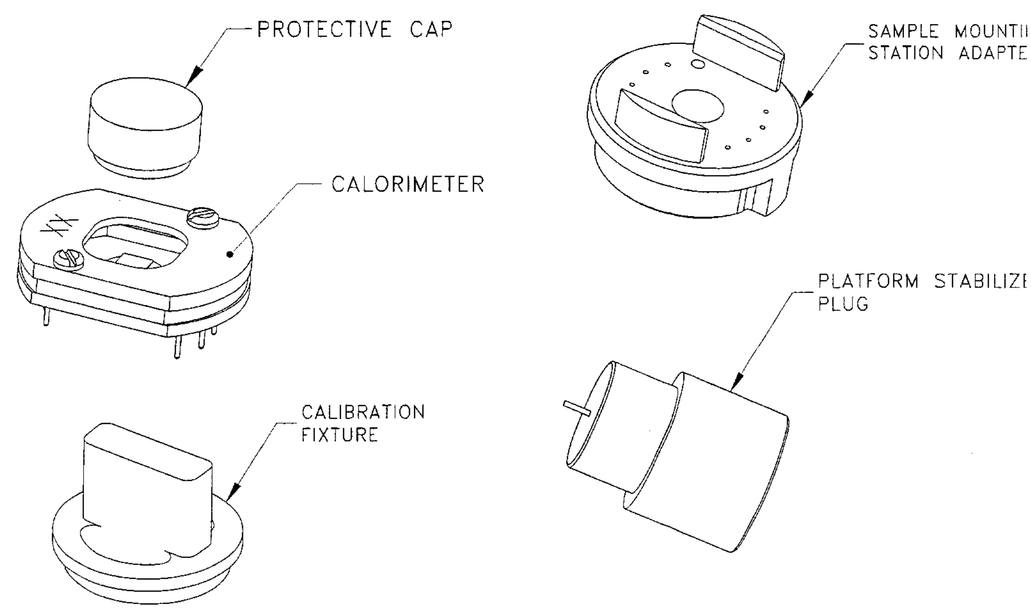


Figure 2-10. Heat Capacity Sample Mount and Accessories

For more information about taking heat capacity measurements when the Helium-3 insert is installed, refer to the *Physical Property Measurement System: Heat Capacity Option User's Manual.*

2.7 Other Accessories

- **Grease.** Apiezon N Grease and Apiezon H Grease are included with the Helium-3 system. Grease is used on the contact fingers near the bottom of the probe for improved thermal contact between the sample chamber and probe. Grease can also be used between the sample mount and sample holder, as well as between the sample mount and sample. N Grease is recommended unless the temperature will exceed 320 K. If the temperature will exceed 320 K, H Grease should be used because it does not melt.
- **Wrenches and screws.** Two small hex wrenches are provided for mounting samples and adjusting the sample holder position. Small screws are provided for attaching both the Resistivity and Heat Capacity sample mounts to the sample holder on the bottom of the insert.
- **Electrical splitter box.** An electrical splitter box (part number 4076-060-01) attaches to the auxiliary port on the back of the Model 6000. The purpose of this is to allow the connections to be made to the Helium-3 controller through this port, without blocking access to the port for other user functions.
- **Storage accessories.** When the probe is stored in the cart, the probe cover can be placed over the end of the probe, and the vinyl O-ring cover can be placed over the white O-ring.

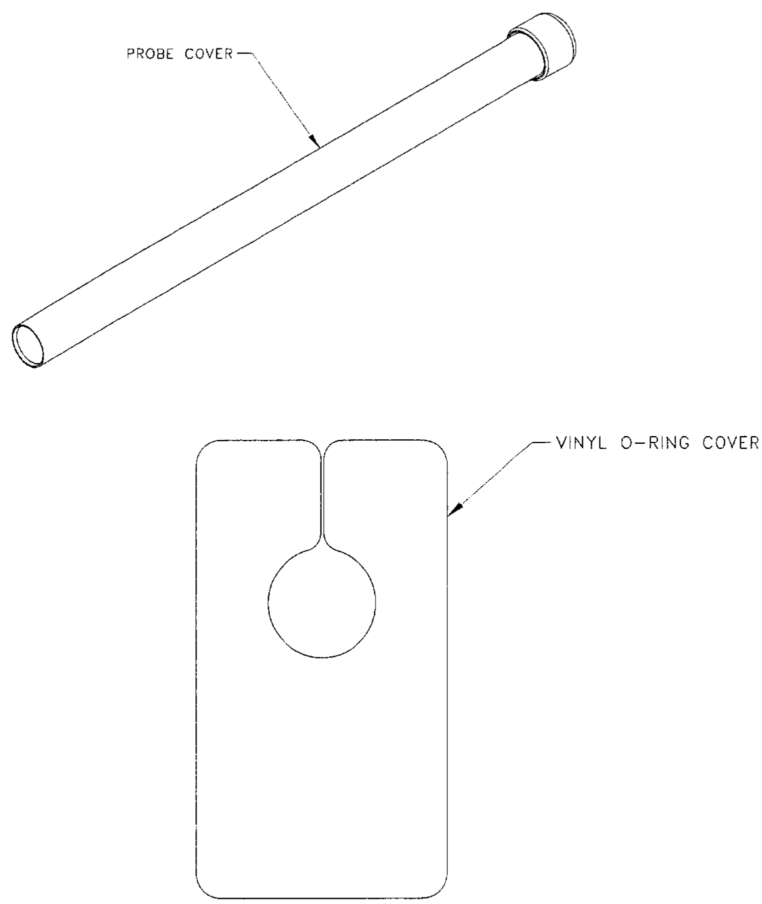


Figure 2-11. Storage Accessories

C H A P T E R 3

Software

3.1 Introduction

This chapter contains the following information:

- Section 3.2 discusses the architecture of the Helium-3 software.
- Section 3.3 discusses temperature-control data logging.
- Section 3.4 discusses the Helium-3 maintenance utility.

3.2 Helium-3 Software Architecture

The software provided with the Helium-3 system consists of a main temperature control module, diagnostics utilities, and maintenance utilities. This software is usually installed in the `\qdppms\He3Option` directory. The configuration information for the specific serial number is contained in the file `\qdppms\He3Option\Config\He3Option.cfg`.

To enable temperature control with the Helium-3 insert, the Helium-3 Control Console application must be running on the PC. This application implements the various control modes described in Section 1.4 and controls the transitions between them. All real-time aspects of the temperature control program, including PID control, are executed in the Model 6000 PPMS Controller.

3.2.1 Temperature Command Redirection

The Helium-3 system temperature control state engine is executed on the PC. However, the standard interface to the normal PPMS temperature control is handled completely through the Model 6000. When any application program needs to set a new temperature, it is done by sending a GPIB command to the Model 6000, executing a sequence with temperature commands, or by simply entering the new temperature set point directly from the front panel of the Model 6000. To ensure compatibility with existing software, a special software architecture has been chosen to preserve this interface while the main temperature control engine executes on the PC.

When the Helium-3 software is initialized, it sends a command to the Model 6000 that instructs it to forward future temperature commands to the control program executing on the PC. The Model 6000 then operates in this special redirected mode until command redirection is cancelled when the control program is terminated. In this mode, the temperature control status information is also redirected. The PC determines whether the temperature is "Chasing," "Near," or "Stable" and sets the status word on the Model 6000 appropriately. Any application programs, including PPMS MultiVu, determine the state of the temperature control engine by querying this status word.

Information appearing in the Model 6000 front panel indicates when the Helium-3 software is running and the commands are redirected. When temperature control is redirected, a small up-and-down arrow appears by the **TEMP** command. The arrow indicates that temperature control is being processed on the PC. If you use the Model 6000 **Temperature** menu to enter a temperature, an "He3" indicator appears in the upper left corner of the Model 6000 front panel. If you enter a temperature command, the stability indicator on the Model 6000 front panel reads "PC" until the software returns the appropriate stability. While "PC" status is indicated on the front panel, the PPMS temperature status word indicates an "unknown" temperature state.

In rare cases when the PC crashes or the software stops responding, the "PC" indicator may remain lit and you do not see the normal status messages. To fix the problem, you must restart the Helium-3 Control Console application. The software will automatically recover from the crash. If you want to recover normal PPMS control without restarting the Helium-3 software, you can terminate the command redirection on the Model 6000 by entering the **CTRL** menu, selecting item 4, and then entering 2.

3.2.2 Software Initialization and Self-Test

The control software is normally launched just before or after the Helium-3 insert is installed in the PPMS sample chamber. The software functions as a separate program that runs in the background. It can be launched from within PPMS MultiVu or from Windows.

When the software is launched, it reads configuration information from the `He3Option.cfg` file. If the insert is already in the sample chamber, the insert configures the Model 6000 for temperature command redirection, and then the control software enters the standby state. In this state, the temperature control remains inactive until a new temperature set point is entered. At this point, a hardware self-test is performed and the temperature control begins.

If the insert is not in the sample chamber, the system enters the probe-out state. In this state, the software is effectively inactive. Any new temperature set points are simply passed on to the standard PPMS temperature control engine. Only when the insert is installed will the self-test begin.

The self-test can identify a number of hardware failures. However, the primary purpose is to detect cables that are not properly connected.

3.2.3 Helium-3 Option Control Console

The main window of the Helium-3 Control Console application is used to access status information in real time and in a logging mode. You can also shut down the temperature control engine and force it into the shutdown mode when necessary.

The **Status** panel provides a short description of the current state of the Helium-3 temperature control.

The **Logging** button opens the **LoggingDialog**, from which you can monitor and log different hardware parameters related to the option's inner workings.

The **Shut Down He3 Engine** button prompts the Helium-3 option to enter the standby state. In the standby state, the Helium-3 temperature control is idle while it waits for a new set point, and the Helium-3 hardware is shut down.

The **Close** button exits the Helium-3 option. The option's temperature control engine should be shut down before an attempt is made to exit the option. If **Close** is selected and the temperature control engine has not been shut down, a message pops up to remind you to shut down the temperature control engine.

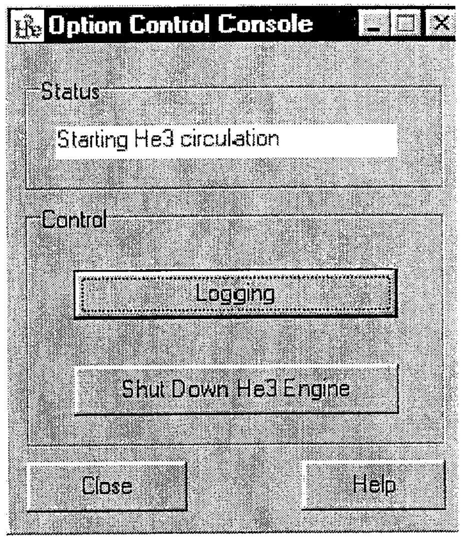


Figure 3-1. Helium-3 Option Control Console

3.3 Temperature-Control Data Logging

Sometimes it may become necessary to monitor the various state variables of the Helium-3 tempera-ture control engine. This is usually required only to diagnose problems with the temperature control.

3.3.1 LoggingDialog

The **LoggingDialog** (refer to Figures 3-2 through 3-4) in the option control console allows you to monitor different diagnostic parameters for the Helium-3 option. It produces files that are compatible with the PPMS MultiVu data file format and can therefore be displayed in real time within PPMS MultiVu. It provides you with considerable information about the option's inner workings.

To use the Logger, you (1) select the file to which the diagnostics will be written, (2) select a logging frequency, (3) choose the fields to log, and then (4) push the **Start** button. The Logger remembers the state it was in the last time the Helium-3 option was running, so it may start logging as soon as the option is launched. The Logger does not remember whether the **Overwrite** box was checked, and by default it always appends data to the selected file.

3.3.2 Logging Set Up

The **General** tab in the **LoggingDialog** allows you to set a file by either browsing over existing files or by entering a new name for a file in the **Diagnostics File Name** text box. It also allows you to select whether to log at a fixed interval or to log just on events.

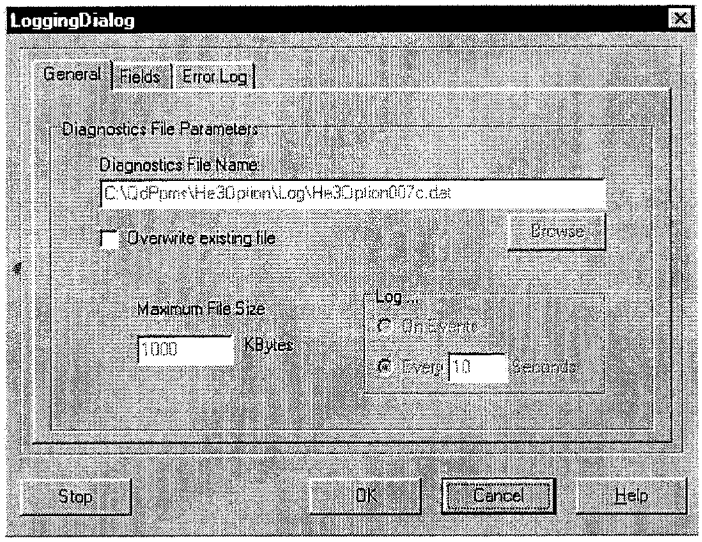


Figure 3-2. **General** Tab in **LoggingDialog**

3.3.3 Selecting the Fields

The **Fields** tab in the **LoggingDialog** allows both the real-time monitoring of the different parameters as well as the selection of parameters for the log file. Parameters that are checked while the logging to file is running go into the log file only after you accept the changes by selecting the **OK** button.

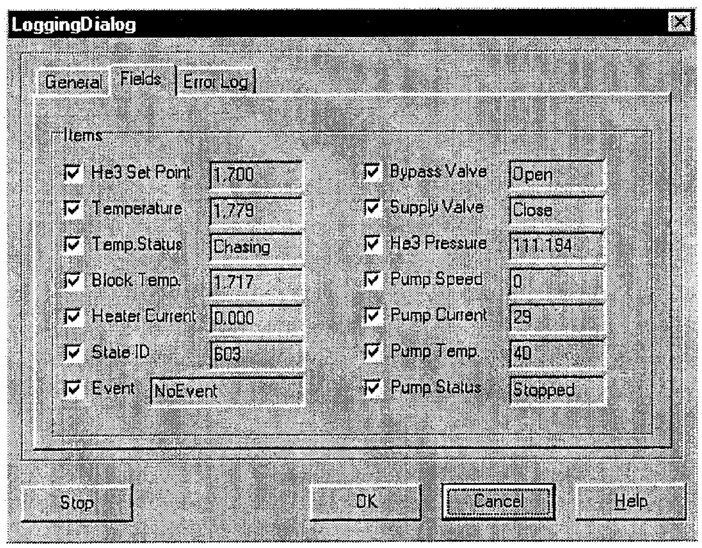


Figure 3-3. **Fields** Tab in **LoggingDialog**

Table 3-1. Helium-3 Log Fields

LOG FIELD	FUNCTION
He3 Set Point	Temperature set point for Helium-3 system. Helium-3 set point is active only at temperatures lower than ≈ 4 K. At higher temperatures, set point reverts to normal PPMS set point.
Temperature	Temperature as reported by Helium-3 system thermometer located close to sample and thus sample temperature reported by PPMS MultiVu and other Quantum Design applications. When Helium-3 system enters standby state, temperature reverts to PPMS thermometry.
Temperature Status	Stability status for sample temperature (for example, "Chasing," "Near," "Stable").
Block Temperature	PPMS, or block, temperature.
Heater Current	Approximate current, in milliamps, through Helium-3 system heater.
State ID	ID number corresponding to actual state of temperature state machine. There is close correspondence between state ID number and status description in Helium-3 option control console.
Event	Brief description of event being processed by state machine.
Bypass Valve	State of bypass valve. A "1" indicates bypass valve is open. This is normally the case when system is in standby state or one-shot state.
Supply Valve	State of supply valve. A "1" indicates supply valve is open. This is normally the case when system is in circulating state.
He3 Pressure	Gas pressure in Helium-3 tank. Helium-3 gas is completely enclosed in system, so it can be related to liquid level on pot. Therefore a large pressure indicates a large amount of gas in tank and an empty pot, and a small pressure indicates that most ^{3}He gas has condensed down into pot.
Pump Speed	Speed, in kRPM, of Helium-3 turbo pump. Value is generally between 9 and 75 kRPM.
Pump Current	Turbo pump drive current, in mA. Pump has power-limiting features that hold current below certain value. This value depends on current operating speed and gas flow. Generally, it is limited to be less than about 600.
Pump Temperature	Temperature of turbo pump bearing. Pump has temperature-limiting feature that causes it to shut down if its temperature goes above 60°C.
Pump Status	Brief description of status of turbo pump controller.

3.3.4 Error Log

The **Error Log** tab in the **LoggingDialog** displays all the error, warning, and information messages that the Helium-3 option has produced since it was launched. The tab also displays the software version number.

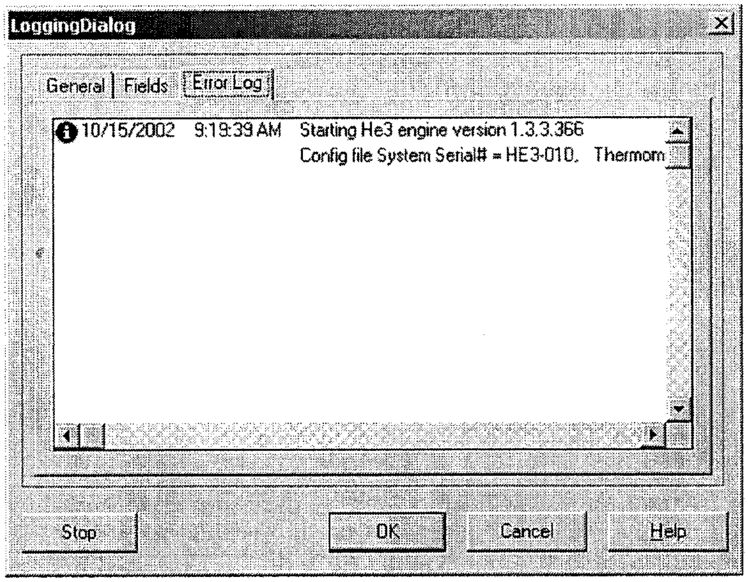


Figure 3-4. **Error Log** Tab in **LoggingDialog**

3.4 Helium-3 Maintenance Utility (He3GasMon.exe)

The Helium-3 Option Maintenance Utility application (He3GasMon) has been designed to provide direct manipulation of the Helium-3 system hardware, as well as pre-written macros (wizards) for performing certain common maintenance procedures. The location of the utility is `\qdppms\He3Option\He3GasMon.exe`. To run the maintenance procedure, you select the Windows **Start** button and then you select **Programs** >> **Quantum Design** >> **He3Option** >> **He3GasMon**.

Caution! You are advised to close the Helium-3 Control Console application before you start the He3GasMon maintenance utility. You are strongly advised to close the Helium-3 Control Console application before you run any of the software wizards. During normal operation, the Helium-3 system is designed to be controlled by only the Helium-3 Control Console application.

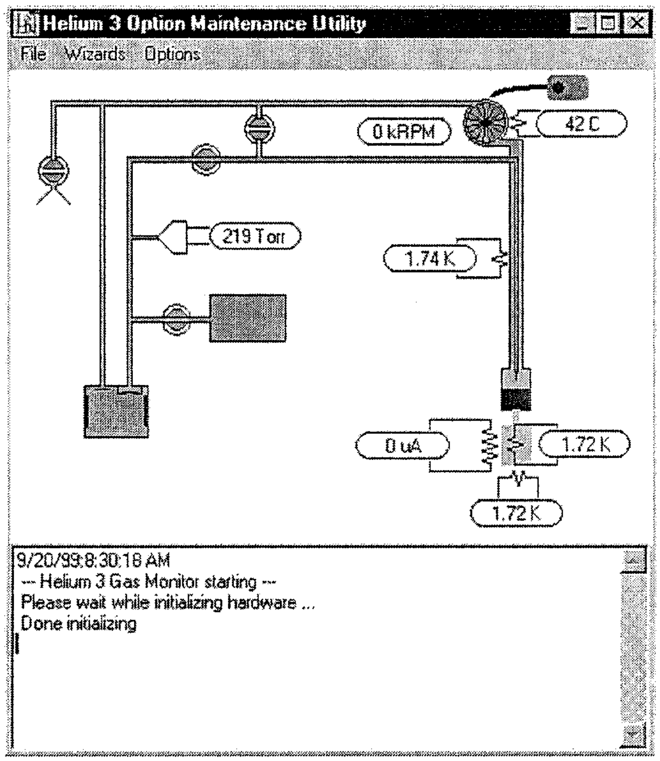


Figure 3-5. Helium-3 Maintenance Utility

3.4.1 Visual Manipulation of the Gas-Handling System

The maintenance utility provides a visual representation of the Helium-3 gas-handling system. When the program is activated, it is in the display-only mode. To allow control of the hardware, you check various options under the **Options** menu. For example, if you check the **Allow Valve Control** item, you can double-click on a valve to toggle its state. If the **Allow Pump Control** item is checked, you may activate the turbo pump by clicking on the icon representing the pump switch.

3.4.2 Wizards

The **Wizards** menu in the maintenance utility contains a number of macros for performing a variety of maintenance procedures. Specific instructions for these wizards are in chapter 5.

A log file containing all messages from the wizards is located in the file `\qdppms\He3Option\He3GasMonWizards.log`.

CHAPTER 4

System Operation

4.1 Introduction

This chapter contains the following information:

- Section 4.2 explains how to set up and shut down the Helium-3 system.
- Section 4.3 summarizes procedures for taking measurements when the Helium-3 system is installed.
- Section 4.4 explains how to manually position the sample holder area.

4.2 System Setup and Shutdown

NOTE

If you are installing the Helium-3 system for the first time, please refer to the detailed installation instructions in Appendix A.

After the Helium-3 option has been set up for the first time, very little work is required to shut down and reactivate the option between usages. The electrical connections between the cart, computer, and Model 6000 PPMS Controller are easily disconnected and reconnected. Software initialization is handled automatically by simply launching the Helium-3 Control Console application.

The following instructions assume that the Helium-3 cart with the Helium-3 insert and the diaphragm pump has been previously disconnected from the cabinet and computer for storage. The instructions begin with reconnecting the system. However, you may choose not to disconnect the system between usages if sufficient space is available for storing the cart adjacent to the PPMS probe and rack.

4.2.1 Connecting the Electrical Cables

1. Position the Helium-3 cart so that it is near the PPMS dewar, control computer, and PPMS electronics cabinet.
2. Note whether your system has a single black connector for all control signals. If your system has a single black connector, you may reconnect the cable to the cart. Otherwise, follow steps 3 and 4.
3. Plug the 25-pin connector into the "P8–Auxiliary" port on the back of the Model 6000.

4. Plug the serial cable into the "COM1" port on the back of the computer.
5. Plug the power connector into the power strip on the back of the electronics cabinet.
6. Plug in the gray Lemo cable for your measurement option. Refer to the appropriate option manual for specific information about the Lemo cable that enables your option.

4.2.2 Launching the Helium-3 Control Console Application

Once the hardware is connected, you may activate the software. The Helium-3 Control Console application is a stand-alone program. As such, it can be invoked by launching the executable from the Windows desktop. It may also be accessed through the PPMS MultiVu **Utilities➤Activate Option** menu option, where you click on **Helium3** and then select the **Activate** button.

Notice that you can minimize the Helium-3 option control console. The Helium-3 software runs in the background, so the option control console does not have to be visible in the PPMS MultiVu interface.

Launching the Helium-3 option starts up the Helium-3 engine. When the option is activated, it defaults to the standby state. As soon as a new temperature set point is received, the software wakes up, runs a series of hardware tests, and starts controlling.

4.2.3 Shutting Down the Helium-3 Control Console Application

When you will no longer use the Helium-3 system, set it in standby state by selecting the **Shut Down He3 Engine** button in the Helium-3 option control console (see Figure 3-1). Selecting this button makes the Helium-3 option relinquish temperature control on the current set point to the Model 6000. However, if the Helium-3 insert is still in the sample chamber and a new temperature set point is selected, the Helium-3 option takes over temperature control again.

After the system enters the standby state, you can quit the application by selecting the **Close** button in the Helium-3 option control console.

If for some reason the software terminates abnormally or crashes, always restart the application and shut it down properly. When the software is shut down normally, it properly shuts down the hardware and places it in a safe state.

4.2.4 Disconnecting and Storing the Hardware

Follow the instructions in Section 2 for removing and safely storing the Helium-3 insert on the cart. Then simply reverse the steps in Section 4.2.1 to disconnect and store the cart in a safe place.

4.3 Taking Measurements

The following procedures are generic and assume that all electrical connections to the Helium-3 system have already been made. For specific information about using a PPMS measurement option with the Helium-3 system, refer to the appropriate option manual.

4.3.1 Start the Software

1. Activate the Helium-3 Control Console application as described in Section 4.2.2.
2. Start up the software application for your measurement option (Resistivity, AC Transport, or Heat Capacity). You can (*a*) select the program icon or (*b*) select **Utilities >> Activate Option** in PPMS MultiVu, click on the option name, and then select the **Activate** button.

4.3.2 Attach the Sample Mount

1. Follow the sample preparation and mounting instructions as contained in the specific user manual for the type of measurement you will perform.
2. Apply a small amount of Apiezon H Grease or N Grease to the bottom side of the plug-in sample mount. Applying additional grease may be unnecessary if grease is left over from a previous run.
3. Place the Helium-3 insert in the Helium-3 cart if the insert is not already in the cart. The insert and cart are specifically designed so that when the insert is in the cart, the sample holder is at a convenient height for you to reach.
4. Hold the plug-in sample mount so that the guide hole on it lines up with the guide pin on the sample holder and then push the sample mount onto the holder. If necessary, use tweezers or a similar tool to push the sample mount into position.
5. Use a hex ball driver to gently snug—but not tighten—the two hex Allen screws on the back of the sample holder. Be careful to hold the ball driver as straight as possible so that the screw heads aren't stripped. It is not possible to hold the driver perfectly straight on systems with the horizontal sample mount, so be especially careful when tightening the screws on such a system. Snug the screws until they just hold the plug-in sample mount against the mounting plate.
6. Apply a small amount of Apiezon H Grease or N Grease to the condenser contact fingers that are on the gold-plated sample cage area on the insert. Refer to Figure 4-1. Apply only enough grease so that the grease is not visible, but the contact fingers just feel tacky.

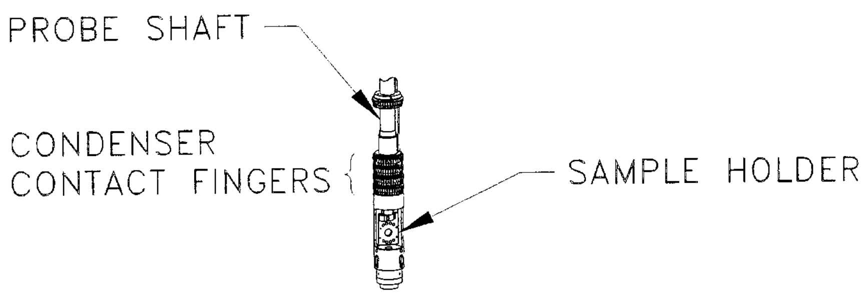


Figure 4-1. Condenser Contact Fingers

4.3.3 Install the Helium-3 Insert

Caution! Handle the Helium-3 insert very carefully. To help prevent the refrigerator probe on the insert from being damaged, stand on the provided step stool when you install the insert into the PPMS sample chamber or when you remove it.

NOTE If the Helium-3 insert has been recently removed from the PPMS sample chamber, verify that the refrigerator probe is dry. The shaft of the probe is usually cold when it is removed, and any moisture that condenses on the probe can impede the high-vacuum system.

1. Place the step stool that is included with the Helium-3 option next to the PPMS dewar.
2. Start up the installation wizard that will step you through the procedures to run a sample measurement for your measurement option. The installation wizard prompts the system to set the temperature to room temperature and flood the sample chamber with helium.
3. Wait for the installation wizard to indicate that system conditions are correctly set for installing the Helium-3 insert in the sample chamber.
4. Unlatch and remove the clamp that surrounds the sample chamber access port. If a flange is in the access port, remove the flange. Refer to the appropriate option manual for more specific information about opening the sample chamber access port.
5. Open the safety latch on the Helium-3 cart, and then lift the Helium-3 insert out of the cart.
6. Inspect the white silicon O-ring that is at the base of the turbo pump. It may be necessary to clean it and apply a small amount of Apiezon M Grease to ensure that it provides a good sealing surface.
7. Turn the Helium-3 insert so that the turbo pump is at the top of the probe shaft and the sample cage area is at the bottom of the shaft. Refer to Figure 2-1.
8. Verify that the cables attached to the turbo pump lie naturally and are not overly twisted or kinked. Straighten the cables, if necessary. The cables can be damaged if you insert the refrigerator probe into the sample chamber while the cables are twisted or kinked.
9. Step up on the stool, and lift the insert above the dewar. Hold the insert so that the fins on the turbo pump face backwards and the large, black mesh cable hangs over the right side of the insert.

Caution! Avoid stressing the shaft of the refrigerator probe in any way while you are installing the Helium-3 insert in the sample chamber. The material out of which the shaft is constructed is thin and fragile and can easily bend or dent.

10. Slowly lower the insert into the PPMS sample chamber while securely holding the turbo pump. You should feel the resistance of the contact fingers increase in the last 4–5 cm.
11. Make sure the O-ring is properly seated on the sample chamber flange.
12. Complete any additional tasks the installation wizard prompts you to perform before you run the measurement.

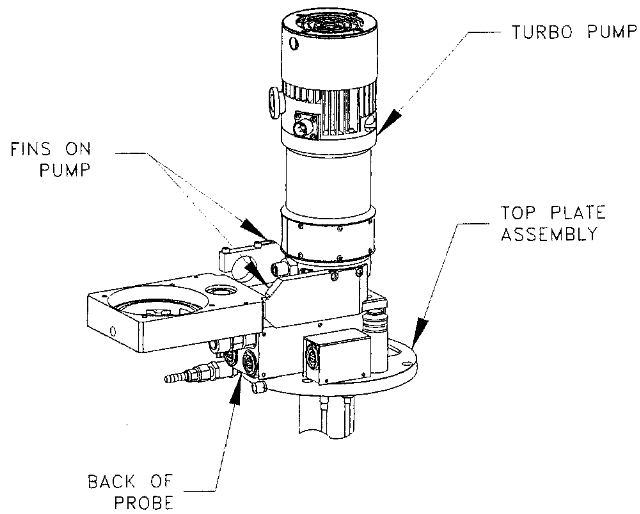


Figure 4-2. View of Turbo Pump When Helium-3 Insert Is Installed in Sample Chamber

4.3.4 Run the Measurement

1. Verify that the sample chamber is purged. The measurement option should have prompted you to do this. If you did not run the installation wizard, you must purge the chamber before you run the measurement.
2. Run a measurement as you would normally. All procedures for running a measurement in immediate mode or sequence mode are identical whether or not the Helium-3 insert is installed. However, when the insert is installed you can take measurements below 0.4 K.

4.3.5 Remove the Helium-3 Insert

1. Complete any additional tasks the installation wizard prompts you to perform.
2. Wait for the installation wizard to indicate that system conditions are correctly set for removing the insert from the sample chamber.

NOTE

The system temperature must be between 295–315 K and the sample chamber must be flooding with helium before you can remove the insert from the sample chamber. The installation wizard correctly sets these system conditions. You must set the temperature and vent the chamber if you did not run the installation wizard.

Caution!

Avoid stressing the shaft of the refrigerator probe in any way while you are removing the Helium-3 insert from the sample chamber. The material out of which the shaft is constructed is thin and fragile and can easily bend or dent.

3. Step up on the stool, and then gently pull the insert out of the dewar.
4. Turn the insert so that the turbo pump is at the bottom of the probe shaft and the sample cage area is at the top of the shaft. Place the insert in the cart, then close the safety latch on the cart.

4.3.6 Remove the Sample Mount

1. Use a hex wrench to loosen—but not remove—the two hex Allen screws on the back of the sample holder. Keep the two screws inside the slots on the sample holder. When the screws remain in the slots, you can use them to gently push the plug-in sample mount away from the socket on the probe.
2. Remove the sample mount by pulling it straight out using fingers or tweezers. The pins can be easily bent, so be careful.

4.4 Manually Positioning the Sample Holder Area

If your Helium-3 system has a vertical sample holder, you can manually position the sample holder so that it is aligned at different angles. This adjustment allows you to vary the angle between the plate of the sample holder and the applied magnetic field in systems with a transverse magnet. The sample holder can be manually rotated up to 140° around the longitudinal axis of the sample space.

The orientation of the sample holder is set using two hex Allen screws. Small wrenches have been provided for loosening these screws. When adjusting the orientation, make sure the heater wire attached to the underside of the mounting plate is not stressed. Tighten the screws snugly enough that you get good thermal contact between the part that rotates and the part that is stationary. Be careful that you do not strip the screws; they are very small.

CHAPTER 5

Troubleshooting and Maintenance

5.1 Introduction

This chapter contains the following information:

- Section 5.2 is a troubleshooting guide for the Helium-3 system.
- Section 5.3 explains how to perform common maintenance procedures for the Helium-3 system.

5.2 Troubleshooting Guide

The following sections describe the causes, symptoms, and remedies for the most common problems that can occur while using the Helium-3 system.

5.2.1 Plugged Impedance

A plugged impedance is the most common reason the system fails to cool below 1.8 K.

CAUSE

The impedance that feeds ^{3}He gas into the pot of the Helium-3 system becomes plugged by a gradual buildup of contamination from out-gassing and minute leaks. The ice plug stops the circulation of gas.

SYMPTOM

The temperature control operates normally but cannot cool below the normal PPMS base temperature of about 1.8 K. On the first attempt to go below about 1.8 K, the Helium-3 Control Console application indicates the system is in the "He3 Circulating" state, but does not reach or stabilize at a lower temperature.

VERIFICATION

If the system has not been cryocleaned in more than a month or so, the lack of cleaning is the most likely cause of the problem. Do the following to verify the problem:

1. Shut down the Helium-3 Control Console application while the system is still at the lowest temperature it can reach.
2. Wait about 10 minutes or until the PPMS base temperature is less than 2 K.

3. Enter a temperature of 0.5 K from the front panel of the Model 6000.
4. Wait for the Helium-3 pump to start running.
5. Open the **LoggingDialog** in the Helium-3 option control console, and select the **Fields** tab.
6. Note the He3 pressure, He3 temperature, and block temperature.

While the system was shut down, ^{3}He gas was allowed to accumulate; hence the He3 temperature may drop well below 1.8 K as ^{3}He gas evaporates from the pot. However, if the impedance is plugged, the pot eventually goes dry, and the temperature rises back up to the block temperature. Also, if the impedance is plugged, the pressure rises continuously to some value greater than about 250 torr, reaching a maximum value when the pot goes dry. The pressure never decreases if the impedance is plugged. In addition, the turbo pump speed probably increases to the maximum of 75 kRPMs once the pot is dry, because there is little gas flow in this case.

REMEDY

Follow the cryocleaning procedure in Section 5.3.1 to remove the contamination from the ^{3}He gas.

5.2.2 Poor Thermal Contact to Condenser

CAUSE

This problem is caused by weak mechanical contact between the lower walls of the sample chamber and the contact fingers located along the shaft of the Helium-3 insert. Although problems are usually caused by poor contact with the condenser contact fingers at the very bottom, poor contact higher up the shaft can lead to poor performance as well.

SYMPTOM

In the worst case, the system does not cool below about 2 K. In moderate cases, it may take more than 1 hour to cool from 1.5 to 0.5 K. Unlike the symptoms of a plugged impedance, the system may be able to maintain temperatures below 1.5 K.

VERIFICATION

The following procedures detail the simplest way to determine whether the contact is sufficient:

1. Press the **Shut Down He3 Engine** button and close the console if it is currently running, and then launch the He3GasMon utility as described in Section 3.4.
2. Run the "Check Condenser Contact" wizard.

This procedure makes certain the sample chamber is at high vacuum and that no condensed ^{3}He is present in the pot. It then sets the temperature to the lowest value and measures any temperature difference between the ^{3}He thermometer and the PPMS system thermometer.

Generally the wizard reports a temperature difference of about 0.1 K between the PPMS neck temperature and helium-3 thermometer.

REMEDY

If the temperature difference is larger than about 0.15 K, you should make sure the contact fingers are not completely dry. Add a small amount of N or H Grease as necessary. In unusual cases, the bottom of the sample chamber may have been previously stretched by an ice plug resulting from a gross leak into the sample chamber, thus requiring servicing by Quantum Design.

5.2.3 Gas System Leaks

CAUSE

Gas system leaks can result from damage to the probe, corrosion, or from a rupture of a diaphragm in the pumping assembly.

SYMPTOM

If there is a small system leak, the system may simply plug more frequently than normal and hence require cryocleaning more often. The system is considered normal if it takes a month or more to develop a plug without cryo-cleaning. In more extreme cases, the Helium-3 application may report a loss of pressure. Refer to Section 5.2.1, "Plugged Impedance," to verify the symptoms of lack of cryocleaning.

VERIFICATION–REMEDY

To test for a gross leak and a large loss of ^{3}He, run the "Pressure Verification" wizard as indicated in Section 5.3.7. If the pressure is more than 10% different, there is probably a leak. To perform a complete leak check of the system, you need to have a helium leak detector. If you are prepared to perform a complete leak check, run the following wizards:

1. "Clean and Secure He3 Gas" wizard (Section 5.3.5).
2. "Leak Check System" wizard (Section 5.3.8). If leaks are found, the system must be repaired. If the system is leaking around the heads of the diaphragm pump, it may be necessary to replace the rubber diaphragms (Section 5.3.9). After all repairs are made, rerun the wizard and leak check the system until no leaks are found.
3. Run the "Evacuate and Seal" wizard (Section 5.3.6) once the system is leak free.

5.2.4 Diaphragm Pump Deterioration

CAUSE

The constant motion of the rubber components in the diaphragm pump causes the rubber to gradually break down over time. The diaphragms may crack and leak or the flapper valves may stop sealing properly.

SYMPTOM

Cracked diaphragms produce a gas system leak as described above in Section 5.2.3. If the flapper valves degrade, the system does not leak or plug, but may exhibit poor cooling characteristics due to poor backing pressure for the turbo pump. The system may no longer be able to cool below 0.4 K when in one-shot mode.

VERIFICATION

To determine whether the flapper valves in the diaphragm pump need servicing, run the "Pressure Verification" wizard as described in Section 5.3.7. If the wizard indicates that the turbo pump cannot achieve the maximum speed, the flapper valves may require servicing.

REMEDY

To replace the diaphragms or service the flapper valves, perform the following procedures:

1. Run the "Clean and Secure He3 Gas" wizard (Section 5.3.5) to save the gas into the tank.
2. Complete the steps (Section 5.3.9) to replace the diaphragms or service the flapper valves.
3. Run the "Leak Check System" wizard (Section 5.3.8) to leak check the pump.
4. Run the "Evacuate and Seal" wizard (Section 5.3.6).

5.2.5 Software and Firmware Problems

Due to the complexity of software and firmware, it is sometimes necessary to reinitialize the entire system. Although symptoms vary, many intermittent software problems that appear over time are "fixed" by the following procedure:

1. Exit all programs—in an orderly fashion if possible—executing on the PC.
2. Shut down the PC from the Windows **Start** menu in the normal way.
3. Turn off the Model 6000 PPMS Controller and wait for at least 1 minute. Do not cycle the power more rapidly than this because there is a risk of damaging the controller.
4. If you have a Model 6500 Option Controller, turn it off as well.
5. Turn the Model 6000 and the Model 6500 back on and restart the computer.

5.3 Maintenance Procedures and Wizards

Most of the maintenance procedures described in this section are at least partially automated by using the Helium-3 Option Maintenance Utility application (He3GasMon). The maintenance utility provides a graphic display of the gas-handling system (see Figure 3-5) along with a menu of software wizards that guide you through the most common maintenance procedures. Each wizard mentioned in the sections below consists of a series of partially automated instructions for completing specific maintenance procedures.

To run the maintenance utility, you must first shut down and quit the Helium-3 Control Console application if it is already running. Then from the Windows **Start** menu, select **Programs >> Quantum Design >> He3Option >> He3GasMon**. To launch a specific wizard, select it from the **Wizards** menu.

Caution! You are advised to close the **Helium-3 Control Console** application before you start the **He3GasMon** maintenance utility. You are strongly advised to close the **Helium-3 Control Console** application before you run any of the software wizards. During normal operation, the Helium-3 system is designed to be controlled by only the **Helium-3 Control Console** application.

Several of the procedures require the use of the cryocleaning pump-out hose (part number 4092-630) provided with the system. This hose connects between the PPMS sample chamber and the Helium-3 cart and uses the PPMS as a high-vacuum pumping station.

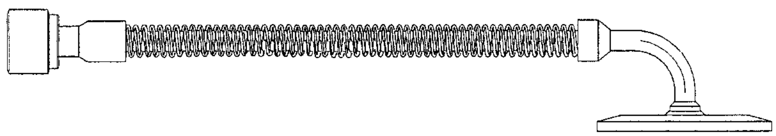


Figure 5-1. Cryocleaning Hose

5.3.1 Cryocleaning the Helium-3 Gas Using LN_2 Cold Trap

If the Helium-3 impedance becomes plugged, it will be necessary to cryoclean the ^{3}He gas. A plugged impedance results in a lack of cooling below about 1.8 K. To prevent impedance plugs, perform the cryocleaning procedure about once every two weeks when the system is under heavy usage. Or perform the procedure before using the Helium-3 system if it has been idle for more than two weeks. Little-to-no ^{3}He gas is lost during this procedure, so you can perform the operation often without the expense of adding ^{3}He gas to the system.

To perform this operation, run the **Cryo-Clean He3 with LN2 Trap** wizard. The software will guide you through the following steps:

1. Verify that the LN_2 trap is *not* in an overpressure condition. If it is, regenerate the trap by using the "Regenerate LN2 Trap" wizard.
2. Cool the LN2 cold trap by submerging it in liquid nitrogen.
3. Apply a thin film of Apiezon M grease to the double-sealing connectors on the cold trap and on the Helium-3 gas manifold.
4. Use the double-sealing connectors to connect the cold trap to the gas manifold.

5. Wait while the wizard flushes the ^{3}He gas into and out of the cold trap, removing all non-helium gases.
6. Pump the ^{3}He gas out of the cold trap.
7. Disconnect the cold trap from the Helium-3 gas manifold. Wipe off any excess grease on the surfaces of the double-sealing connectors and replace the rubber caps to prevent dirt from getting on the connectors.
8. Measure the pressure of the ^{3}He gas in the system and update the configuration file.

The entire operation will take about an hour if there is a fair amount of contaminant gas present and less time if the ^{3}He gas is clean.

5.3.2 Regenerating the Cold Trap

If the room temperature pressure in the cold trap is greater than ambient (atmospheric) pressure, regenerate the cold trap by pumping the gas out of the cold trap. The pressure gauge on the cold trap reads zero when the pressure in the trap is at ambient pressure and reads to the right of zero when the pressure is greater than ambient. A reading to the left of zero indicates a vacuum condition and 30 in Hg indicates a hard vacuum.

To regenerate the trap, run the "Regenerate LN Trap" wizard. The software guides you through the following steps.

1. Connect the cold trap to the PPMS sample chamber using the trap regeneration fitting and the cryocleaning hose.
2. Pump out the cold trap using the PPMS high vacuum system.
3. Disconnect the cold trap from the trap regeneration fitting using the double sealing connectors, preserving the vacuum in the trap.

5.3.3 Cryocleaning the Helium-3 Gas Using PPMS

This procedure allows cryocleaning of the ^{3}He gas without the LN_2 cold trap. Instead of removing the contaminants using the cold trap, the Helium-3 probe is cooled in the PPMS sample chamber, and contaminants are condensed on the walls of the Helium-3 probe. Only perform this if you do not have the LN_2 cold trap.

To perform this operation, run the "Cryo-Clean He3" wizard. The software guides you through the following steps:

1. Cool the Helium-3 insert to about 10 K to allow the cold surfaces inside the insert to freeze out the non-helium contamination.
2. Pump the remaining ^{3}He gas into the reservoir tank and close the tank valve.
3. Warm up the system and place the Helium-3 insert in the Helium-3 cart.
4. Remove contaminants from the system by evacuating the entire gas-handling system except for the tank where the clean ^{3}He gas is stored.
5. Seal the system and let the ^{3}He gas back into the system.
6. Measure the remaining pressure of the ^{3}He gas in the system and update the configuration file.

The entire cryocleaning procedure requires from 3 to 10 hours. The length of the procedure depends on whether the probe is already cold when you start the procedure, and how long you choose to pump on the system when it is warm.

Notice that each time this procedure is performed, the system looses about 3% of the remaining ^{3}He gas. Hence, this procedure may be performed about 10 times before it is necessary to add more gas. See Section 5.3.4 for adding ^{3}He gas to the system.

5.3.4 Adding Helium-3 Gas to the System

After running the cryocleaning procedure multiple times, or after repeated maintenance operations, it will become necessary to add more ^{3}He gas to the system.

To perform this procedure you need a bottle of ^{3}He gas connected to a tee pump-out fixture. This fixture consists of a tee joint with the following three branches. The first branch consists of a female VCO-type, face-seal fitting for connecting to the "FILL" port on the diaphragm pump assembly. The second branch consists of a valve (labeled "Gas Valve") connected to the ^{3}He gas supply bottle. The third branch consists of a valve (labeled "Pump") connected to a male VCO-type, face-seal fitting. The fittings, without the ^{3}He gas, are provided with the Helium-3 system.

To obtain the gas, please contact Quantum Design or a gas supplier directly. The 99.8% pure grade is adequate for the Helium-3 system. This can be obtained from Cambridge Isotope Laboratories, Inc., (www.isotope.com) under the part number HE-29. To be able to connect to the fill manifold, the bottle must have a male ¼ NPT-type fitting. It is also recommended that the bottle be fitted with a needle valve for precise control of filling.

Before starting the procedure, verify that the system is in the normal operating configuration with the "TANK" valve open and the "FILL" valve closed. Then run the "Add He3 to system" wizard. The software guides you through the following steps:

1. Place the Helium-3 insert in the cart.
2. Connect the fill-bottle fixture to the fill port on the diaphragm pump assembly and evacuate the fixture to remove any air from the fill port.
3. Add ^{3}He gas to the system until the pressure reaches about 250 torr.

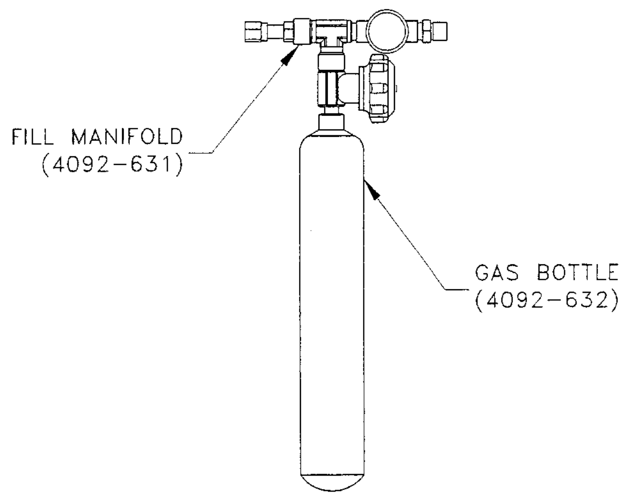


Figure 5-2. Helium Fill Manifold

5.3.5 Securing the Helium-3 Gas in the Tank

In order to save as much of the ^{3}He gas as possible before performing any maintenance operation that requires opening the system, you must secure the ^{3}He gas into the tank. Maintenance operations requiring that the system be opened include repairing a bad system component like a solenoid valve, or repairing or cleaning the diaphragm pump.

Before starting this procedure, verify that the system is in the normal operating configuration with the "TANK" valve open and the "FILL" valve closed.

To save the ^{3}He gas into the tank, run the "Clean and Secure He3 Gas" wizard. The software guides you through the following steps:

1. Cool the Helium-3 insert to about 10 K to allow the cold surfaces inside the insert to freeze out the non-helium contamination.
2. Pump the remaining ^{3}He gas into the reservoir tank and close the manual valve.
3. Warm up the system and place the Helium-3 insert into the Helium-3 cart.

If you need to open the system but do not need to clean the gas, you may run the "Quick Secure He3 Gas" wizard. This simply performs the second step noted above without the need to thermally cycle the system.

5.3.6 Evacuating and Sealing the System

After the system has been opened for maintenance or cryocleaning, it must be evacuated and the gas stored in the tank must be let back into the system.

Before starting this procedure, verify that the system is in the helium-stored configuration with both the "TANK" valve and the "FILL" valve closed.

To perform this operation, run the "Evacuate and Seal" wizard. The software guides you through the following steps:

1. Evacuate the system through the "FILL" line.
2. Close the "FILL" valve.
3. Open the "TANK" valve to let the ^{3}He gas back into the system.
4. Measure the remaining quantity of ^{3}He gas in the system and update the configuration file.

5.3.7 Verifying the Helium-3 Pressure

This procedure detects the presence of a gross leak in to or out of the ^{3}He gas system. It also indicates whether the diaphragm pump is providing adequate backing pressure for the turbo pump.

Before starting this procedure, verify that the system is in the normal operating configuration with the "TANK" valve open and the "FILL" valve closed.

Run the "Pressure Verification" wizard. The software guides you through the following steps:

1. Run the diaphragm assembly to pump the ^{3}He gas into the tank.
2. Measure the pressure of the gas in the tank and compare it to the value last recorded in the configuration file.
3. Measure the maximum turbo pump speed. If it is less than 75 kRPM, a warning is issued.

The program indicates whether there is a significant difference between the current pressure and the original pressure. If there is a significant difference, you need to determine whether there is a leak in the system. Leak checking the system requires the use of helium leak detector and someone trained in leak-detector operation. Refer to Section 5.3.8 for more on leak checking.

If this procedure indicates that the turbo pump cannot achieve the maximum speed, the flapper valves in the diaphragm pump require servicing. Refer to Section 5.3.9 for more on rebuilding the diaphragm pump.

5.3.8 Leak Checking the System

Leak checking the ^{3}He gas space requires the use of a helium leak detector. If you do not have access to a leak detector or if you do not have sufficient expertise with using a leak detector, please contact Quantum Design for assistance.

Before starting this procedure, verify that the system is in the helium-stored configuration with both the "TANK" valve and the "FILL" valve closed. That is, you must have already run the "Clean and Secure He3 Gas" wizard as described in Section 5.3.5.

If you have access to a helium leak detector, run the "Leak Check System" wizard. The software guides you through the following steps:

1. Hook up a leak detector to the fill access port on the diaphragm pump assembly. You may want to use the provided cryocleaning hose (part number 4092-630) or an appropriate VCO-type adapter to make the connection to the leak detector.
2. Open the green valve labeled "FILL."
3. Start the leak detector.
4. Run the turbo pump and diaphragm pump while leak checking the system.
5. Once leak checking is complete, close the "FILL" valve and turn off the pump.

If you discover that the system is leaking, the system must be repaired and the above steps repeated until a leak-free system is achieved.

5.3.9 Rebuilding the Diaphragm Pump

This procedure must be followed to service the diaphragm pump. If you are replacing the diaphragms, you must have obtained the proper replacement parts from Quantum Design or the pump manufacturer. If there are no leaks into the system and you are only servicing the flapper valves, you should only need to clean the valves with alcohol. In either case, it is strongly recommended that you have a leak detector available for this procedure.

Before starting this procedure, verify that the system is in the helium-stored configuration with both the "TANK" valve and the "FILL" valve closed.

1. Place the Helium-3 insert assembly in a safe place other than the cart. You will need to have full access to the diaphragm pump assembly located inside the cart and the insert will interfere if it is in the cart.
2. Remove the diaphragm pump assembly from the cart and place it on a low work surface or on the floor in front of the cart. To remove it from the cart, you may need to loosen the strain-relief associated with the large black connector running between the insert and pump assembly.
3. Vent the system to atmosphere by opening the "FILL" valve.
4. Unscrew the VCO-type fittings on the two short, flexible hoses that connect the pump to the manifold.
5. Remove either (*a*) the connecting bar or (*b*) the bellows hose from the top of the diaphragm pump-head assembly. *Your system has either the connecting bar or the bellows hose.*
   - To remove the connecting bar, unscrew the banjo bolts at either end of the bar. Note the amount of compression in the O-rings (Viton size 2-110) so that you can reinstall them with the right force when the rebuild operation is complete. If you are replacing the diaphragms, you also need to remove the cam cover.
   - To remove the bellows hose, remove the VCO connector fittings at either end of the hose.
6. If possible, lay the pump assembly on one side before removing the first head. There are loose components inside that may fall out if the pump is in its normal upright orientation.
7. Before disassembling each head, note the orientation and location of the two head pieces with respect to the pump body. These parts must go back together in exactly the same configuration.
8. On the head that is facing up, remove the four screws using a 3-mm hex wrench and carefully lift off the silver plate. You should see two rubber disks still stuck to the brown plate. These disks, each with a small hole in the middle, function as flapper valves.
9. Remove the flapper valves and clean them thoroughly in isopropyl alcohol, and then set them aside. If you are replacing the diaphragms, you may discard the flapper valves because new ones are included in the diaphragm repair kit.
10. Carefully clean any debris on the silver plate by using alcohol or another solvent and a cotton swab. Clean the debris out of the holes as well. Set the silver plate aside.
11. Carefully lift the brown plate off and clean it thoroughly with alcohol or another solvent. Be careful not to get any debris into the holes.
12. If you are replacing the diaphragms, lift up the edges of the old diaphragm and unscrew it. Work carefully so that you do not lose the washers on the other side of the diaphragm. Install the new diaphragm using the original washers. If you are not replacing the diaphragms, thoroughly clean the diaphragm surface with alcohol without removing the diaphragm from the pump.
13. Put a small bead of Apiezon H Grease around the outer 2 mm of the diaphragm. Place the brown plate back onto the diaphragm in the original orientation.
14. Place the cleaned, or new, rubber flapper valves back onto the cleaned brown plate in the original location.
15. Put the four socket cap screws in the silver plate and lower it back onto the brown plate, using the screws to precisely align the parts. Verify that the rubber gaskets and O-ring still have a small amount of H Grease for sealing. However, make sure that the flapper valves do not have any grease on them; grease on the flapper valves will cause them to stick. Tighten down the four screws using a "round-robin" technique until the O-ring is compressed and the metal plates are held tightly together.
16. Lay the pump on its other side and repeat the above steps for the second head.

17. Reinstall either (*a*) the connecting bar or (*b*) the bellows hose on the top of the diaphragm pump-head assembly. *Your system has either the connecting bar or the bellows hose.*
    - To reinstall the connecting bar, tighten the banjo bolts to compress the O-rings as noted in step 5 (approximately 80 inch-pounds using a torque wrench). Use a small amount of H Grease on the O-rings. If you replaced the diaphragms, reinstall the cam cover first.
    - To reinstall the bellows hose, reconnect the VCO connector fittings at either end of the hose.
18. Reattach the VCO-type fittings that are on the flexible hoses to the manifold.

A P P E N D I X A

Installation Instructions

A.1 Introduction

This appendix contains the following information:

- Section A.2 explains how to install the Helium-3 option.

A.2 Installing the Helium-3 Option

These installation instructions assume that the High-Vacuum option (Model P640) is already installed in the PPMS unit. The High-Vacuum option must be installed before you can install the Helium-3 option. Refer to your high-vacuum option manual.

You must have the following tools to install the Helium-3 option:

☑ 9/64-inch hex wrench

☑ 3/16-inch nut driver

☑ 9/32-inch nut driver

☑ Philips and standard screwdrivers

A.2.1 Install the Software

To install the software, follow the printed instructions that are provided with the software disks. If no separate printed instructions are included, perform the following steps:

1. Install PPMS MultiVu. Do the following: (*a*) insert PPMS MultiVu Disk 1 into the PC, (*b*) select the `A:` drive, (*c*) run `setup.exe` from the installation disk, and then (*d*) follow the on-screen instructions.
2. Install the Helium-3 option software. Do the following: (*a*) insert Helium-3 Installation Disk 1 into the PC, (*b*) select the `A:` drive, (*c*) run `setup.exe` from the installation disk, and then (*d*) follow the on-screen instructions. Insert the configuration disk when you are prompted to do so.

   The Helium-3 software consists of the installation disk(s), which contain the program and utilities, and a disk containing the configuration files for the Helium-3 insert.

3. Install the Heat Capacity software, version 2.0 beta or later, if you will be using the Heat Capacity option (Model P650). Refer to the procedures in step 2.

A.2.2 Change the EPROMs

1. Back up the ROM configuration information by running the ROM configuration utility. Do the following: (*a*) double-click on the **PPMS 32-bit Tools** icon on the PC desktop, (*b*) run the Romcfg32 utility, (*c*) select the **Diag (all Configs including above)** check box, (*d*) select the **Read Configuration** button, (*e*) specify a file name for the configuration you are saving, and then (*f*) select **OK**.
2. Turn off power to the Model 6000 PPMS Controller.
3. Remove the power cord from the Model 6000.
4. Remove the lid from the PPMS electronics cabinet.
5. Remove the lid from the Model 6000.
6. Remove the two EPROMs from the CPU board. When you face the front of the electronics cabinet, the CPU board is the board located the furthest to the left.
7. Install the two new EPROMs provided with the option into the CPU board. The EPROMs are labeled "PPMS #1" and "PPMS #2." The CPU board is labeled to indicate the correct placement of the EPROMs. The notch in the EPROMs should line up with the notches in the sockets.

A.2.3 Install the Boards

1. Examine the board in the "P1–User Bridge" slot on the Model 6000. If the board does *not* have part number 3076-050, or if there is no board in the slot, install the user bridge board included with the Helium-3 option, and connect the ribbon cable.

   After you connect the ribbon cable, tuck it under the user bridge board in order to make room for the expansion circuit board.
2. Remove any connectors plugged into the "P8–Auxiliary" port, and then attach the aluminum splitter box (part number 4076-060-01) to the "P8–Auxiliary" port. Reattach the connectors you just removed.

NOTE

The remainder of the procedures in this section explain how to install the expansion circuit board (part number 3076-015). If the expansion circuit board is already installed in the lower right corner of the Model 6000, skip to Section A.2.4. A PPMS using the cryopump version of the High-Vacuum option should already include the expansion board.

3. Use a 9/32-inch nut driver to remove the CPU board from the Model 6000. Removing the CPU board exposes a large circuit board, called the motherboard.
4. Check for an installed chip in the U55 socket in the motherboard. If no chip is present, proceed to step 5. If a chip is present in the socket, its label should read "PPMS_SEL 2." If the revision <u>and</u> the "CKSUM" numbers are identical to those on the upgrade chip,[1] then you do not need to replace the chip that's already installed. If the revision or the "CKSUM" numbers are different, replace the chip in the motherboard with the upgrade chip.
5. Insert the PAL chip labeled "PPMS_SEL2" into the empty "U55" socket on the exposed circuit board. The notch on the PAL chip should line up with the notch in the socket.

---

[1] Included with the Helium-3 option.

6. Reinstall the CPU board.
7. Remove any board that is installed in the “P3–Option” slot on the Model 6000.
8. Install the expansion circuit board (part number 3076-015) as follows: (*a*) remove the nut and washer holding the lower right corner of the motherboard, (*b*) attach the standoff included with the Helium-3 option, (*c*) install the expansion board into the standoff, and (*d*) reinstall the washer and nut.

   If the standoff does not stand vertically, you may need to bend it to make it straight. The expansion circuit board will not fit unless the standoff is straight. The two connectors on the underside of the board should completely engage the connectors on the motherboard.

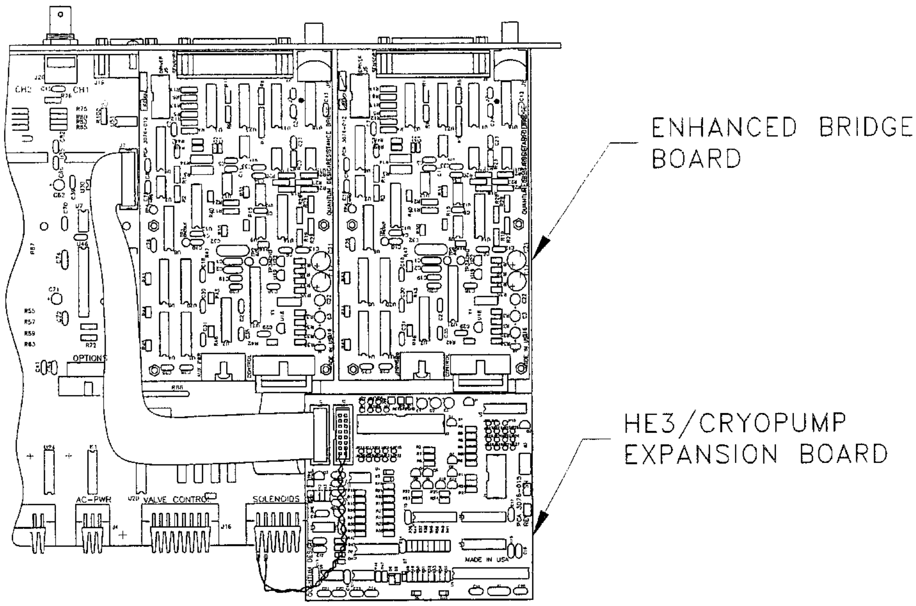


Figure A-1. Expansion Circuit Board and Enhanced User Bridge Board in Model 6000

8. Remove the 16-pin connector at the “J7-Aux-Spare” position on the motherboard and plug it into the “J2” connector on the expansion circuit board.

   A jumper connector is installed between the “J24-Solenoids” and “J7-Aux-Spare” positions on the motherboard only if the High-Vacuum option is already installed. The High-Vacuum option must be installed before you can install the Helium-3 option. For installation instructions, refer to your high-vacuum option manual.
9. Install the “Auxspare-to-Expansion Board” ribbon cable (part number 3076-018) between the “J1” connector on the expansion board and the “J7-Aux-Spare” connector on the motherboard. Do not let the ribbon cable touch the large resistors above the “Valve Control” connector; these resistors can get very hot. Try running the cable under the system bridge board.
10. Reinstall the board you removed from the “P3–Option” slot.

NOTE Perform the remainder of the procedures in this section only if the PPMS uses a turbo pump version of the High-Vacuum system. If the PPMS does not include a turbo pump, skip to Section A.2.4.

11. Remove the dongle connector labeled “P8–Auxiliary” from the “P8–Auxiliary” port on the Model 6000. This connector is a rectangular metal box with 25-pin connectors on each end.
12. Place the “P6–Dewar” sticker included with the Helium-3 option over the original sticker on the dongle connector.
13. Unscrew the connector from the “P6–Dewar” port on the Model 6000.

14. Plug the relabeled "P6–Dewar" dongle connector into the "P6–Dewar" port by inserting the dongle between the plug and the jack.

A.2.4 Power Up the Model 6000

1. Put the cover back on top of the Model 6000.
2. Reinsert the Model 6000 power cord.
3. Turn on the power to the Model 6000.
4. Run the ROM configuration utility, and send the previously backed-up ROM configuration to the Model 6000.
5. Set the system temperature to 300 K so that the PPMS sample chamber will be ready for the testing you will subsequently perform during the Helium-3 installation.

A.2.5 Place the Diaphragm Pump Assembly in the Cart

Caution! It is strongly recommended that at least two people handle the pump and probe assembly while completing the following procedure. The Helium-3 refrigerator probe is very fragile. The thin wall of the probe shaft can be easily dented or bent, and the turbo pump mounted on the shaft is very sensitive to mechanical shocks. The diaphragm pump assembly contains many gas-tight seals that could be compromised if the diaphragm pump is dropped or handled roughly.

1. Remove the diaphragm pump assembly and the attached Helium-3 insert from the packing crate.
2. Verify that the power selector on the diaphragm pump assembly is set to the proper line voltage (for example, 110 V or 220 V). To set the voltage, remove the fuse holder and change the selector. The fuse holder is part of the power connect located on the tank end of the controller.
3. Lay the Helium-3 insert on the floor or have someone hold it.
4. Carefully lift up the diaphragm pump assembly. Reattach any electrical connectors that were unplugged for shipping.
5. Carefully place the diaphragm pump assembly at the back of the open cabinet area in the Helium-3 cart. Position the tank so that its four rubber feet fit into the four holes in the floor of the cabinet. Refer to Figure A-2 on the following page. Work with extreme care to avoid torquing, crimping, or loosening any of the attached hoses.

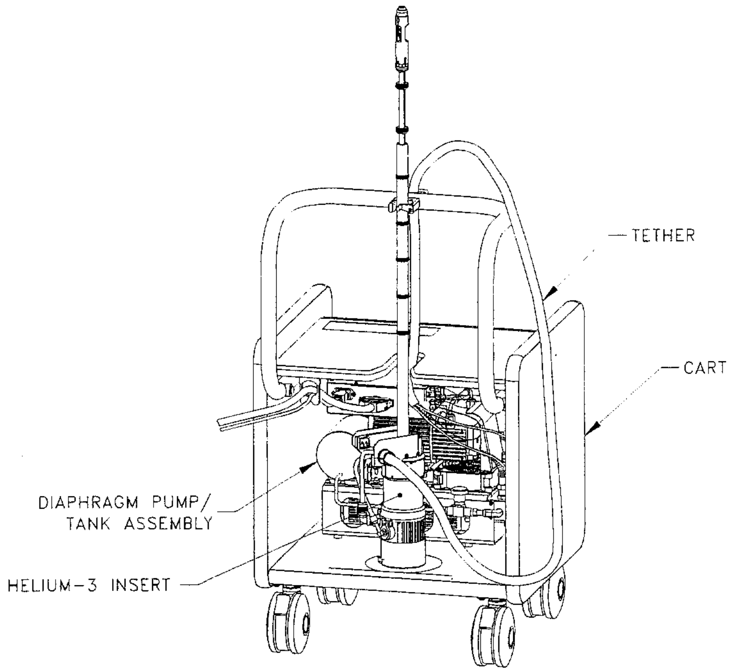


Figure A-2. Helium-3 Cart Assembly

6. Attach the tether, which is the black cable running between the diaphragm pump assembly and the probe, to the handle of the cart by using the strain-relief clamp located on the back side of the cart handle. To do this, you must pass the probe under the handle so that the tether can run directly up to the clamp from inside the cart. Use the provided 9/64-inch hex wrench to tighten the clamp.
7. Orient the refrigerator probe so that the turbo pump is at the bottom and the probe shaft is at the top. Place the refrigerator probe in the holder in the Helium-3 cart. The turbo pump should rest on the rubber mat that is on the floor of the cabinet area. Close the safety latch on the cart.
8. Store the pump-out hose (part number 4092-630) inside the cart by hanging it from the cable hanger located on the right side next to where the handle is attached.
9. Place the step stool included with the Helium-3 option at the base of the PPMS dewar.

A.2.6 Connect the Cables

1. Connect the Helium-3 power cable (part number 3092-401) between the power connector on the diaphragm pump assembly and the power connector in the back of the PPMS electronics cabinet or to another power supply.
2. Connect the large connector on the black control cable (part number 3092-355) to the mating connector on the diaphragm pump connector. Connect the 25-pin connector to the splitter on the "P8–Auxiliary" connector at the back of the Model 6000. Connect the 9-pin serial cable connector to the COM1 port on the back of the computer.
3. Use the cable hanger located inside the Helium-3 cart on the left-hand side to hold both the control cable and the power cable.

A.2.7 Adjust the Helium-3 Insert for the Sample Chamber Orientation

Before the Helium-3 insert can be used, it must be adjusted so that it fits the specific PPMS sample chamber. The first adjustment is setting the orientation of the electrical connector at the bottom of the probe to match the orientation of the mating connector in the sample chamber.

Complete the following steps to verify or set the connector orientation:

1. Verify that the sample chamber temperature is 300 K and that the chamber is venting continuously.
2. Connect the user bridge cable with the gray Lemo connector between the "P1–User Bridge" port on the back panel of the Model 6000 and the gray color-coded connector at the head of the PPMS dewar. The user bridge cable will be used to read the Helium-3 thermometer.
3. Start up the PPMS MultiVu software.
4. Select **Instrument➤Bridge Channels** in PPMS MultiVu. Turn on bridge channel 3. Keep the **Bridge Channels** dialog box open.

Caution! Avoid stressing the shaft of the refrigerator probe in any way while you are installing the Helium-3 insert into or removing it from the sample chamber. The material out of which the shaft is constructed is thin and fragile and can easily bend or dent.

5. Test the orientation of the electrical connector at the bottom of the refrigerator probe as follows: (*a*) insert the refrigerator probe into the sample chamber and (*b*) monitor the resistance on user bridge channel 3. If the resistance on channel 3 is a consistent value between 30 and 60 ohms, the connector does not require adjustment. You may skip the following step. If the resistance is not a valid value, the connector must be adjusted by continuing with the next step.
6. Adjust the electrical connector at the bottom of the refrigerator probe if necessary. Do the following:
   a. Remove the Helium-3 insert from the sample chamber.
   b. Use a flashlight to look into the sample chamber. Note the orientation of the keyway at the bottom of the chamber. The keyway should face directly toward the front of the PPMS dewar. The front of the dewar faces away from all electrical connectors and hoses on the probe head. If the keyway does not face the front of the dewar, you must adjust the electrical connector on the refrigerator probe so that the connectors on the probe and in the sample chamber line up.
   c. Use the smallest hex wrench included with the Helium-3 kit to loosen the three set screws inserted in the holes closest to the electrical connector on the refrigerator probe. Gently twist the electrical connector the correct amount in the correct direction so that it will line up with the connector in the sample chamber. Then retighten the set screws.

Warning! Do not twist the electrical connector on the refrigerator probe more than a few degrees. Twisting the connector more than a few degrees will permanently damage the wiring assembly. Using any appreciable force to twist the connector should be unnecessary.

   d. Test the orientation of the electrical connector by inserting the refrigerator probe into the sample chamber and monitoring the resistance on user bridge channel 3. Refer to step 5.

A.2.8 Cryoclean the Helium-3 Gas

The 3He gas often becomes somewhat contaminated during shipment of the Helium-3 system. Therefore, you should cryoclean the gas before attempting to use the system. Follow the procedure "Cryocleaning the Helium-3 Gas Using the LN2 Cold Trap" (Section 5.3.1).

A.2.9 Test the Helium-3 System

1. Put a film of Apiezon N Grease on the contact fingers on the sample housing tube.
2. Insert the refrigerator probe into the sample chamber. You should feel resistance to the insertion of the probe in the bottom 4–5 cm. It should be enough to just support the weight of the probe.
3. Once the O-ring is firmly seated, purge the sample chamber.
4. Start the Helium-3 software from the Windows **Start** menu. The Helium-3 software enters a standby state.
5. Use the Model 6000 front panel or PPMS MultiVu to set a temperature of 1 K. Setting this first temperature causes the Helium-3 program to perform a self-check before proceeding down to 1 K. Depending on the probe, it takes from 2 to 3 hours to reach this temperature.

   Once the system reaches 1 K, it should remain stable at that temperature and the Helium-3 software should indicate that it is in the He3 circulating state.
6. Verify that the system holds 1 K adequately. Then enter a set point of 0.31 to determine the base temperature of the instrument. It usually takes less than 30 minutes to reach the base temperature below 0.4 K. The status display in the Helium-3 option control console indicates it is in the "circulating" mode until the pot is filled, and then it enters the "one-shot" mode where it will reach the ultimate base temperature.

NOTE

If the system does not cool to below about 1.7 K, the system may be plugged and should be cryocleaned to remove contamination. Cryocleaning the system is a routine procedure described in Section 5.3.1. You may start the procedure with the system already cold and the insert installed.

APPENDIX B

Pin Description and Wiring Diagrams

B.1 Introduction

This appendix contains the following information:

- Section B.2 illustrates the Helium-3 system connections.
- Section B.3 contains the Helium-3 system pinout tables.

B.2 System Connections

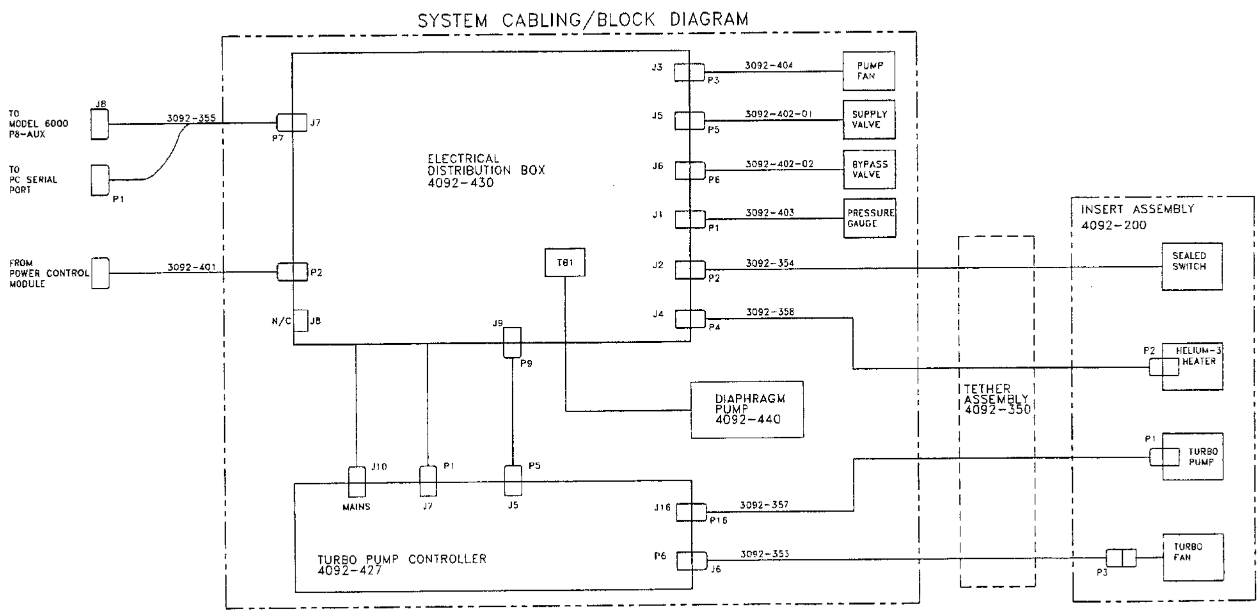


Figure B-1. System Cabling/Block Diagram

B.3 Pinout Tables

Table B-1. Interconnection Table for Helium-3 Interface Cable (Part Number 3092-355)

25-PIN/COAX D-SHELL CONNECTOR AT P7 ON DIAPHRAGM PUMP ASSEMBLY	DB-9 SERIAL PORT CONNECTOR AT P1 ON COMPUTER	DB-25 AUX. PORT CONNECTOR AT J8 ON MODEL 6000	DESCRIPTION
1	1	No connection	
2	2	No connection	Serial port RXD
3	3	No connection	Serial port TXD
4	4	No connection	Serial port DTR
5	5	No connection	Serial port ground
14	6	No connection	Serial port DSR
15	7	No connection	Serial port RTS
16	8	No connection	Serial port CTS
17	9	No connection	
18	Drain	No connection	Serial cable shield
10	No connection	4	+15 V pressure gauge supply
23	No connection	5	Pressure gauge/sealed switch common
11	No connection	9	Pressure gauge readback voltage
24	No connection	22	Probe-sealed switch signal
13	No connection	10	Supply solenoid driver
12	No connection	11	Bypass solenoid driver
9	No connection	No connection	
25	No connection	23	Solenoid driver return
22	No connection	13	Helium-3 control wiring shield
A1–center	No connection	21	Helium-3 heater
A1–shield	No connection	No connection	Helium-3 heater coax shield

Table B-2. Pin Mapping for Helium-3 Thermometer Wiring with the User Bridge Cable

HELIUM-3 PROBE CONNECTOR	GRAY LEMO CONNECTOR ON PROBE HEAD	P1-USER BRIDGE (25-PIN D SHELL)	FUNCTION
3	3	5	User/resist ch1 I+
4	4	18	User/resist ch1 I–
5	5	6	User/resist ch1 V+
6	6	19	User/resist ch1 V–
7	7	7	User/resist ch2 I+
8	8	20	User/resist ch2 I–
9	9	8	User/resist ch2 V+
10	10	21	User/resist ch2 V–
11	11	9	Helium-3 therm I+
12	12	22	Helium-3 therm I–
13	13	10	Helium-3 therm V+
14	14	23	Helium-3 therm V–

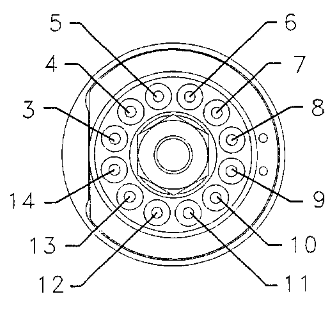


Figure B-2. Bottom View of Probe Connector

References

Quantum Design. 2000. *Physical Property Measurement System: AC Transport Option User's Manual.*

———. 2000. *Physical Property Measurement System: Heat Capacity Option User's Manual.*

———. 1999. *Physical Property Measurement System: Resistivity Option User's Manual.*

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Quantum Design

Physical Property Measurement System

EverCool Dewar Option User's Manual

Part Number 1099-100, B-0

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Trademarks

U.S. Patents

4,791,788	Method for Obtaining Improved Temperature Regulation When Using Liquid Helium Cooling
4,848,093	Apparatus and Method for Regulating Temperature in a Cryogenic Test Chamber
5,311,125	Magnetic Property Characterization System Employing a Single Sensing Coil Arrangement to Measure AC Susceptibility and DC Moment of a Sample (patent licensed from Lakeshore)
5,647,228	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber
5,798,641	Torque Magnetometer Utilizing Integrated Piezoresistive Levers

Foreign Patents

U.K.	9713380.5	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber

Safety Instructions

No operator-serviceable parts are inside. Refer servicing to qualified personnel.	For continued protection against fire hazard, replace fuses only with same type and rating of fuses for selected line voltage.

Observe the following safety guidelines when you use your system:

- To avoid damaging the system, verify that the system power requirements match the alternating current (AC) power available at your location. If the system has not been configured for the correct power available at your location, contact your local service representative before you proceed with the system installation.
- To prevent electrical shock, verify that the equipment is properly grounded with three-wire grounded plugs.
- To prevent electrical shock, unplug the system before you install it, adjust it, or service it.
- Do not spill food or liquids on the system or its cables.
- Refer to the section titled "Safety Precautions" before you install or operate this system. Direct contact with cryogenic liquids, materials recently removed from cryogenic liquids, or exposure to the boil-off gas, can freeze skin or eyes almost instantly, causing serious injuries similar to frostbite or burns.
- Wear protective gear, including clothing, insulated gloves, and safety eye protection, when you handle cryogenic liquids.
- Transfer liquid helium only in areas that have adequate ventilation and a supply of fresh air. Helium gas can displace the air in a confined space or room, resulting in asphyxiation, dizziness, unconsciousness, or death.
- Keep this system away from radiators and heat sources. Provide adequate ventilation to allow for cooling around the cabinet and computer equipment.
- Refer to the manuals for the supplied computer and monitor for additional safety warnings and notices before you operate the system.

Regulatory Information

- This apparatus has been tested to the requirements of the EMC Directive 89/336/EEC.
- This apparatus is defined as ISM Group 1, Class A and B equipment per EN 50011:1991 (industrial and light industrial environment limits of radio frequency emission).
- This apparatus has been tested to the requirement of the Low Voltage Directive 73/23/EEC.
- See the EU Declaration of Conformity for additional regulatory information regarding your PPMS.

C O N T E N T S

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Contents and Conventions

P.1 Introduction

- Section P.2 discusses the overall scope of the manual.
- Section P.3 briefly summarizes the contents of the manual.
- Section P.4 illustrates and describes conventions that appear in the manual.

P.2 Scope of the Manual

This manual explains how to use the Quantum Design PPMS EverCool Dewar option software and hardware, start up the EverCool system, and perform basic system maintenance and troubleshooting.

P.3 Contents of the Manual

- Chapter 1 introduces the EverCool option and describes the system hardware.
- Chapter 2 explains how to start up the EverCool system.
- Chapter 3 explains how to perform basic and advanced EverCool system operations.
- Chapter 4 describes maintenance and troubleshooting procedures.
- Appendix A discusses and illustrates the electrical connections and ports.
- Appendix B discusses the function of the `Evercool.ini` file.

P.4 Conventions in the Manual

File menu	**Bold** text distinguishes the names of menus, options, buttons, and panels appearing on the PC monitor or on the Model 6000 PPMS Controller LCD screen.
File >> **Open**	The >> symbol indicates that you select multiple, nested software options.
`.dat`	The `Courier` font distinguishes characters you enter from the PC keyboard or from the Model 6000 PPMS Controller front panel. The `Courier` font also distinguishes code and the names of files and directories.
Alt+Enter	A plus sign + connecting the names of two or more keys distinguishes keys you press simultaneously.
Important	Text is set off in this manner to signal essential information that is directly related to the completion of a task.
Note	Text is set off in this manner to signal supplementary information about the current task; the information may primarily apply in special circumstances.

C A U T I O N !

Text is set off in this manner to signal conditions that could result in loss of information or damage to equipment.

W A R N I N G !

Text is set off in this manner to signal conditions that could result in bodily harm or loss of life.

W A R N I N G !

Text is set off in this manner to signal electrical hazards that could result in bodily harm or loss of life.

C H A P T E R 1

Introduction to the EverCool Option

1.1 Introduction

- Section 1.2 presents an overview of the operation of the EverCool option.
- Section 1.3 discusses safety precautions when using the PPMS EverCool system. .
- Section 1.4 discusses the EverCool hardware.
- Section 1.5 provides contact information for Quantum Design.

1.2 Theory of Operation

The Quantum Design PPMS EverCool Dewar option allows continuous operation of the Quantum Design Physical Property Measurement System (PPMS) without having to transfer liquid helium. The EverCool option features an integrated cryocooler–dewar system that recondenses and liquefies gaseous helium directly within the EverCool dewar.

In the Quantum Design PPMS EverCool system, cold helium gas is recondensed at a low temperature before it leaves the dewar, making it much more efficient in power consumption and cooling requirements than helium-liquefying systems that recover the helium gas at room temperature. The PPMS plumbing is modified to route the helium that cools the sample chamber back into the dewar where it is recondensed.

A helium-gas supply cylinder is attached to the PPMS EverCool system to replenish any that is lost during normal system operation. (Operations that can cause some helium loss include rapid cooling of the sample chamber and frequent, prolonged use of the magnet.) The system always keeps the dewar above atmospheric pressure to prevent air from leaking into the dewar. Running the cold head at less than 100% of the duty cycle reduces wear on the seals of the cold head. The duty cycle varies according to system operations, but in a static system (when the PPMS is in **Shutdown** mode), the typical duty cycle is approximately 60%.

You will use the same procedures for measuring sample properties with the PPMS EverCool Dewar option as with other PPMS options. The EverCool dewar does not affect most system operations. All EverCool functions are integrated into the PPMS MultiVu software application, and most EverCool system operations can be automated, including control of the helium level in the dewar. However, note that the operation of the cold head can introduce noise (vibration or electromagnetic) into some measurements. You can prevent vibrations by using stabilization techniques and you can eliminate the electromagnetic noise by briefly pausing operation of the cold head.

Important: To prevent a magnet quench, do not drive a magnet to maximum field under extreme or unusual conditions (e.g., dewar pressures above 20 kPa). Although normal dewar pressures are 1.0–2.0 psi (7.0–14.0 kPa) and the control software vents the sample chamber to help prevent high-pressure conditions, the pressure might rise as high as 6 psi (42 kPa) under extreme operating conditions.

CAUTION!

Do not charge a magnet to full field when dewar pressures are high (above 20 kPa), because the magnet might quench. At high dewar pressures, magnets are more likely to quench when they are driven to maximum field.

1.3 Safety Precautions

WARNING!

The EverCool option is used in conjunction with the Physical Property Measurement System (PPMS), so you should be aware of the safety considerations for all the equipment. PPMS-related safety precautions include those for the use of superconducting magnets and electricity, as is reviewed below. For more information on safety, refer to the *Physical Property Measurement System: Hardware Manual*.

For basic personal safety, it is important that PPMS users understand and follow the precautions that are given throughout this manual. Above all, Quantum Design and its staff ask that you use standard safe laboratory procedures.

- Use common sense.
- Attend to the state of the system and to your surroundings.
- If the system appears to be behaving abnormally, investigate to see if there is a malfunction and take the appropriate action (e.g., troubleshoot, shut down the system, contact Quantum Design).
- Supervise inexperienced users and train them in general electrical safety procedures.

The EverCool dewar and PPMS have safety features to prevent accidents from causing injury or serious equipment damage. *If you use the equipment in a manner that is not specified by Quantum Design, the protection afforded by the equipment may be impaired.*

1.3.1 Cryogens

WARNING!

Always wear protective clothing and ensure that the room has good ventilation when you work with cryogenic materials such as liquid helium and liquid nitrogen. These precautions will protect you against cryogenic material hazards: (1) they can expand explosively when exposed to room temperature; (2) they can cause serious burns.

The PPMS EverCool option uses a cryogenic liquid (liquid helium) for temperature control. Cryogens can burn skin on contact, and they expand rapidly when warmed. The following precautions are specific to the safety of personnel who work with and around cryogens.

1.3.1.1 PROTECTIVE GEAR

- Always wear protective clothing such as thermal gloves, eye goggles, and covered shoes when working with liquid helium or any other cryogen.
- Avoid loose clothing or loose fitting gloves that could collect cryogenic liquids next to the skin.

  The extreme cold of liquid and gaseous cryogens can cause serious burns and has the potential to cause the loss of limbs. Your skin will freeze almost instantly if it directly contacts cryogens. Such contact can occur when the cryogens are on surfaces, in materials just removed from the helium bath, or in high boil-off gas flows.

1.3.1.2 VENTILATION

- Always work in a well-ventilated area when you are using liquid helium—in the gaseous state, it will displace oxygen from the air. This can lead to asphyxiation if enough helium is vented in an enclosed space.
- Vent the room immediately and evacuate all personnel if the EverCool dewar ruptures or spills cryogenic materials.

1.3.1.3 PRESSURE-RELIEF VALVES

- ***Do not*** change, tamper with, or disable the relief valves, unless you are following specific instructions from this manual or from your Quantum Design representative. The Quantum Design helium dewars have relief valves and burst disks to provide safe operation in the event there is a leak into any of the insulating vacuum spaces or the superconducting magnet quenches.

1.3.1.4 POSITIVE PRESSURE

- Always maintain a positive pressure within any container that stores liquid helium and keep all ports and openings (except proper relief valves) closed, unless you require immediate access to the helium.

Liquid helium is a very effective cryopump because it is the coldest liquid that will exist at atmospheric pressure. Left in a vessel that is open to the atmosphere, it will rapidly condense and solidify gases from the air. Ice formed in the EverCool dewar will plug pressure-relief passages, transfer ports, and other components of the gas-handling system. Furthermore, high pressure develops quickly within the container because helium gas is constantly evaporating from the surface of the liquid helium.

1.3.1.5 WORK AREAS

- Keep exposed work areas clean and free of spontaneously combustible materials such as oil or grease. When cryogens contact spontaneously combustible materials, the materials can ignite.

  When helium-cooled surfaces are exposed to the atmosphere, they can attract and condense air. Because it has a lower boiling point than oxygen, nitrogen gas will evaporate from the air first, leaving an oxygen-enriched residue that can flow onto surrounding surfaces.

1.3.2 Magnets

WARNING!

Any person who wears a pacemaker, electrical medical device, or metallic implant must stay at least 5 m (16.5 ft.)[1] from the PPMS dewar. In addition, personnel should keep all ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar.

The following precautions should be followed to ensure the safety of personnel who work with or around a PPMS with a superconducting magnet. This material is covered in more depth in Chapter 1 of the *Physical Property Measurement System: Hardware Manual.*

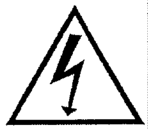
- Verify that any person who has a metallic implant or is wearing a pacemaker or electrical or mechanical medical device stays at least 5 m (16.5 ft.) from the PPMS dewar. Large magnetic fields are dangerous to anyone who has a metallic implant or is wearing a pacemaker or other electrical or mechanical medical device.

  Important: Safety considerations must include adjacent spaces (e.g., nearby walls, the ceiling, and the floor), because the three-dimensional magnetic field of the PPMS superconducting magnets will penetrate these areas. Furthermore, the automated control system of the PPMS can turn on the magnet while the system is unattended.

- Keep all iron, nickel, and other ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar. Large magnets, such as the PPMS superconducting magnets, can attract iron and other ferromagnetic materials with great force. The observable effects of magnetic fields are listed in Chapter 1 of the *Physical Property Measurement System: Hardware Manual.*

[1] At the current time (August 2004), 5 m should be a large enough distance to protect wearers of metallic implants or medical devices from most magnetic fields produced by Quantum Design magnets. However, the safe distance from newer magnets (in development) could be greater. Hence, personnel who work with and around the superconducting magnets should review thoroughly documentation for new equipment.

1.3.3 Electricity



WARNING!

The PPMS is powered by nominal voltages between 100 V to 240 V AC. These voltages are potentially lethal, so you should exercise appropriate care before opening any of the electronics units, including turning off the equipment and disconnecting it from its power source.

- Turn off and unplug all electronic equipment before removing any equipment covers.
- Keep electrical cords in good working condition and replace frayed and damaged cords.
- Keep liquids away from the workstations.

1.4 System Hardware

Figure 1-1 shows a cross section of the EverCool dewar and the major components of the EverCool option, which are described in the following sections.

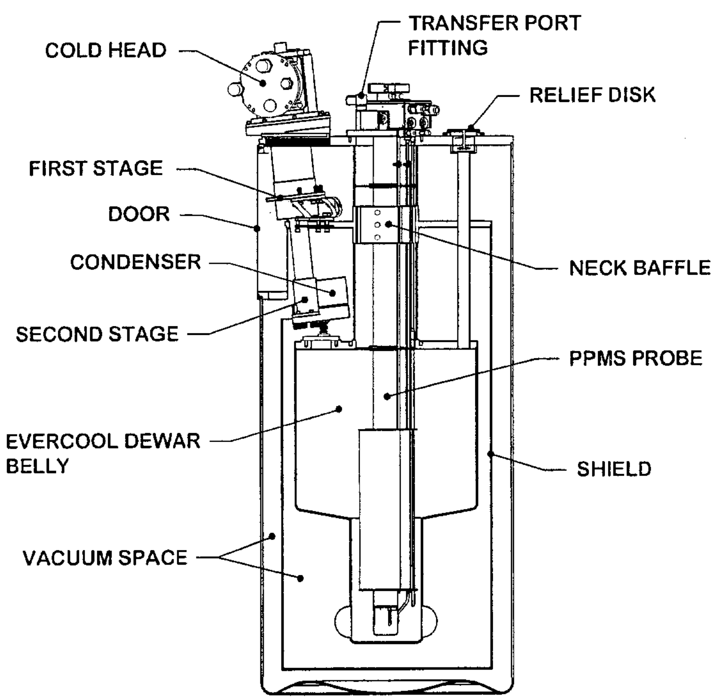


Figure 1-1. Cross-section view of EverCool Dewar, cold head, and condenser

1.4.1 EverCool Dewar and Cryocooler System

The EverCool dewar virtually eliminates helium loss and allows the PPMS cryosystem to re-liquefy helium gas. The dewar is connected to an external helium-gas supply cylinder that the system uses to automatically replenish any helium gas that is lost during operations (e.g., during purging and sealing the sample chamber). The EverCool software is coordinated with system operations so that the level of liquid helium in the dewar belly remains nearly constant. With the PPMS EverCool system, you can maintain optimal helium levels by simply exchanging the helium-gas supply cylinder when it is empty.

A dewar shield protects the dewar belly from thermal radiation. The bottom of the helium tank in the EverCool dewar allows the helium level to rise more quickly during initial system cool down. The dewar–cryocooler system operates continuously between regularly scheduled system maintenance cycles, which are required only about every 20,000 hours.

A small door on the side of the EverCool dewar allows access to the condenser and the first stage on the cold head in the dewar vacuum space. This door must never be opened under normal operating circumstances. The dewar door and the valve next to it are only for the use of service personnel. *Never remove the screws holding this door to the dewar, never open this door, and never turn this valve.* A Lemo connector port in the door is used to attach a cable for reading diagnostic thermometers. This connector port must be used with care—damage to the port or the O-ring seals inside it can ruin the vacuum seal of the dewar.

WARNING!

- ***Never*** tamper with the door on the EverCool dewar or the valve next to the door. You might cause a rapid loss of vacuum in the dewar, leading to a rapid helium loss and possibly to asphyxiation. A rapid loss of vacuum in the dewar also can generate explosive pressures inside the dewar.
- ***Never*** tamper with, disable, or place weight on the relief disk located on top of the dewar. For safe operation of the EverCool, the relief disk must be able to relieve the pressure in the dewar at its normal set point.
- ***Immediately*** contact your Quantum Design service representative if the EverCool ***ever*** stops liquefying helium properly, and no appreciable helium escapes if you gently open the relief disk.

For more information on safety precautions, see Chapter 1 of the *PPMS Hardware Manual*.

The EverCool system is designed to operate continuously between compressor-maintenance cycles, which should be regularly scheduled for every 20,000 operating hours. A timer is located on the front of the compressor to help you track when you will need to schedule equipment maintenance. It is important to adhere to the maintenance schedule, and to facilitate this, we have provided a maintenance log in Chapter 4.

The cryocooler system can be seriously damaged if the required servicing is not performed. Other system components also should be serviced at the same time as the compressor. For example, the cold head will operate at optimal efficiency for at least 10,000 hours, but because it has a reduced duty cycle, it will require servicing at about the same time as the compressor, which operates continuously.

Important: Only qualified Sumitomo or Quantum Design personnel should perform maintenance work on the cryocooler. Contact your Quantum Design service representative to schedule maintenance on the cryocooler.

CAUTION!

To avoid serious damage to the cryocooler system it is critical to service the compressor after every 20,000 hours of operation.

Only qualified Sumitomo or Quantum Design personnel should perform maintenance work on the cryocooler. Contact your Quantum Design service representative to schedule maintenance on the cryocooler.

1.4.1.1 CONDENSER

The condenser liquefies the helium gas in the EverCool dewar belly. The body of the condenser is constructed out of high-conductivity, oxygen-free copper to maximize thermal conduction. Special flexible bellows attach the condenser to the dewar belly. As shown in Figure 1-1, the condenser is attached to the second stage of the cold head. The system uses a diagnostic thermometer on the condenser to monitor its temperature.

1.4.1.2 CRYOCOOLER

The cryocooler unit consists of the cold head and the compressor. It is a closed-cycle, Gifford-McMahon style cryo-refrigerator that uses high-pressure helium as the working gas. The cold head cools the condenser and the dewar shield, and the compressor drives the cold head.[2] Quantum Design designed a bypass unit that can interrupt cold-head operations without affecting compressor operations. The cold head vibrates while running, which can cause acoustic noise in the dewar. To dampen the vibrations, the cold head is supported by an attenuation flange with a rubber mat. In most cases, the acoustic noise in the dewar is not visible in PPMS measurements.

The cold head includes two stages that supply cooling power. The first stage supplies approximately 30 W of cooling power at approximately 45 K. The second stage supplies 1.5 W of cooling power at 4.2 K. A diagnostic thermometer on the second stage monitors the temperature of the second stage while the cold head is running.

The pressure of the helium gas in the EverCool dewar determines the normal operation cycle, or duty cycle, of the cold head. When the helium-gas pressure reaches a high enough level, the system turns on the cold head, and when the pressure is low enough, the system turns off the cold head. The minimum and maximum pressure limits that affect the cold head are factory-set calibration values. Generally, when the system uses the default pressure limits, the cold head is on for approximately 10 minutes and off for approximately 6 minutes.

The compressor provides power and high-pressure, 16-bar helium gas to the cold head. The helium gas in the cryocooler does not mix with the helium in the EverCool dewar. When the cold head is off, a bypass valve on the compressor unit opens to shunt the flow of high-pressure helium around the cold head.

[2] The cold head and compressor are components of the SRDK-415 Cryocooler manufactured by Sumitomo Heavy Industries. The *Operation Manual* written by Sumitomo Heavy Industries describes the operation and maintenance of the cold head and compressor in detail.

Important: Remember that the compressor and related parts require critical maintenance after approximately 20,000 hours of normal operation. If you see reduced cold-head performance before that time, check the timer on the bypass unit to see if the cold head has operated more than 10,000 hours. Symptoms of cold-head breakdown include a deterioration of the seal, increased noise during operation, longer times to liquefy helium, or difficulty maintaining a constant level of liquid helium.

1.4.1.3 HIGH-TEMPERATURE SUPERCONDUCTING (HTS) MAGNET LEADS

The PPMS EverCool option includes a lead upgrade for systems with magnets, making it possible for you to charge the magnet without losing helium. With these high-temperature superconduction (HTS) leads, the dewar will lose less helium when you drive the magnet at full field, provided that you do not simultaneously cool the sample chamber.

1.4.1.4 NECK BAFFLE

The neck baffle attached to the PPMS probe helps prevent convection in the neck of the EverCool dewar and removes impurities from the helium-gas recirculation circuit. The closeness of the neck baffle and dewar shield creates a thermally shielded environment, which is especially important for helium liquefaction during the initial cool down of the system.

The neck baffle has charcoal-filtering conduits that are directly in the helium-gas flow in the neck of the EverCool dewar. As the helium gas recirculates, the charcoal traps impurities that might plug the impedance or the condenser and prevent helium-gas liquefaction. The temperature of the neck baffle is approximately 45 K so that the purifying power of the charcoal is activated.

If you feel any resistance when you are trying to remove the PPMS probe from the EverCool dewar, immediately stop pulling on it. Resistance probably indicates that ice has formed inside the dewar neck and the neck baffle is stuck, so forcing the probe out of the dewar could damage components on the probe. Warm the system to room temperature before you continue attempts to remove the probe.

CAUTION!

Do not remove the PPMS probe from the EverCool dewar if you feel resistance when you first pull on it, because resistance suggests ice has formed inside the dewar or around the probe. Warm up the system to room temperature before you try to remove the probe again.

1.4.1.5 TRANSFER-PORT FITTINGS

For the EverCool Dewar option, two new fittings (the transfer-port fittings[3]) are installed in the transfer ports on the top of the dewar (Figure 1-2). These fittings allow helium to escape from the dewar in the event there is a leak and ice collects in its neck.

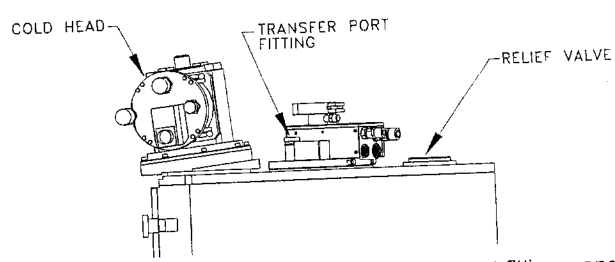
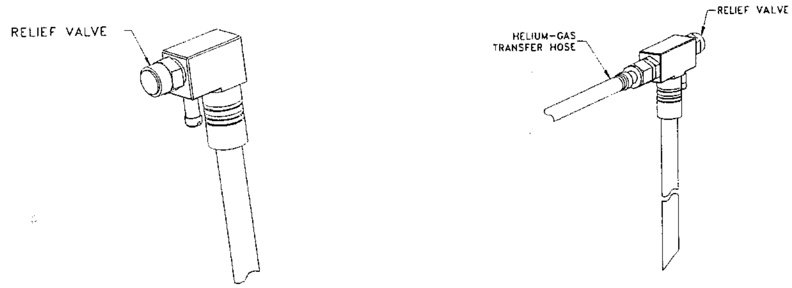


Figure 1-2. Top of EverCool dewar, transfer-port fittings, and relief valve

[3] The transfer-port fitting is also referred to as the fill-arm fitting.

Because the pressure in the dewar is greater than atmospheric pressure, the fittings are locked in place by a latch. Each fitting has a relief valve that is critical for proper operations. ***Do not*** tamper with or disable the relief valves on the transfer-port fittings.

Figures 1-3A and 1-3B show the two types of transfer-port fittings. Type 1 fittings only have a relief valve, but Type 2 fittings have a relief valve and an opening for the helium-gas transfer hose.



A. Type 1 transfer-port fitting: relief valve only

B. Type 2 transfer-port fitting: relief valve and opening for the helium-gas transfer hose

Figure 1-3. Two types of transfer-port (fill-arm) fittings used on the PPMS EverCool system

At various times you will remove a transfer-port fitting in order to perform a task. For example, during the initial cool-down of the system, you will briefly replace one of the transfer-port fittings with the liquid-helium transfer line.

Important: ***Always bleed off excess dewar pressure*** at the relief valve of a transfer-port (fill-arm) fitting to lower the pressure below 2.2 psi (15 kPa) before you remove a fitting. Use a small blunt object (e.g., a fingernail or the round end of a paper clip) to hold open the relief valve.

Because the transfer-port fittings are extremely cold, moisture from the air will condense on them. To avoid introducing water into the system, dry off the transfer-port fitting before you insert it back into the EverCool dewar.

WARNING!

Always bleed off excess dewar pressure at the relief valve of a transfer-port fitting before removing it. ***Do not*** tamper with or disable the relief valve on the transfer-port fitting.

1.4.1.6 DIAGNOSTIC THERMOMETERS

The EverCool dewar has two thermometers that you will read only for diagnostic purposes. One of the thermometers monitors the temperature of the second stage while the cold head is running, the other monitors the temperature of the condenser. Channels 1 and 3 on the Model 6000 user-bridge board read these thermometers over the standard user-bridge cable. Section 3.3.5 has further instructions for reading the diagnostic thermometers, including the related PPMS MultiVu software commands.

When the system has been cold for more than 15 hours, typical readings for the second-stage thermometer are 4.0–4.2 K, but typical readings for the condenser thermometer are 4.4–4.6 K. In the event temperatures deviate significantly from the typical values, it indicates that the condenser is plugged, the cryocooler system has a leak, or the cold-head motor or seals require maintenance.

Note: The only way to clear a plugged condenser is to warm the entire dewar to room temperature. Condensers become plugged when contaminants reach the dewar belly.

1.4.2 Helium-Gas Supply Cylinder

The PPMS EverCool system uses a helium-gas supply cylinder to provide helium gas to the EverCool dewar in the event that the liquid-helium level in the dewar gets low. Typically, the EverCool system requires standard high purity (99.995%) helium gas. The rate that helium is consumed from the supply cylinder during normal operation depends on your use of the system—with typical usage, you might require a new cylinder every 1–2 months.

1.4.3 EverCool Controller Card

The EverCool controller card resides in the Model 6000 P3–Option port. This card monitors the dewar pressure sensor and turns the cold head on-and-off based on the dewar pressure. It also coordinates the various valve states that control the flow of helium into, out of, and through the EverCool system.

1.4.4 Gas-Handling System

The EverCool gas-handling system has two pumps so that the sample-space pumping circuit and cooling-annulus pumping circuit are independent and air is kept from the helium-gas recirculation system. Unlike systems that use regular PPMS dewars, EverCool systems have a diaphragm pump that controls the sample-space pumping and a scroll pump that controls only the cooling-annulus pumping. The manifold of the diaphragm pump (see Figure 1-7A) creates leak-tight gas connections for recirculating the helium gas from the EverCool dewar and scroll pump. The Model 6000 PPMS controller has been modified to accommodate the EverCool gas-handling capabilities, but the internal plumbing of the Model 6000 has not been changed. Figures 1-4 and 1-5 illustrate schematics of the EverCool gas-handling system with and without the Turbo Pump High-Vacuum system.

The Model 6000 automates operation of the valves on the manifold. During normal operating conditions, the recirculation valve (SV1) is open and the vent valve (SV2) is closed so that the exhaust of the scroll pump is directed back into the dewar. This is called the **recirculating** state. Occasionally the pump exhaust is allowed to escape to the atmosphere by closing the recirculation valve and opening the vent valve (e.g., during the initial cool down of the system). This is called the **pump-exhausting** state. (You can monitor the helium flow through the cooling annulus by connecting the Dwyer ball gauges to the output of the vent valve.)

When helium levels are being automatically controlled, the Model 6000 opens the helium-supply valve (SV4) for the helium transfer and closes it when the helium level reaches the specified maximum. When the supply valve is open, the EverCool system is in a **filling** state. The system uses the pumpout valve (SV3) to pump air out of the dewar only during the pumpout and backfill procedure that is part of the initial system start up. At all other times the pumpout valve should remain closed. Table 3-1 summarizes all the valve states.

CAUTION!

The pumpout valve (SV3) is open only during the pumpout and backfill procedure that is part of the initial system start up. The pumpout valve should never be open when there is liquid helium in the belly of the EverCool dewar.

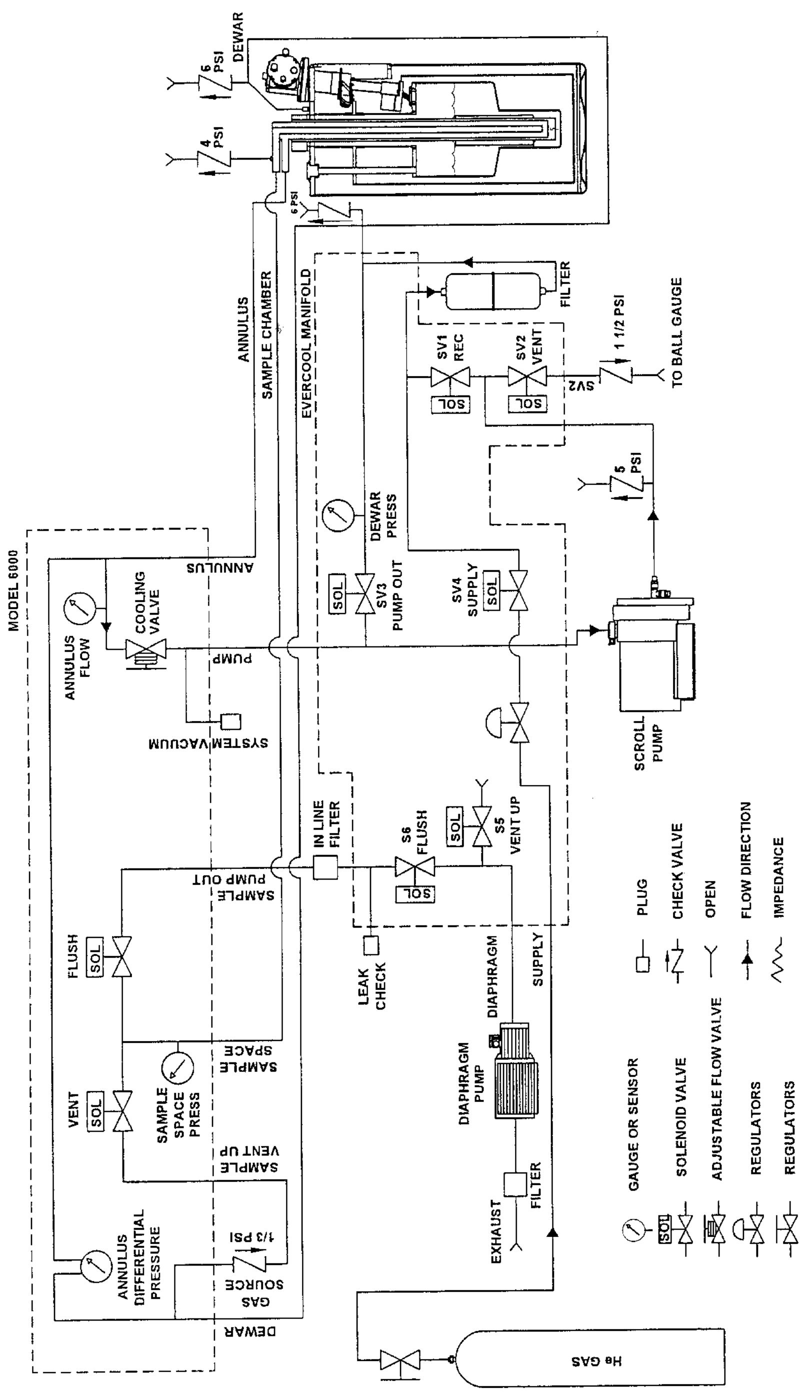


Figure 1-4. Schematic of the EverCool gas-handling system when the Turbo Pump High-Vacuum option is *not* installed.

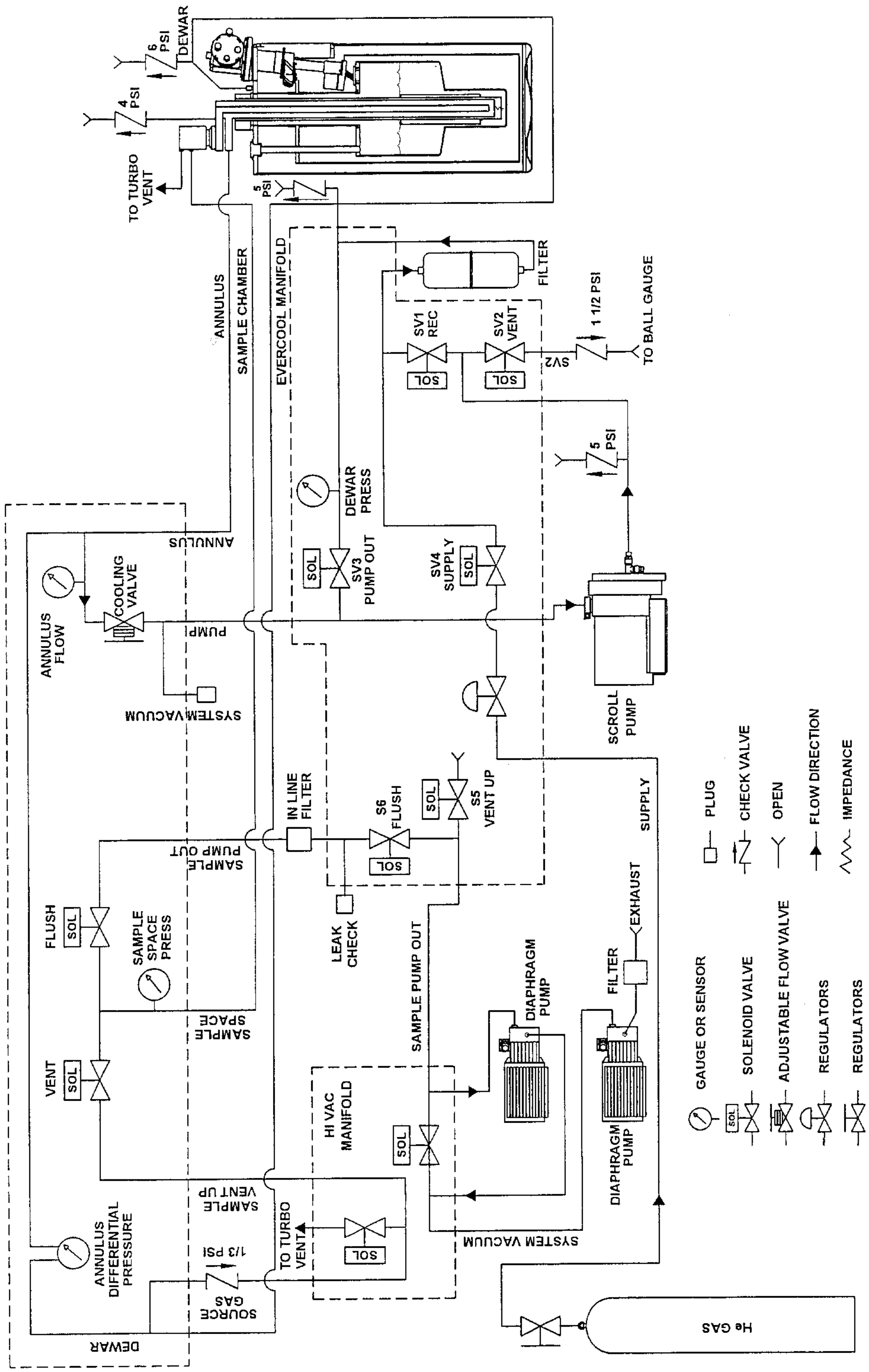


Figure 1-5. Schematic of the EverCool gas-handling system when the Turbo Pump High-Vacuum option *is* installed.

The regulator on the EverCool manifold (see Figures 1-7A and 1-7B) is set to 1.6 psi (11 kPa), which optimizes the dewar pressure during the filling state. If you believe that the filling state pressure in the dewar is significantly different than 1.6 psi (11 kPa), please contact Customer Service at Quantum Design.

1.4.4.1 SCROLL PUMP

The scroll pump[4] (Figure 1-6) provides the vacuum for the cooling annulus and for controlling temperature of the PPMS probe. This pump is oil-free, so the recirculating helium gas remains clean.

The EverCool is a closed-cycle system, and the scroll pump must remain sealed. Do not twist or open any of the fittings on the pump while the system is operating.

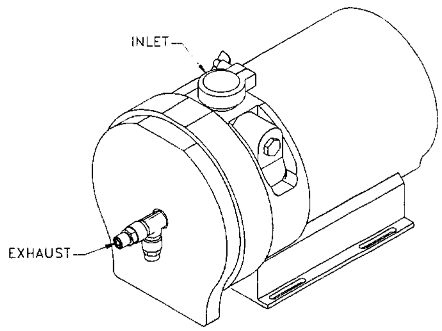


Figure 1-6. Scroll pump

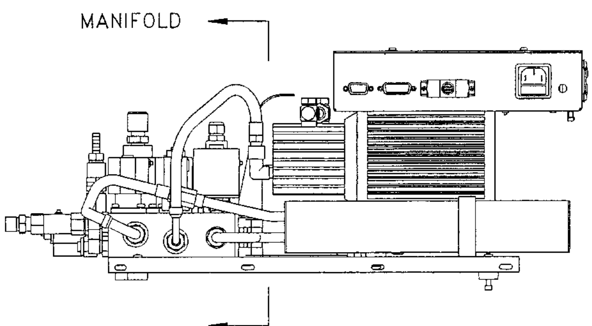
The tip seals in the scroll pump will wear and require replacement. When the tip seals have become worn, you will see rising PPMS base-temperature capabilities.

Special precautions must be taken during replacement of the tip seals or any other part of the pump to prevent contaminating the dewar with air. Therefore, pump servicing in the EverCool should only be performed under the direction of a qualified Quantum Design representative. Tip-seal replacement is a standard part of the services performed during the recommended bi-yearly EverCool maintenance routine (refer to Chapter 4).

1.4.4.2 DIAPHRAGM-PUMP ASSEMBLY

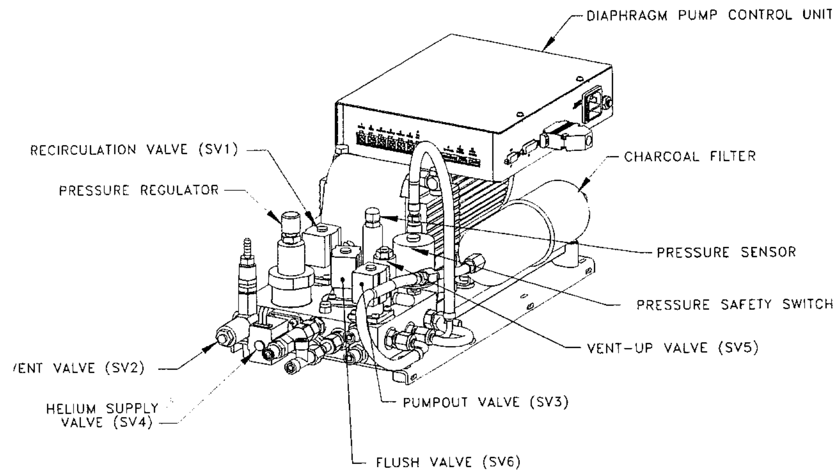
The diaphragm pump provides an oil-free pumping station for the PPMS sample space. This diaphragm pump does not operate continuously—the EverCool system uses a dedicated pump for the sample space, so the Model 6000 turns on the diaphragm pump only to evacuate the sample chamber. This procedure extends the life of the pump.

The manifold, which is the lower front part of the diaphragm-pump assembly (Figure 1-7A), contains all system plumbing valves and coordinates the plumbing activity generated by the addition of a second pump.



A. Side view of diaphragm-pump assembly illustrating location of manifold

[4] Earlier models of the PPMS EverCool used a rotary-vane pump. Information on that pump can be found in the *PPMS EverCool Option User's Manual* shipped with the system.



B. Front view of diaphragm-pump assembly illustrating valves on manifold

Figure 1-7. Two views of the diaphragm-pump assembly

The Model 6000 automates operation of the recirculation valve (SV1), the helium-supply valve (SV4), the vent valve (SV2), and the dewar pumpout valve (SV3), as is explained earlier in this section. All these valves are physically located on the manifold of the diaphragm-pump assembly (see Figures 1-7A and 1-7B).

The pressure sensor on the manifold reads the pressure in the EverCool dewar. The diaphragm-pump control unit contains the electronic circuitry that actuates the solenoid valves in the manifold. The charcoal filter mounted on the side of the pump assembly removes water and other contaminants from the helium before they reach the dewar.

The pressure-safety switch on the manifold is a fail-safe valve that opens if the normal pressure-control circuit fails and the pressure in the EverCool dewar drops to less than approximately 0.5 psi. By opening at low pressure, the safety switch prevents the formation of a vacuum in the dewar. The pressure-safety switch is in series in the circuit by which the cold head is turned on-and-off.

The system might trigger the pressure-safety switch while the PPMS sample chamber is venting because gas from the dewar is used for the venting operation. Although helium venting is a normal occurrence, you should not perform operations that vent the PPMS sample chamber for extended periods of time, because the cold head will shut off and you will lose a significant amount of helium.

CAUTION!

Do not vent the PPMS sample chamber for extended periods of time, because the cold head will shut off and there will be significant helium loss.

1.5 Contacting Quantum Design

If you have trouble with your PPMS or EverCool, please contact your local Quantum Design service representative for assistance. Your service representative will ask you to describe the problem, the circumstances involved, and the recent history of your system.

United States

Quantum Design World Headquarters
6325 Lusk Boulevard
San Diego, CA 92121

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1-800-289-6996
Fax: 1-858-481-7410

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Web: http://www.lot-oriel.com

Service for Austria, Belgium, Crete, Croatia, Czech Republic, Denmark, England, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and Yugoslavia

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Fax: 886-2-8780-5225

Email: lonson.lin@omega-cana.com.tw

Service for Taiwan, Hong Kong, Singapore

CHAPTER 2

EverCool System Start Up

2.1 Introduction

- Section 2.2 summarizes the start-up procedures.
- Section 2.3 explains how to verify the system connections.
- Section 2.4 explains how to use the **EverCool Start-up Wizard** to verify the system parameters.
- Section 2.5 explains how to use the **EverCool Start-up Wizard** to prepare the dewar for a liquid-helium fill.
- Section 2.6 explains how to use the **EverCool Start-up Wizard** to fill the EverCool dewar with liquid helium.
- Section 2.7 gives recommendations on filling the dewar by using helium gas.

2.2 Overview

The EverCool software includes the **EverCool Start-up Wizard**, an automated program that guides you through the procedures to fill a dry, room temperature, EverCool dewar with helium. You will initiate these procedures after you have organized the physical components of the liquid-helium transfer (refer to Appendix B of the *PPMS Hardware Manual).*

The helium-fill process is organized into four phases:

- verifying the system connections and power
- verifying the system parameters
- preparing the EverCool dewar for the helium fill
- filling the dewar with helium

In the first phase, you will check that the system is physically prepared to operate. Then, the PPMS **EverCool System Start-up Wizard** will guide you through the remaining procedures.

To facilitate the start-up process, Quantum Design staff recommend that you become familiar with the procedures before you begin them. Even though the setup process has been automated, many aspects require your participation. Familiarity with the process will help you prepare for those tasks. The complete dewar-fill process will take approximately 4 hours.

Important: You will require 60–100 liters of liquid helium and a cylinder of compressed helium gas to fill the EverCool dewar.

2.3 Verify System Connections

The system connections are shown in Figures 1-4, 1-5, and A-1, and the cables and hoses are labeled. The *PPMS Hardware Manual* has detailed instructions for connecting the PPMS and its components and for transferring helium. Refer to Chapter 4 of this manual for instructions on the physical setup and procedures for transferring liquid helium into a cold EverCool dewar.

1. Verify that the system components are properly connected according to the electrical interconnect diagram (Figure A-1), the gas-handling system schematics (Figures 1-4 and 1-5), and the labels on the cables and hoses.
2. Verify that the Model 6000 and system electronics are connected and plugged in.
3. Verify that the diaphragm-pump control unit (Figures 1-7A and 1-7B) and the scroll pump (Figure 1-6) are plugged in and turned on.
4. Verify that the compressor is connected, plugged into a power source, and turned on.
   a. If the compressor is air-cooled, verify that it has sufficient airflow.
   b. If the compressor is water-cooled, verify that
      - the "Remote Drive" switch on the back of the compressor is in external ("EXT") mode
      - the compressor has a sufficient supply of water

   Note: After the compressor has been turned on, it will not begin operating until the software activates it.
5. Verify that all hose connections are leak tight. The EverCool system must be free of air leaks in order to ensure prolonged and trouble-free operation.
6. Verify that a helium-gas supply cylinder is attached to the EverCool manifold supply port with a stainless steel hose and that the cylinder pressure is regulated from 5–30 psi (35–210 kPa).

CAUTION!

Before the initial system cool down, verify that all hose connections are leak tight. The EverCool system must be free of air leaks to ensure prolonged and trouble-free operation.

2.4 Verify System Parameters

You will use the automated **EverCool System Start-up Wizard**, which is integrated into the MultiVu software application, to check critical system parameters.

1. On the personal computer, start the MultiVu software.
2. On the MultiVu main toolbar, select **Instrument** >> **EverCool** to open the **EverCool System** control dialog. This sequence and the **EverCool System** control dialog are illustrated in Figure 2-1. (Chapter 3 has a detailed explanation of the **EverCool System** control dialog.)
3. In the **EverCool System** control dialog, click on the **Startup Wizard** button in the lower right of the **Controls** section.

4. The introductory page of the **EverCool System Start-up Wizard** will open (Figure 2-2), with an overview of the dewar-fill procedures. Note the suggestion to review the complete set of procedures before beginning the fill procedures.

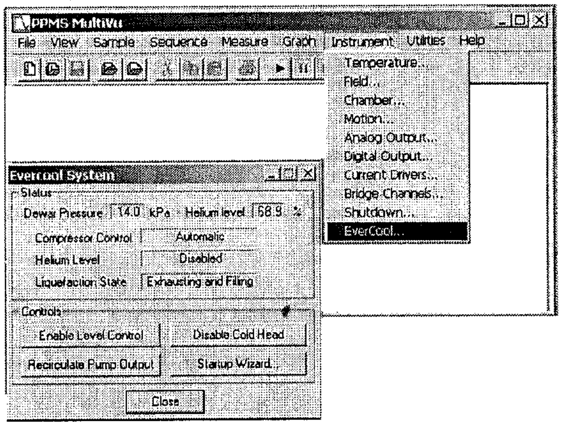


Figure 2-1. Starting the PPMS EverCool System dialog

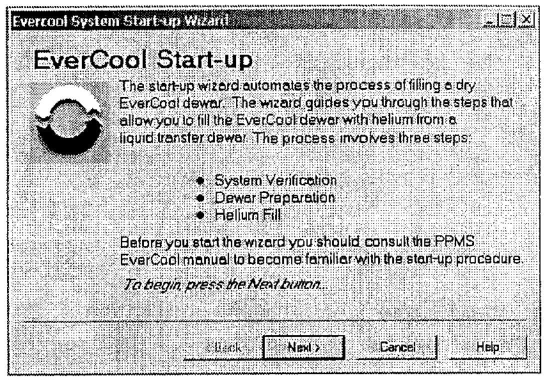


Figure 2-2. Introductory page of the EverCool System Start-up Wizard

5. Click on the **Next** >> button at the bottom of the dialog box to move to page 1 and begin the system-verification process.
6. Page 1 of the **Start-up Wizard** contains the **Check-Up List** (Figure 2-3), which instructs you to verify that initial external system conditions have been met.
7. When you know that a condition has been met, click on the arrow. When all the conditions have been met, go to page 2 of the wizard by clicking on the **Next** >> button at the bottom of page 1.
8. Page 2 of the wizard displays the status of the **System Verification** process (Figure 2-4).

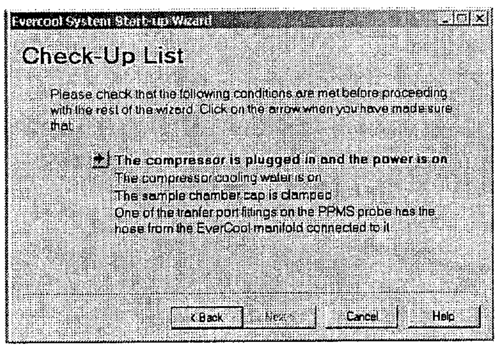


Figure 2-3. Start-up wizard, page 1: Check-up

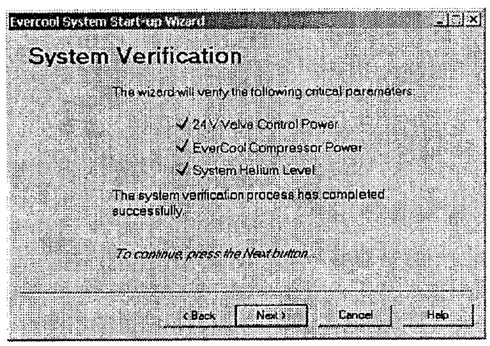


Figure 2-4. Start-up Wizard, page 2: Verification

During **System Verification**, the wizard verifies the 24 V valve-control power, the power to the compressor, and the helium level in the system.

While a parameter is being verified, it will appear in bold text. When the verification process for the parameter has been completed, a check mark (√) or "X" will appear next to the parameter. A check mark indicates that the parameter value has been verified and is acceptable. An "X" next to the parameter indicates that for some reason the parameter was not verified or acceptable. Table 2-1 lists the parameters and some common reasons that they might not be acceptable.

9. If the wizard cannot verify a parameter, the wizard will not move to the next phase. Correct the underlying condition, then click on the "**Repeat**" button. The wizard will attempt to verify the parameters again.

Table 2-1. Causes of system parameter-check failures

PARAMETER	CAUSE
24-V Valve Control Power	The Model 6000 is not turned on.
	All cables are not connected or they are not plugged in completely.
	The diaphragm pump or the junction box is not receiving power.
	The scroll pump is not receiving power.
EverCool Compressor Power	The large power switch in the front of the compressor control unit is not turned on.
	The compressor is not plugged in to an appropriate three-phase power source.
System Helium Level	The dewar is not dry and warm—the wizard will not cool down an EverCool dewar that contains liquid helium (see Chapter 4).

10. When the wizard has successfully verified all three parameters, click on the **Next** >> button. You will now move to the introductory page of the dewar preparation procedures.

2.5 Prepare the EverCool Dewar

Dewar preparation is covered on Pages 3 and 4 of the **Start-up Wizard** (Figures 2-5 and 2-6). During dewar-preparation, the wizard removes air from the EverCool dewar and pumping lines until the output flow drops below 200 cc/min. Then the wizard backfills the system with helium gas until the dewar pressure rises above 1 psi (7 kPa). This pumpout and backfill cycle is performed twice.

1. Before you start the verification procedures, verify that the helium-gas supply cylinder is attached to the system and is regulated from 5–30 psi (35–210 kPa).
2. If you would like to monitor the system flow, attach the helium-flow gauges (flowmeter) to the tubing that leads from the diaphragm-pump assembly to the pump output.
3. To go to the next page (Figure 2-6), click on the **Next** >> button at the bottom of the dialog box.

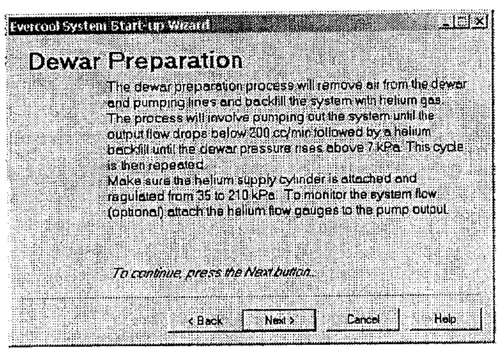


Figure 2-5. Page 1 of the **Dewar Preparation** dialog

4. This page contains the **System Status** area and a list of the pump-out–backfill steps. The readings in the **System Status** area are the following:
   - **Pressure** is the gas pressure in the dewar.
   - **Valve State [S,P,V,R]** is the status of the four main plumbing valves—**S**upply (SV4), **P**umpout (SV3), **V**ent (SV2), and **R**ecirculation (SV1). The valve is closed when the status is "C"; the valve is open when the status is "O."
   - **Time Remaining** is the time remaining until a part of the cycle has been completed.
5. Click on the **Start** button to initiate the two pump-out–backfill cycles. The current operation will be shown in bold text below the **System Status** area.

   The system will again mark whether an operation has been successfully completed—a (√) indicates that it was, an "X" means that it was not. The wizard will not go to the next phase until any problems have been corrected.

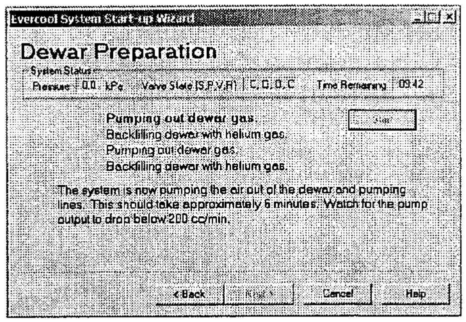


Figure 2-6. Page 2 of the **Dewar Preparation** dialog

6. Some of the reasons that an operation might not be successful include the following:
   - The helium-gas supply line is not connected.
   - The helium-supply cylinder is not connected to the dewar.
   - The regulator for the helium-supply cylinder is turned off.
   - The system has a leak.
   - The scroll pump does not have power or the pump is turned off.
   - There is no power to the system.
7. If any procedures are unsuccessful, correct the underlying condition, then click on the **Start** button. The program will again attempt to complete two dewar-preparation cycles.
8. When the two pump-out–backfill cycles have been successfully completed, click on the **Next** >> button. You will now move to the dewar-fill phase.

2.6 Fill the EverCool Dewar with Liquid Helium

The **Helium Fill** procedures are covered on pages 5–10 of the **EverCool System Start-up Wizard**. Page 5 is the introductory page, which explains that liquid helium is used to "cool down" (fill) the EverCool dewar. After the initial cool down, the liquid-helium level will be maintained with helium gas from the supply cylinder.

Note: You should start the liquid-helium transfer with 60–100 liters of liquid helium on hand—cooling down the EverCool dewar can require up to 100 liters of liquid helium.

1. If necessary, click in the box on the introductory page, next to "Fill the dewar by transferring liquid helium directly."
2. Click on the **Next** >> button at the bottom of the introductory page. Page 1 of the **Helium Fill: Liquid Transfer** pages (Figure 2-7) will open and guide you through the fill process that is outlined here.

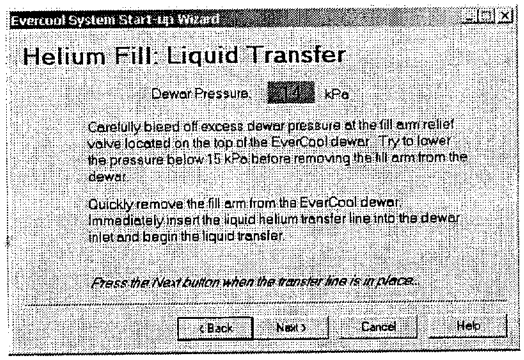


Figure 2-7. Page 1 of the Helium Fill dialog

3. Carefully bleed off excess dewar pressure at the relief valve of either transfer-port (fill-arm) fitting (see Figures 1-2 and 1-3) to lower the pressure below 2.2 psi (15 kPa). Use a small blunt object (e.g., a fingernail or the round end of a paper clip) to hold open the relief valve.
4. Quickly remove either transfer-port fitting from the EverCool dewar. Immediately insert the liquid-helium transfer line into the transfer-port (helium-fill) inlet and begin the liquid-helium transfer.[1] Aim the cold gas that exhausts from the dewar away from the cold head so that it is not damaged.

CAUTION!

The cold gas that exhausts from the dewar should be aimed away from the cold head to avoid damaging it or its seals.

5. When the transfer line is in place and the liquid helium is being transferred to the dewar, click on the **Next >> button**. The wizard will open the second page of the **Helium Fill: Liquid Transfer** instructions (Figure 2-8).

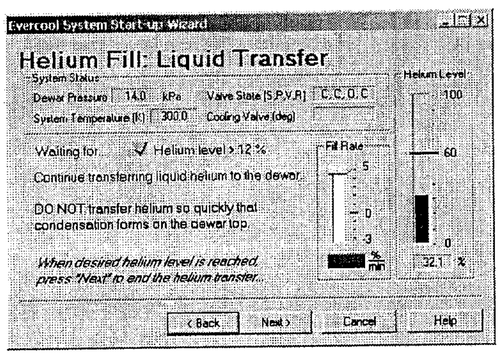


Figure 2-8. Page 2 of the Helium Fill dialog indicates when helium is at an acceptable level

[1] Detailed instructions for transferring liquid helium into the PPMS dewar are given in the *Physical Property Management System: Hardware Manual.*

CAUTION!

If excessive moisture begins to collect on top of the EverCool dewar, reduce the helium-fill rate by reducing the pressure from the gas cylinder that is being used to pressurize the liquid-helium supply dewar.

Excessive moisture indicates that the dewar is too cold—this can damage the O-ring seals and cause them to fail. Failure of the O-ring seals will cause catastrophic failure of the dewar vacuum.

6. Watch the helium level until it is at least 20%.[2] A helium level of about 60–65% is ideal for the initial fill of the EverCool dewar. ***Do not*** fill it more than 65% or the condenser might become plugged. For normal operating levels, see the *PPMS Hardware Manual.*

   Note: The cool down will take approximately 2 hours, and the dewar will lose a few liters of liquid helium (about 10%) over the next 12 hours as the system continues to thermally stabilize.

7. When the helium has reached the desired level, click on the **Next** >> button. The wizard will open the third page of the **Helium Fill: Liquid Transfer** instructions (Figure 2-9).
8. To complete the liquid-helium transfer process, slow the transfer rate and quickly remove the transfer line from the EverCool dewar inlet.
9. Dry the tube on the EverCool transfer-port fitting, if necessary.
10. Immediately insert the transfer-port fitting back into the dewar inlet. Push firmly on the fitting so that it seats completely, and lock the latch so that the fitting will not be forced out of the dewar by the high pressure inside.
11. Click on the **Next** >> button. The wizard will open the last page of the **Helium Fill: Liquid Transfer** instructions (Figure 2-10) and verify when the system has met three final conditions:
    - Dewar pressure has risen above 1.43 psi (10.0 kPa).
    - Compressor–cold head control has been enabled.
    - Helium control has been enabled.

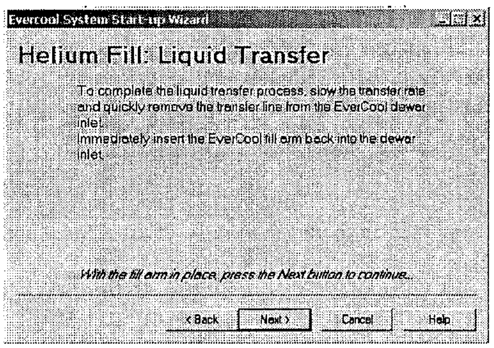


Figure 2-9. Page 3 of the Helium Fill dialog—Slow-down transfer rate

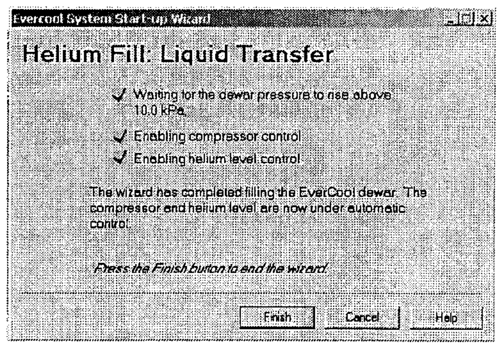


Figure 2-10. Final page of the Helium Fill: Liquid Transfer dialog—Final conditions

[2] The helium-level meter can reliably read the helium level only after it is above 20%. However, magnets should not be operated when helium levels are this low, as explained in the *Physical Property Management System: Hardware Manual.*

The wizard will again indicate conditions that have been successfully met by using a (√) and conditions that have not been successfully met with an "X." If any of the conditions are not met, the system will not complete the fill process until you have corrected the problem. See Table 2-2 for a list of reasons a condition might not be met. Call Customer Service at Quantum Design if a problem persists.

Table 2-2. Causes of liquid-helium transfer problems

CONDITION	POSSIBLE CAUSE
Dewar pressure does not reach 10.0 kPa (1.43 psi)	Dewar system leaks or the fill arm is not seated completely
	No power to compressor
Compressor or cold head does not enable	Dewar system leaks or the fill arm is not seated completely
	No power to compressor
Helium-level control does not enable	No power to the diaphragm-pump assembly
	Bad power connections

12. When all the final conditions have been met, click on the **Finish** button to end the **Start-up Wizard**.
13. Loosely cover the relief valve on the transfer-port fitting with a plastic bag to prevent ice building up on the valve. Once the dewar pressure has decreased you can remove the bag.

    Important: Watch the system for several hours after the helium transfer has been completed to verify that the dewar pressure eventually begins to decrease and that the relief valves close properly. Initially, the dewar pressure will be high enough to keep the relief valve open and to allow ice to form on it, which will prevent it from resealing properly. Covering the valve loosely with a plastic bag will prevent ice buildup and allow helium to escape.
14. As soon as the helium transfer begins, the output of the scroll pump will be exhausted for 8 hours to flush out contaminants. Hence, you will not be able to prompt the system to recirculate helium, even though this is the normal operating state. During the exhaust process, you will see a warning message if you click on the **Recirculate Pump Output** toggle button in the **Evercool System** dialog box. After this period, the system will automatically enter recirculating mode, which is the normal liquefaction state of the system (refer to Table 3-1 for an explanation of these states).
15. The level of liquid-helium in the dewar can drop 10% in the first 24 hours after you have filled the dewar. It is not necessary to add more helium, but you can if you prefer.

2.7 Helium-Gas Transfer

Quantum Design recommends only the liquid-helium transfer method for the initial cool down of the PPMS EverCool system, as is explained in Section 2.6.

CHAPTER 3

System Operation

3.1 Introduction

- Section 3.2 explains the basic operation of the EverCool system.
- Section 3.3 explains how to perform more advanced operations with the EverCool system.
- Section 3.4 discusses option compatibility and special considerations for sensitive measurements.
- Section 3.5 discusses magnet operation in the EverCool dewar.

3.2 Basic System Operations

The software that manages the EverCool system is fully integrated into the PPMS MultiVu application program. The status of the EverCool system is shown in the **Status Bar** at the bottom of the PPMS MultiVu window and in the **Status** section of the **Evercool System** control dialog box (Figure 3-1). The buttons in the **Controls** area of this dialog box can be used to set EverCool system-activity modes.

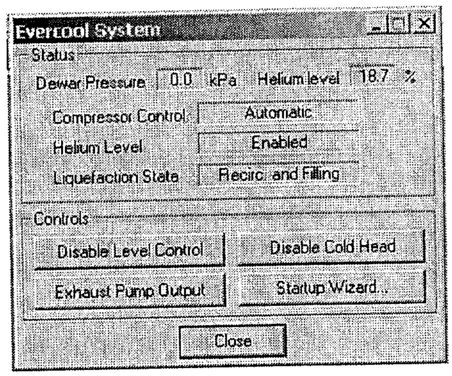


Figure 3-1. **EverCool System** dialog box

To access the **Evercool System** control dialog, select **Instrument** >> **EverCool** from the main tool bar of the PPMS MultiVu window.

The readouts in the **Status** area of the **Evercool System** dialog box indicate the following:

Dewar Pressure: the helium-gas pressure in the EverCool dewar (e.g., 11.1 kPa)

Helium Level: the liquid-helium level in the EverCool dewar

Compressor Control: the control mode for the compressor and cold head

Helium Level: the control mode for the helium-level control

Liquefaction State: the liquefaction state of the system

The **Controls** section of the **Evercool System** dialog has toggle buttons that you can use to enable or disable (override) automatic control of the helium level, the cold head, and the scroll-pump exhaust.

To change the status of any activity mode, click on the appropriate button. The **Enable (Disable) Level Control** toggle button starts and turns off automatic (system) control of the helium level (see Section 3.2.1). The **Disable (Re-enable) Cold Head** toggle button disables automatic cold-head control for 20 minutes or re-enables automatic control (see Section 3.2.2) The **Exhaust (Recirculate) Pump Output** toggle button changes the system output mode to exhaust or to recirculate helium (see Section 3.2.3). As you might recall from Chapter 2, the **Startup Wizard** helps you prepare the PPMS EverCool system and fill an empty dewar with liquid helium.

3.2.1 Helium Level

The PPMS EverCool system uses the **Low-** and **High-Level Control** calibration factors (see Section 3.3) to automatically maintain a constant level of liquid helium in the dewar unless you disable automatic control with the **Disable (Enable) Level Control** toggle button (see Figure 3-1). The **Helium Level** status field in the **Evercool System** control dialog box shows how the helium level is being regulated—it displays **Enabled** when the helium level is being automatically controlled by the system, and it displays **Disabled** when you have over-ridden system control of the helium level.

The helium level indicates, as a percentage, how full of helium the dewar is. Ideally, the helium level should remain at approximately 70–75% so that the dewar belly has enough space for the gas to expand and keep the cold-head duty cycle close to the default length of 20 minutes. The gas must be able to expand to prevent the dewar pressure from becoming so high that it causes venting and loss of helium. Further, if the liquid helium level drops below about 55%, a magnet cannot be operated safely. For operation at high fields, the dewar should contain more than 65% helium.

When automatic helium-level control is enabled and the helium level in the dewar drops below 70%, the system opens the supply valve (SV4) to the helium-gas supply cylinder and begins to transfer helium gas. The helium transfer will continue until the helium level reaches the specified maximum (e.g., 75%); then the system closes the supply valve. The system opens and closes the supply valve only after the Model 6000 obtains a new helium-level reading, which occurs once an hour.

If automatic cold-head control is enabled (see Section 3.2.2), operation of the cold head will be affected by the helium transfer. During helium transfer the gas pressure rises, because the EverCool pressure regulator keeps the pressure above the system-defined, low-pressure limit at which the system turns off the cold head. The cold head thus turns on and remains on during the helium transfer, liquefying the helium gas from the supply cylinder. When the transfer has been completed, the system closes the supply valve (SV4) and the gas-pressure level drops low enough for the cold head to be turned off. The cold head then resumes its normal operation cycle.

The regulator on the helium-gas supply cylinder should be set to a pressure between 5–30 psi (35–200 kPa). The stainless-steel flex line that connects the regulator to the EverCool gas system is equipped with a zero-volume, self-closing fitting so that you can safely change the supply cylinder, regardless of the valve state of the EverCool system. The small regulator on the EverCool manifold is set at the factory to maintain 1.6 psi (11 kPa) pressure in the dewar during filling. The setting on this regulator should never be changed.

3.2.2 Cold-Head Operation

Control of the cold-head is usually set to automatic mode, enabling the system to regulate cold-head activity according to the helium-gas pressure in the EverCool system. The helium-gas pressures at which the system turns the cold head on and off are defined by the **High-** and **Low-Pressure Limit** calibration factors (see Section 3.3.1). The default high- and low-pressure limits of 2.0 psi (14 kPa) and 1.0 psi (7 kPa) create a cold-head on-and-off cycle of approximately 20 minutes.

The **Compressor Control** status field in the **EverCool System** control dialog (Figure 3-1) shows how the cold-head is being controlled—it displays **Automatic** when the cold-head is being controlled by the system, and it displays **Override** when you have disabled system control.

To change control of the cold head, click on the **Disable (Re-enable) Cold Head** toggle button in the **Evercool System** control dialog (Figure 3-1). This is an immediate-mode command—when you disable automatic control, it turns off the cold head for 20 minutes or until you re-set the button. After 20 minutes, cold-head control returns to the automatic mode. Refer to Section 3.5.1 for a sequence-mode version of this command.

For example, you might find it useful to override (disable) automatic cold-head control for 20 minutes before you perform sensitive measurements, because the cold head causes vibrations that can reduce measurement sensitivity. During development of the EverCool system, reduced measurement sensitivity was observed in low-temperature heat-capacity measurements taken at high fields with a Helium-3 Refrigerator system. To minimize the effects of the vibration for these types of measurements, use the platform-stabilizer plug included with the Heat Capacity kit for the Helium-3 Refrigerator system. (Refer to the *Physical Property Measurement System: Heat Capacity Option User's Manual* for instructions on using the platform-stabilizer plug.)

Important: Always remember to re-enable automatic cold-head control as soon as possible—the cold head prevents the dewar pressure from rising so high that helium must be vented out of the system and lost.

3.2.3 Pump-Output Mode

During normal operations of the EverCool, the recirculation valve (SV1) is open and the other plumbing valves are closed. Thus, the helium that is used to control temperature in the sample chamber is recirculated back to the EverCool dewar and recondensed. Helium is exhausted out of the system only when it is necessary to monitor the rate of helium-gas flow through the cooling annulus, clean the system, or prevent excessive dewar pressure. To exhaust helium, the system opens the vent valve (SV2) and closes all other plumbing valves. Figure 1-5 illustrates the plumbing valves on the manifold of the diaphragm pump.

The dewar pressures at which the system automatically exhausts or recirculates the scroll-pump output are defined by the **Pump-Output Exhaust Limit** and **Pump-Output Recirculate Limit** calibration factors (Section 3.3.1). As shown in Table 3-2, the pump output will be exhausted when the dewar pressure reaches 2.9 psi (20.0 kPa) and recirculated when the dewar pressure falls to 2.2 psi (15.0 kPa).

To change the pump-output mode to either exhaust or recirculate helium, click on the **Exhaust (Recirculate) Pump Output** toggle button on the **EverCool System** control dialog box (Figure 3-1). The resulting liquefaction state will be shown in the **Liquefaction States** status field. The different liquefaction states are explained in Table 3-1.

Table 3-1. Liquefaction states in the PPMS EverCool system

LIQUEFACTION STATE	VALVE STATUS	DESCRIPTION
All Valves Closed	All valves closed.	Valve diagnostics were used to put system in this state. Dashed lines in liquefaction status fields identify this state.
Recirculating	Recirculation valve open. Other valves closed.	Normal operating state–valve states when the helium is being recirculated through the system.
Exhausting and Filling	Vent and supply valves open. Other valves closed.	Valve states when the output of the scroll pump is being exhausted while helium is transferred into the dewar.
Recirc. and Filling	Recirculation and supply valves open. Other valves closed.	Valve states when helium is being recirculated through system while helium is transferred into the dewar.
Pump Exhausting	Vent valve open. Other valves closed.	Output of scroll pump is exhausted – exhausting helium out of system.
Dewar Venting	Recirculation and vent valves open. Other valves closed.	Valve states when the system is relieving dewar pressure.
Dewar Pumpout	Vent and pumpout valves open. Other valves closed.	Valve states when the dewar is evacuated during the pre-startup purging sequences.

3.3 Advanced System Operation

3.3.1 Calibration Factors and Parameters

Table 3-2 shows the three types of calibration factors that control the EverCool system: **High-Level Control** and **Low-Level Control**; **High-Pressure Limit** and **Low-Pressure Limit**; and **Pump-Output Exhaust Limit** or **Pump-Output Recirculate Limit.**

3.3.1.1 HELIUM-LEVEL LIMITS

The **Low-** and **High-Level Control** calibration factors define the helium levels at which the system automatically starts and stops transferring helium into the system. The default low and high levels are 70% and 75%, respectively. When the system includes a magnet, the helium level should remain at approximately 70% so that the magnet is immersed in liquid helium. To display the current values of the **High-Level Control** and **Low-Level Control** calibration factors, select **Utilities >> EverCool >> Advanced >> Helium Level Control** from the main tool bar of the PPMS MultiVu window.

3.3.1.2 DEWAR-PRESSURE LIMITS

The **High-Pressure Limit** and **Low-Pressure Limit** calibration factors define the helium-gas pressure at which the system turns the cold head on-and-off when it is in automatic mode. The specified maximum pressure limit must not be lower than the specified minimum pressure limit. The opposite is also true; the specified minimum pressure limit must not exceed the specified maximum pressure limit.

The **Low- and High-Pressure Limit** calibration factors are set in the electronics of the EverCool controller card and reflect the unique attributes of the individual EverCool unit. The standard lower and upper pressure limits in the PPMS are 1.0 psi and 2.0 psi (7 kPa and 14 kPa). Advanced users can override these limits when they are performing nonstandard tasks, but normal EverCool operations should not require any modification to the calibration factors.

3.3.1.3 PUMP-OUTPUT LIMITS

The **Pump-Output Exhaust Limit** and **Pump-Output Recirculate Limit** calibration factors define the dewar pressures at which the system automatically exhausts or recirculates the scroll-pump output. As shown in Table 3-2, the pump output will be exhausted when the dewar pressure reaches 2.9 psi (20.0 kPa) and recirculated when the dewar pressure falls to 2.2 psi (15.0 kPa).

Table 3-2. EverCool calibration factors

CALIBRATION FACTOR	WHAT CALIBRATION FACTOR DEFINES	NORMAL VALUE	RANGE
High-Level Control	Helium level at which helium transfer stops.	75%	0.0–100.0%
Low-Level Control	Helium level at which helium transfer starts.	70%	0.0–100.0%
High-Pressure Limit	Dewar pressure at which system turns on cold head.	2.0 psi (14.0 kPa)	0.7–7.4 psi (5.0–50.7 kPa)
Low-Pressure Limit	Dewar pressure at which system turns off cold head.	1.0 psi (7.0 kPa)	0.7–7.4 psi (5.0–50.7 kPa)
Pump-Output Exhaust Limit	Dewar pressure at which pump output is automatically exhausted.	2.9 psi (20.0 kPa)	0.7–7.4 psi (5.0–50.7 kPa)
Pump-Output Recirculate Limit	Dewar pressure at which pump output is automatically recirculated.	2.2 psi (15.0 kPa)	0.7–7.4 psi (5.0–50.7 kPa)

Setting Calibration Factors

The EverCool controller card uses pre-specified (factory set) values for the **Low-** and **High-Pressure Limit** calibration factors that control when the cold head is automatically turned on and off. These limits are 1.0 psi and 2.0 psi (7.0 kPa and 14. 0 kPa), which are safe operating parameters. Pressure-limit settings remain in effect until they are reset.

Advanced users can set the **Low-** and **High-Pressure Limit** calibration factors by using the **EverCool Dewar Pressure Control** dialog box (Figure 3-2), as is explained below. However, you should contact Customer Service at Quantum Design if the system is not using the limits set in the software, because it is likely that this problem will not be fixed by changing the pressure limits.

1. Open the **EverCool Dewar Pressure Control** dialog box by selecting **Utilities** >> **EverCool** >> **Advanced** >> **Dewar Pressure Control** from the main PPMS MultiVu tool bar.
2. Enter the new settings in the **High** and **Low** text boxes.
3. Click on the **Set** button at the bottom right of the dialog box. The change will not take effect unless you click on the **Set** button.

   Note: You can also use the **Disable** toggle button in this dialog box to disable and re-enable automatic cold-head operation.

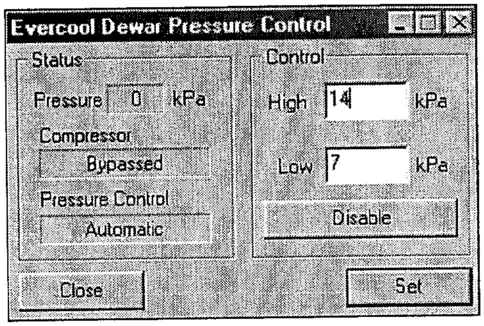


Figure 3-2. EverCool Dewar Pressure Control dialog box

3.3.2 Plumbing-Valve Diagnostics

The plumbing valves are controlled automatically by the EverCool system. However, highly trained personnel can use the instructions below to override the automatic settings and open or close the recirculation valve (SV1), vent valve (SV2), pumpout valve (SV3), or supply valve (SV4).

> **CAUTION!**
>
> Never open the pumpout valve (SV3) when there is liquid helium in the dewar. This valve is used only to evacuate the dewar in preparation for system startup. Opening it at any other time causes a rapid loss of helium.

For a list and description of the EverCool system liquefaction states, see Table 3-1. The current liquefaction state is reported in the **Liquefaction States** status field of the **EverCool System** control dialog box (Figure 3-1). Figures 1-4 and 1-5 show schematics of the gas-handling system, and Figure 1-7B illustrates the position of the plumbing valves.

Changing the Plumbing Valve Status

You will use the **Evercool Valve Diagnostics** dialog box (Figure 3-3) to open or close a valve.

1. Select **Utilities** >> **EverCool** >> **Advanced** >> **Valve Control** in the PPMS MultiVu main tool bar.
2. The **Evercool Valve Diagnostics** dialog box will open, displaying a **Status** area on the left that shows the current status of the plumbing valves. A **Controls** area on the right side contains the valve setting controls.

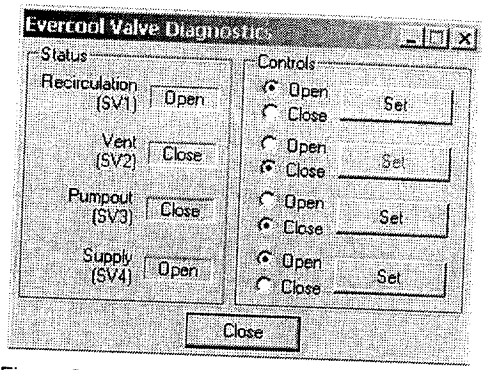


Figure 3-3. EverCool Valve Diagnostics dialog box

3. To change a valve setting, select the desired **Open** or **Close** option for the appropriate valve
4. Click on the **Set** button for that valve. After several seconds, the **Status** section of this dialog should show the new state.
5. Click on the **Close** button after you have made your changes.

Important: You must click on the **Set** button for your changes to take effect.

3.3.3 EverCool Status Dialog Box

The EverCool controller card sends readings to low-level status diagnostics that indicate whether the operation of individual hardware components is enabled or disabled. Table 3-3 describes the state of each hardware component when its status bit is high. Status readings are displayed in the **Evercool Status** dialog box (Figure 3-4). To open this dialog box, select **Utilities** >> **EverCool** >> **Status**.

As is shown in the figure, black text indicates high bit values (1) and enabled hardware. Gray text indicates low bit values (0) and disabled hardware. The most recently changed bit value is indicated with an arrow that briefly appears next to the name of that hardware component. For example, the dialog box in Figure 3-4 has an arrow next to Bit 9, indicating that the activity mode of this component was changed the most recently (the supply valve was closed).

The **Evercool Status** dialog box also offers the following options:

- To prompt the system to read the status bit values again, click on the **Update** button at the bottom left of the dialog box.
- To save the bit values, select the **Write to File** check box. The data will be written to the `ECStatus.dat` file, and a new data line will be appended to the file each time the output changes.
- To see a graph of the status bit values, click on the **View** button.

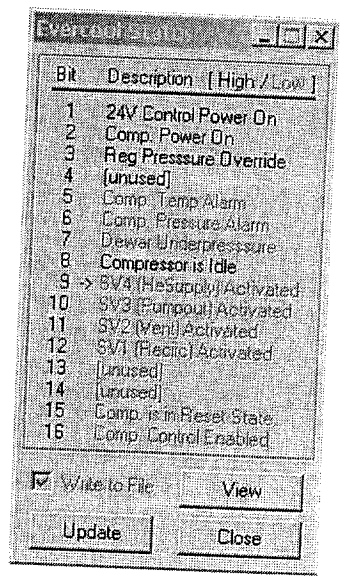


Figure 3-4. EverCool Status dialog box

3.3.4 EverCool Status Diagnostics

Table 3-3 describes the state of each hardware component when the status bit of the component is high (set to 1 and enabled). The opposite state is in effect when the bit is low (set to 0 and disabled).

Table 3-3. Status diagnostic bits

BIT	DESCRIPTION	STATE WHEN BIT IS HIGH
1	24 V Control Power On	The power supply for the diaphragm pump and the valve assembly is on.
2	Comp. Power On	The power supply for the compressor is plugged in.
3	Regulator Pressure Override	The software overrides default pressure regulator values written to EverCool controller card.
4	Unused	----------------------
5	Comp. Temperature Alarm	An overheating alarm condition has been sensed in the compressor. The compressor should cease operation. Refer to the Sumitomo *Operation Manual* for more information.
6	Comp. Pressure Alarm	The helium pressure in the compressor is too low. The compressor should cease operation. Refer to the Sumitomo *Operation Manual* for more information
7	Dewar Under Pressure Alarm	The pressure safety switch turned off the compressor because the pressure in the EverCool dewar was too low.
8	Comp. Is Idle	The compressor is not running.
9	SV4 (He Supply) Activated	The supply valve has been activated (normally closed).
10	SV3 (Pumpout) Activated	The pumpout valve has been activated (normally closed).
11	SV2 (Vent) Activated	The vent valve has been activated (normally closed).
12	SV1 (Recirc.) Activated	The recirculation valve has been activated (normally open).
13	Unused	----------------------
14	Unused	----------------------
15	Comp. Is In Reset State	The cryocooler compressor unit is in the reset state. Refer to the Sumitomo *Operation Manual* for more information
16	Comp. Control Enabled	Automatic cold-head control is enabled.

3.3.5 Diagnostic Thermometers

The EverCool system includes two diagnostic thermometers—you will read them only for diagnostic purposes. Each thermometer is in the area it monitors: the cold-head thermometer monitors the temperature of the second stage of the cold head; the condenser thermometer monitors the temperature of the condenser.

To read the thermometers, you will download the thermometer calibration, or `.tab`, files to the Model 6000 and connect the user-bridge cable to the EverCool dewar and the Model 6000. Channel 1 on the Model 6000 user-bridge board reads the second-stage thermometer, and Channel 3 on the user-bridge board reads the condenser thermometer.

3.3.5.1 CONNECTING THE USER-BRIDGE CABLE

- Plug the gray Lemo connector of the user-bridge cable into the connector port on the side of the dewar. Table 3-4 shows the thermometer connections of the Lemo connector on the user-bridge cable.
- Plug the 25-pin, D-shell connector of the cable into the P1–User Bridge port on the Model 6000.

> **CAUTION!**
>
> Never force the gray Lemo connector on the user-bridge cable into or out of the dewar connector port. Tugging or pushing the Lemo connector, or connecting or disconnecting it too many times, can damage the port or the O-ring seals on the other side of the port. Damaging the port could ruin the dewar vacuum seal.

Table 3-4. EverCool diagnostic thermometer connections

GRAY LEMO CONNECTOR	THERMOMETER LOCATION
3	Second Stage I+
4	Second Stage I–
5	Second Stage V+
6	Second Stage V–
11	Condenser I+
12	Condenser I–
13	Condenser V+
14	Condenser V–

3.3.5.2 DOWNLOADING CALIBRATION FILES

The thermometer calibration files are named `MEC***.tab` (`***` is a three-digit serialization number). These files are specifically calibrated for your system, which uses them to translate thermometer resistances into temperatures. You will use the **Evercool Dewar Diagnostics** dialog box (Figure 3-5) to download the EverCool thermometer calibration files to the Model 6000, as is explained below.

Important: Only download the thermometer calibration files to the Model 6000 when you need to read the diagnostic thermometers. Then, restore the previous calibration files as soon as it is no longer necessary to read the diagnostic thermometers.

1. In MultiVu, select **Utilities** >> **EverCool** >> **Dewar Diagnostics**. When the **Dewar Diagnostics** dialog box opens, notice that it has separate sections for **Dewar Thermometers Setup** and **Dewar Pressure Gauge Setup**.
2. In the **Dewar Thermometers Setup** section, select the mappable channel (**MapDat Channel**) where you want the thermometer reading to appear.

   For example, in Figure 3-5, mappable channels 60 and 61 have been selected. You can log the thermometer temperatures along with other PPMS data by utilizing this mapped data channel.

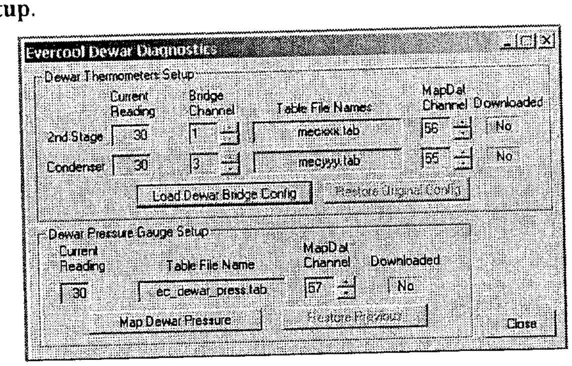


Figure 3-5. EverCool Dewar Diagnostics dialog box

3. Click on the **Load Dewar Bridge Config** button at the bottom of the **Dewar Thermometers Setup** section.

   The system will begin downloading the thermometer calibration files. The bridge channels will be reinitialized to read the dewar thermometers when you plug the user-bridge cable into the side of the EverCool dewar.
4. When the download is complete, the **Download Status** fields (far right of the **Dewar Thermometers Setup** section) will report the status as **Downloaded**.
5. The **Current Reading** field (far left of the **Dewar Thermometers Setup** section) will display the thermometer readings. See Section 3.3.5.3 for typical readings.
6. You can log the temperatures that are read by the diagnostic thermometers by using the **PPMS Data Logger** utility (see Section 3.3.7).
7. To restore the previous calibration files, click on the **Restore Original Config** button.

3.3.5.3 TYPICAL THERMOMETER READINGS

When the system has been cold for more than 15 hours, a typical reading for the second-stage thermometer is 4.0–4.2 K. Typical readings for the condenser thermometer are 4.4–4.6 K. The difference of 0.4 K between these two thermometers indicates normal thermal loss between the second stage and condenser. If the readings deviate significantly (e.g., +/–1.0 K) from the typical thermometer temperatures, it could indicate that the condenser is plugged, trapping all the cooling power for the second stage. It also could indicate that the cold-head motor is worn and needs maintenance.

3.3.6 EverCool Dewar Pressure

The helium-gas pressure in the EverCool dewar is reported in the **Dewar Pressure** field of the **EverCool System** control dialog box (Figure 3-1). You can use the **EverCool Dewar Diagnostics** dialog box and the **PPMS Data Logger** utility to record the EverCool dewar pressure.

1. If necessary, open the **EverCool Dewar Diagnostics** dialog box (see Figure 3-5) by selecting **Utilities >> EverCool >> Dewar Diagnostics**.
2. In the **Dewar Pressure Gauge Setup** section of the dialog box, select the mappable channel (**MapDat Channel**) where you want the pressure reading to appear. You can log the pressure reading along with other PPMS data by utilizing this mapped data channel.
3. Click on the **Map Dewar Pressure** button at the bottom of the **Dewar Pressure Gauge Setup** section. The pressure readings will be displayed in the **Current Reading** field at the left of that section.
4. To log the pressures that are read, use the **PPMS Data Logger** utility (see Section 3.3.7).
5. Quantum Design does not support changes to the dewar-pressure calibration table (unless changes are performed by or guided by our personnel). In the event the dewar-pressure calibration table has been changed, you can restore the original by selecting **Restore Original Mapping** in the **EverCool Dewar Diagnostics** dialog box.

3.3.7 Logging EverCool Data

When you have used the **EverCool Dewar Diagnostics** dialog box (Figure 3-5) to map the data channels for the dewar thermometer readings and the dewar pressure, you can use the **PPMS Data Logger** to record the sensor readings.

To start **PPMS Data Logger** utility and open the **Log Data** dialog box (in immediate mode), select **Utilities >> Log PPMS Data** in the tool bar at the top of the MultiVu window. The log (`*.dat`) file will refer to the data by the mapped channel that you specified in the **EverCool Dewar Diagnostics** dialog box.

Refer to the *Physical Property Measurement System: PPMS MultiVu Application User's Manual* for detailed information about the **PPMS Data Logger** utility and using it in immediate mode and in sequence mode.

3.4 Option Compatibility

3.4.1 EverCool Card

When the EverCool Dewar option is used with the PPMS, an EverCool card is added to the Model 6000 so that it can control the EverCool cryocooler system. The card is placed in the same slot used by other option-specific cards such as the ACMS card. If the system also has been configured for the ACMS, ACT, or TTO option, option-specific cards will be moved to another controller (the Model 6500).

3.4.2 Noise in Sensitive Measurements

3.4.2.1 HEAT-CAPACITY MEASUREMENTS

During development of the EverCool system, reduced measurement sensitivity was observed in low-temperature heat-capacity measurements taken at high fields on a Helium-3 Refrigerator system. You can minimize the effects of the vibration on these types of measurements by using the platform-stabilizer plug included with the Heat Capacity kit for the Helium-3 Refrigerator system. Quantum Design recommends that you use the platform-stabilizer plug whenever you take measurements of this type. The *Physical Property Measurement System: Heat Capacity Option User's Manual* explains the proper use of the platform-stabilizer plug.

If you are concerned that the vibration of the cold head will introduce noise into your measurements, you can disable automatic cold-head control for up to 20 minutes by using the immediate mode **Disable Cold Head** command (see Section 3.2.2). You also can use a MultiVu sequence command to disable the cold head (see Section 3.4.2.3) during a measurement sequence.

Important: Re-enable automatic cold head control as soon as possible. Automatic cold-head control prevents helium loss by turning on the cold head before the system pressure gets high enough to cause helium venting and loss.

3.4.2.2 AC MEASUREMENTS

Most laboratory environments are unavoidably filled with electromagnetic noise at the power-line frequency (typically 60 Hz or 50 Hz, depending on the local power-distribution infrastructure). Notable sources of this noise include power-distribution lines, electric motors, and fluorescent light bulbs. This noise threatens to degrade sensitive measurements of voltage, especially if it couples into a measured signal before it is amplified for analysis. Therefore, it is important to avoid contamination of measured signals with electromagnetic noise at the local power-line frequency.

Short of removing all sources of noise, the best way to avoid this environmental hazard when you are performing AC measurements is to work at frequencies higher than the power-line frequency—avoid the power-line frequency and its harmonics. Digital filtering or lock-in techniques can then obtain a clean signal for analysis. These techniques are performed in the Quantum Design ACMS and AC Transport options.

When you work at frequencies below the power-line frequency, you will see power-line noise as a ripple in the measured signal, which can affect the quality of subsequently derived information. It is generally best in this scenario to work at frequencies that are not integer factors of the power-line frequency. Although the cold-head motor on the EverCool dewar does not represent the most significant source of such noise, you might find that noise decreases if you pause the cold head and turn off its motor when you are making low-frequency measurements with the ACMS or AC Transport options.

Important: The cold head should not be turned off for long periods, because the dewar and helium bath will begin to warm up, possibly creating helium loss and increasing the risk of high-field magnet quenching.

The MultiVu software includes a sequence command that allows you to pause cold-head operations (see Section 3.4.2.3). Note that this pause command is not intended to eliminate vibration noise that could affect low-temperature thermal measurements on a much longer time scale. Vibration noise should be addressed with stabilization techniques such as the platform-stabilizer plug mentioned earlier, so that the cold head does not need to be interrupted for long periods.

3.4.2.3 DISABLING THE COLD HEAD WITH A SEQUENCE COMMAND

Use the **Override Cold Head** sequence command to turn off the cold head while you are taking sensitive measurements. You create the command that tells the system when to disable the cold head and how long it is to be disabled, as explained below.

1. In the MultiVu window, start a new sequence command by selecting **File >> New Sequence** or by clicking on the **New Sequence File** icon. This command opens the **Sequence Commands** bar and a new `*.seq` file.
2. In the **Sequence Commands** bar, open the **Measurement Commands** menu and double click on **"Override Cold Head"**. This opens the **Override Cold Head Command** dialog box (Figure 3-6).

   Note that the dialog box has options organized as **"Wait for Compressor Off"** and **"Compressor Disable Timeout"**.

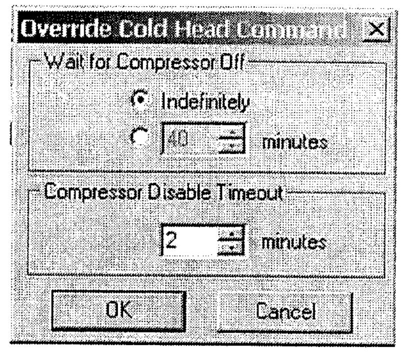


Figure 3-6. Override Cold Head Command dialog box

3. Click in the box for the suitable amount of **"Wait for Compressor Off"** time:
   - If you select the **Indefinitely** option, it means you will wait as long as it takes for the system to automatically disable the cold head. Note that if the EverCool is in the filling state, the cold head might stay on for a day or more.
   - If you select the option with a specific wait time, the command will take effect when the cold head has been on for the specified amount of time. You can specify a wait time of 0–1440 minutes.
4. In the **Compressor Disable Timeout** section of the dialog box, enter the maximum number of minutes the cold head will need to be disabled for your measurements. You can disable the cold head 0–6 minutes by using this dialog box.
5. Click on the **OK button**. Notice that the command is inserted as the first line in the sequence file.
6. Insert the measurement sequence command.
   a. In the **Sequence Commands** bar, double click on the appropriate measurement command.
   b. Set your calibration factors and notice that the sequence command is inserted in the sequence file as line two after the override command.
7. In the **Sequence Commands** bar, open the **Measurement Commands** menu and double click on **"Re-enable Compressor."**

   This command will open the **PPMS MultiVu** popup that says, "Re-enable Compressor?" Figure 3-7).
8. Click on the **OK** button.
9. The re-enable compressor command will now be inserted in the sequence file as line three.
10. Save the sequence file.

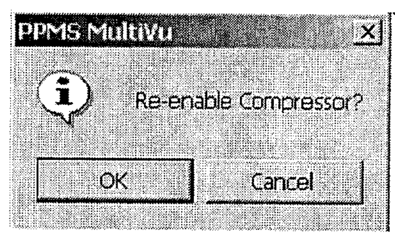


Figure 3-7. Re-enable Compressor popup

3.5 Magnet Operations

Magnet operations in the EverCool dewar are the same as with other PPMS systems. The magnet should not be driven to high fields if the liquid helium level in the dewar is below about 60%. The EverCool option automatically maintains a helium level between user-specified set points. The lower set point should be set no lower than 60% to maintain a safe liquid-helium level for magnet operation.

The pressure in the EverCool dewar is normally maintained between 1.0–2.0 psi (7–14 kPa), but under extreme operating conditions, it might rise as high as 5 psi (35 kPa) before relief valves in the system open to release the excess pressure. When there is such high pressure in the EverCool dewar for a prolonged period, some magnets are at an increased risk of quenching if they are driven to full field.

The main operation that causes increased pressure in the dewar is rapid cooling of the sample chamber. Magnet charging can also contribute to increased pressure in the dewar. The EverCool control software contains a pressure set point (normally 2.9 psi [20 kPa]), so the gas used to cool the sample chamber will be exhausted to atmosphere to reduce the chance of such high pressures in the dewar. Be careful when charging the magnet to high fields if the pressure in the EverCool dewar has been unusually high.

CHAPTER 4

Maintenance and Troubleshooting

4.1 Introduction

- Section 4.2 describes how to perform some typical maintenance procedures for the EverCool system.
- Section 4.3 describes basic troubleshooting procedures for the EverCool system.
- Section 4.4 summarizes the services that will maintain a properly functioning EverCool system and has a maintenance log.

4.2 Maintenance

The EverCool is designed to operate with minimal maintenance for about two years. Quantum Design recommends that you have the EverCool system serviced every two years. Some services must be performed only by a qualified Quantum Design representative, so it is important for you to contact your local Quantum Design representative to schedule the maintenance visit. The following sections describe various maintenance procedures you might need to perform on your EverCool system.

4.2.1 Changing the Helium-Gas Supply Cylinder

Periodically you will need to change the helium-gas supply cylinder that is used to replenish the helium in the EverCool system. The PPMS MultiVu software issues an "**Empty Dewar**" message when the helium-gas supply cylinder seems empty. The **Empty Dewar** message will be generated when the dewar pressure drops below the low-pressure setpoint, even though the supply valve is open.

Important: The **Empty Dewar** message could also appear for the following reasons:

- the compressor power has shut off
- the regulator on the helium-gas supply cylinder has been set too low
- the system has a leak

If you see the **Empty Dewar** message but the helium-gas supply cylinder is not empty, check the items above.

The hose connecting to the supply cylinder has a self-sealing connector so that you can disconnect the hose from the cylinder at any time without introducing air into the dewar.

Follow the steps below to change the helium gas supply cylinder.

1. Close the cylinder regulator and use a 3/4-inch hex wrench or an adjustable crescent wrench to disconnect the helium-gas transfer hose from the supply cylinder at the self-sealing connection, shown by the arrows in Figure 4-1. Only open the self-sealing connection—leave all the other joints sealed.

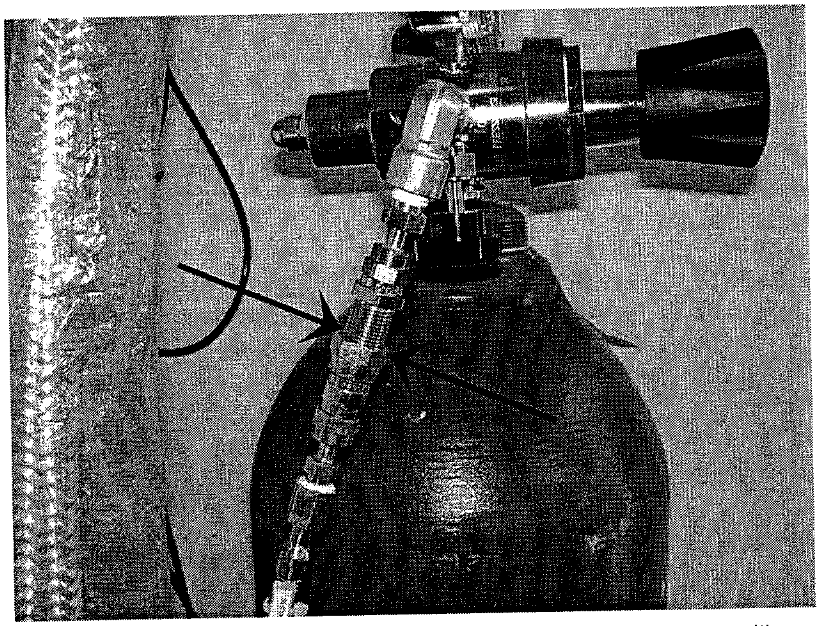


Figure 4-1. Helium-gas supply cylinder and helium-gas transfer hose, with arrows pointing to the self-sealing connection.

2. Remove the regulator from the empty cylinder and connect it to the new cylinder.
3. Before connecting the helium-gas transfer hose to the new cylinder, purge the air from the cylinder connector and regulator by using the relief-valve assembly that is supplied with the EverCool system (see Figure 4-2).
4. Verify that the self-sealing connection is tightened snugly and open the regulator on the new cylinder to between 5-30 psi (35-200 kPa).

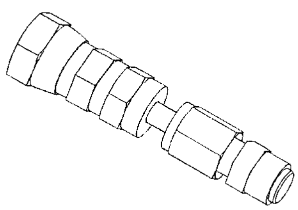


Figure 4-2. Relief-valve assembly for purging air from the regulator of the helium-gas supply cylinder.

4.2.2 Setting the System Helium-Fill Pressure

This procedure is performed at the factory before delivery of the system. Before the EverCool system is operated, the pressure of the helium gas in the EverCool dewar must be set, defining the pressure during the helium transfer.

If you suspect that the correct pressure (about 1.6 psi [11 kPa]) is not being maintained in the dewar during the filling state, contact Customer Service at Quantum Design to assess whether it would be appropriate to reset the helium-fill pressure. *Do not* tamper with the regulator on the EverCool manifold unless a Quantum Design service representative has instructed you to do so.

The procedures for setting the system helium-fill pressure are explained below.

1. Disconnect the dewar hose from the transfer-port fitting. If there is liquid helium in the dewar, bleed off excess dewar pressure at the relief valve of a transfer-port (fill-arm) fitting to lower the pressure below 2.2 psi (15 kPa). Use a small blunt object (e.g., a fingernail or the round end of a paper clip) to hold open the relief valve.
2. Remove a transfer-port fitting (see Figure 4-3) and insert the standard 1-psi relief-valve fitting. (Do not leave a cold EverCool dewar open to atmosphere for a long time.)

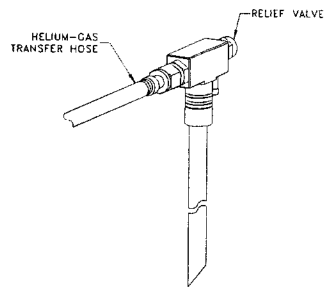


Figure 4-3. Transfer-port fitting with arrows to transfer hose and relief valve

3. Plug the loose end of the dewar hose (e.g., with your thumb).
4. Open the **Evercool System** dialog box (Figure 4-4) and verify that helium-level control is disabled.
   a. Select **Instrument >> EverCool** to open the **Evercool System** dialog box.
   b. Examine the **Helium Level** status field. If it reports that the helium level is **Enabled**, click on the **Disable (Enable) Level Control** toggle button.
   c. Leave this dialog box open.

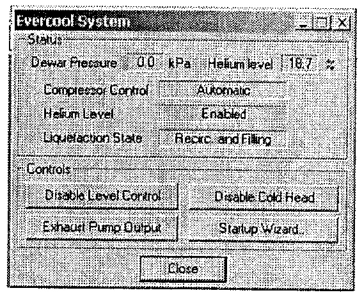


Figure 4-4. Evercool System dialog box

5. Verify that a helium-gas supply cylinder is connected to the system and regulated between 5–30 psi (35–200 kPa).
6. Use the **Evercool Valve Diagnostics** dialog box (Figure 4-5) to open the **Supply valve** (SV4):
   a. Select **Utilities >> EverCool >> Advanced >> Valve Control** to open the **Valve Diagnostics** dialog box.
   b. In the **Controls** panel, click in the **Open** option for the **Supply** valve.
   c. Click on the **Set** button to save the new setting. You must select **Set** to save any changes to valve settings.
   d. Leave this dialog box open.

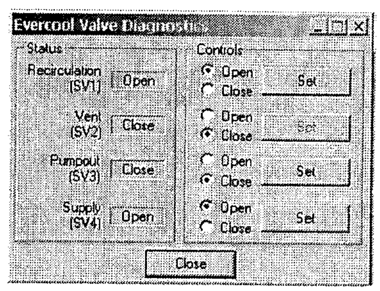


Figure 4-5. Evercool Valve Diagnostics dialog box

7. Turn the pressure regulator on the manifold (Figure 1-7B) clockwise until the dewar pressure setting reads 1.5–1.7 psi (10–12 kPa)—the target pressure is 1.6 psi (11 kPa). If the pressure is too high, turn the regulator counterclockwise several turns and bleed off the excess pressure by briefly loosening the plug on the end of the dewar hose. Slowly turn the regulator knob clockwise until the pressure rises to about 1.6 psi (11 kPa).
8. Watch the **Dewar Pressure** field in the **EverCool System** dialog box to follow the changing dewar pressure. The main regulator on the helium cylinder must be set between 5–30 psi (35-200 kPa).
9. Remove the plug from the dewar hose. Leave the **Supply** valve (SV4) open to keep helium flowing through the hose; this prevents air from entering the system.
10. Reinstall the transfer-port fitting, if necessary, and reconnect the dewar hose to the transfer-port fitting.
11. Use the **Evercool Valve Diagnostics** dialog box (Figure 4-5) to close the **Supply** valve (SV4):
    a. Click in the **Close** option for the **Supply** valve.
    b. Click on the appropriate **Set** button to save the new setting.
    c. Click on the **Close** button at the bottom of the dialog box.
12. Using the **EverCool System** dialog box (Figure 4-4), re-enable helium-level control.
13. Click on the **Enable Level Control** toggle button.
14. Click on the **Close** button at the bottom of the dialog box.

4.2.3 Disconnecting and Reconnecting the Diaphragm Pump

The instructions below explain how to disconnect the diaphragm-pump assembly from the system (e.g., to service the diaphragm-pump assembly). Note that they explain the general process only for removing and reconnecting the diaphragm-pump assembly. If the EverCool system will be out of service for a week or more, you might need to refer to associated procedures, such as those for shutting down and restarting the system.

4.2.3.1 DISCONNECTING THE DIAPHRAGM PUMP

1. Stabilize the system temperature at 300 K. Do not begin the next step until the temperature is stable at 300 K.
2. Turn off the power switch on the front of the compressor.
3. Open the **Evercool System** dialog box (Figure 4-4) and verify that **Helium-Level Control** is disabled.
    a. Select **Instrument** >> **EverCool** to open the **Evercool System** dialog box.
    b. Examine the **Helium Level** status field. If it reports that level control is **Enabled**, click on the **Disable Level Control** toggle button.
4. Exhaust the pump output by clicking on the **Exhaust Pump Output** toggle button in the **EverCool System** dialog box.
5. Open the **Evercool Valve Diagnostics** dialog box (Figure 4-5) to verify that the **Supply** valve (SV4) is closed.
    a. Select **Utilities** >> **EverCool** >> **Advanced** >> **Valve Control**.
    b. If the **Supply** valve is open, select the **Close** option.
    c. Click on the **Set** button to save the new setting.

6. Disconnect the dewar hose from the transfer-port fitting.
7. Use the VCO blank to plug the transfer-port fitting.
8. Disconnect the cooling-annulus hose from the probe head.
9. Disconnect the sample-space hose from the probe head.
10. Turn off the power switch on the scroll pump.
11. Disconnect the power to the diaphragm pump.
12. Close the regulator on the helium-gas supply cylinder.
13. Disconnect the following hoses from the manifold, using the hose labels for a guide (all the manifold hoses are labeled):
    - vacuum-out hose
    - supply hose
    - sample-space hose
    - dewar hoses (2)
    - tray hose
    - vacuum-in hose
14. If necessary, pull the diaphragm-pump assembly away from the PPMS cabinet so that you can work on it.

4.2.3.2 RECONNECTING THE DIAPHRAGM PUMP

The following procedures are only for reconnecting the diaphragm pump to a cold dewar (one that contains liquid helium).

Important: If the system has been sitting for some time and/or it has less than 15% liquid helium, do not go to Section 4.2.3.3. Instead, reassemble the diaphragm pump, connect all the system components, then use the procedures in Chapter 2 to restart the system and begin operations. Call Quantum Design if you have any questions.

1. If necessary, place the diaphragm pump in the PPMS cabinet.
2. Reconnect the following hoses to the manifold, using the hose labels for a guide:
    - vacuum-in hose
    - tray hose
    - dewar hoses (2)
    - sample-space hose
    - supply hose
    - vacuum-out hose

4.2.3.3 RESTARTING THE SYSTEM

1. Set the regulator on the helium-gas supply cylinder between 5–30 psi (35–200 kPa).
2. Seat (but do not connect) the cooling-annulus hose in its port on the probe head.
3. Plug in the power to the diaphragm pump and turn it on.

4. Using the **Evercool Valve Diagnostics** dialog box (Figure 4-5), open the **Vent** valve (SV2) and close the **Recirculation** valve (SV1).
   a. Select **Utilities >> EverCool >> Advanced >> Valve Control**.
   b. Click in the **Open** option for the **Vent** valve and click on the **Set** button to save the setting.
   c. Click in the **Close** option for the **Recirculation** valve (SV1) and click on the **Set** button to save the setting.
   d. Leave the **EverCool Valve Diagnostics** dialog box open.
5. Turn on the scroll pump.
6. Using the **Evercool Valve Diagnostics** dialog box, click in the **Open** option for the **Supply** valve and click on the **Set** button to save the setting.
7. Click on the **Close** button at the bottom of the **Evercool Valve Diagnostics** dialog box.
8. Using the `Gasmon` utility (located in the `QdPpms\Tools` directory), open the **Cooling** valve and wait 4 minutes.
9. Connect the cooling-annulus hose to the probe head.
10. Verify that helium gas is flowing out of the dewar hose.
11. Reconnect the dewar hose to the probe head.
12. Plug in the power to the compressor and turn it on.
13. Open the **Evercool System** dialog box and select the **Enable Level Control** toggle button.
14. The system is now operational.

4.2.4 Transferring Liquid Helium into a Cold EverCool Dewar

WARNING!

- Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium or any other cryogen.
- Always use a well-ventilated room to perform this procedure.
- Immediately vent the room (open doors and windows) if there is an excessive helium release.
- If it has been some time since you worked with liquid helium, please review the procedures for transferring liquid helium and the section on "Cryogens" in the *Physical Properties Measurement System Hardware Manual.*

If you remove the probe or the system has been shut off for more than a day or two, you will need to transfer liquid helium into the dewar. Otherwise, you will rarely need to transfer liquid helium into the EverCool dewar after it has been filled with helium as part of the system startup.

So long as there is liquid helium in the dewar, you will use the general procedures for transferring liquid helium into a standard "cold" dewar given in Chapter 4 of the *PPMS Hardware Manual.* If the dewar is empty, use the procedures in Appendix B of that manual and the EverCool **Startup Wizard**.

We recommend that you review the procedures before you begin. Here we provide a brief summary.

The liquid-helium transfer line and the dewar setup for transferring liquid helium into a **cold** EverCool dewar are shown in Figures 4-6 and 4-7. Note that the transfer line will have a long output extension when you are filling a **warm** dewar (see Appendix B of the *PPMS Hardware Manual).*

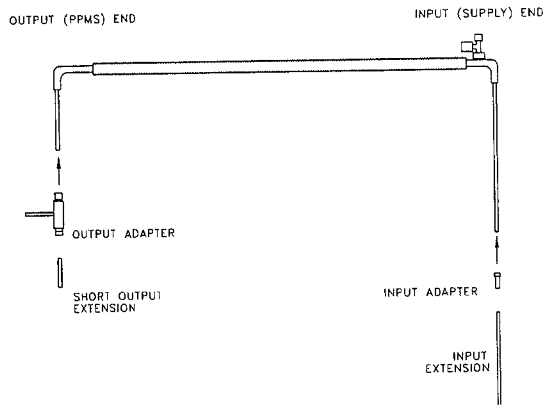


Figure 4-6. Helium-transfer line arrangement with the **short** output extension used for helium transfers into a **cold** dewar The transfer line for **warm** dewar fills has an long output extension.

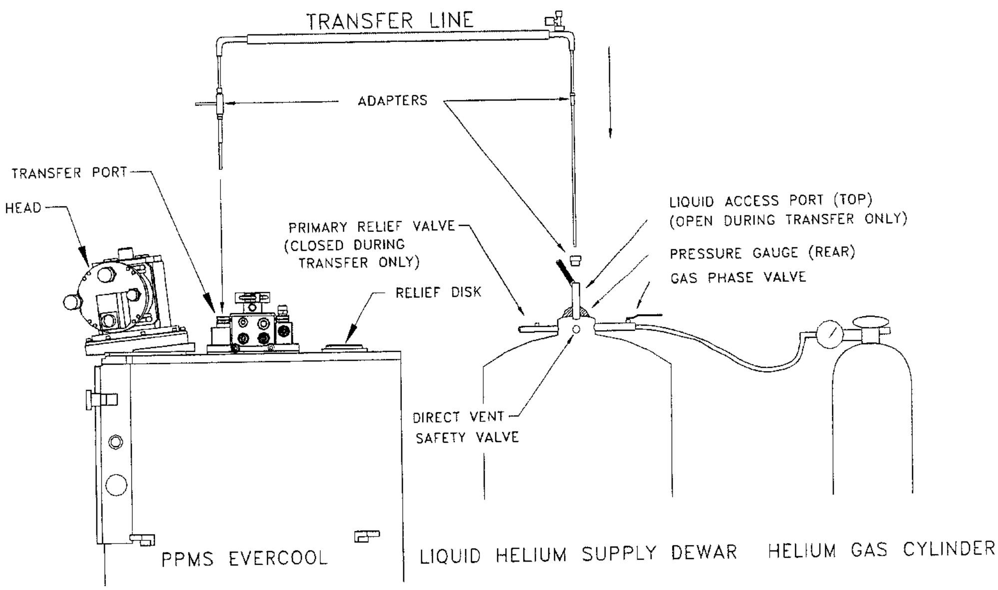


Figure 4-7. Transfer line and dewar setup for transferring liquid helium into a **cold** EverCool dewar.

1. Verify that you have the correct transfer-line adapters and extensions (Figure 4-6) and organize the EverCool dewar and supply dewars as shown in Figure 4-7.

   Note: The remaining instructions summarize the procedures given in Chapter 4 of the *PPMS Hardware Manual.*

2. Vent the pressure from the liquid-helium supply dewar by slightly opening the gas-phase valve and closing it when the pressure has been reduced.
3. Use rubber or plastic tubing to connect the helium-gas cylinder to the gas-phase port on the liquid-helium supply dewar.

4. In PPMS MultiVu, open the **Liquid Helium Fill Status** dialog box (**Utilities** >> **Helium Fill**), which is accompanied by a graph of the helium level (`heliumgr.dat`).

   Figure 4-8 illustrates the dialog box and the information it displays: the time remaining before the graph will automatically close; the current helium **Fill Rate**, **Helium Level**, and EverCool **Dewar Pressure**; and several sets of brief instructions.

   The instructions that are shown in the text box of Figure 4-8 have been incorporated into the current set of procedures.

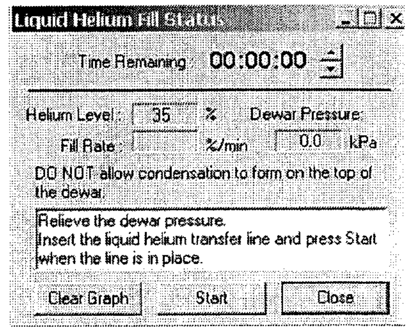


Figure 4-8. Liquid Helium Fill Status dialog box

5. Relieve the pressure in the EverCool dewar: Using a small blunt object such as a fingernail or the blunt end of paper clip, hold open the pressure-relief valve in the transfer-port fitting of the EverCool probe. When the reading in the **Liquid Helium Fill Status** dialog box reaches 0.5 psi (3.5 kPa), you can stop releasing helium gas.
6. At the liquid-helium supply cylinder, perform the following steps:
   a. Open the liquid-access port and close the primary relief valve.
   b. Lower the input end of the transfer line into the liquid-helium supply dewar.
7. At the PPMS EverCool dewar, perform the following steps:
   a. Remove a transfer-port fitting from the top of the dewar.
   b. Insert the output end of the transfer line. When gas flows from the output adapter, direct it away from the cold head on top of the dewar.
8. Click on the **Start (Done)** toggle button at the bottom of the **Liquid Helium Fill Status** dialog box. If the **Supply** valve was open and supplying helium to the dewar through the dewar hose, you can close it to prevent helium escaping from the open transfer-port.
9. At the liquid-helium supply cylinder, open the gas-phase valve.
10. At the helium-gas supply cylinder, open the regulator for transferring helium into the PPMS EverCool dewar.
11. Watch the status information in the **Liquid Helium Fill Status** dialog box and the plot of the helium fill on the graph until the EverCool dewar contains the desired level of liquid helium. We recommend that you fill it no higher than 65% to avoid plugging the condenser.
12. Click on the **Done** button at the bottom of the **Liquid Helium Fill Status** dialog box. The **Supply** valve will open to purge air from the dewar hose before you insert the transfer-port fitting back into the dewar.
13. Dry the transfer-port fitting, if necessary.
14. Insert the transfer-port fitting back into the dewar and lock the latch on it.
15. Click on the **Close** button to close the **Liquid Helium Fill Status** dialog box.

For more information about the helium data file, refer to the *Physical Property Measurement System: PPMS MultiVu Application User's Manual.*

4.2.5 Verifying and Resetting the Helium-Level Meter Calibration

The helium-level meter calibration for the PPMS EverCool system is performed at the factory and it should not be changed without consultation with Quantum Design. Proper operation of the EverCool system requires the standard helium-level meter calibration for the PPMS. If for some reason you believe the level meter calibration is wrong, contact Customer Service at Quantum Design to assess whether it would be appropriate to change the helium-level meter calibration. The standard calibration reads 0% when the level reaches the end of the PPMS probe (so that the helium-flow impedance is exposed), and it reads 100% when the level reaches the top of the dewar belly.

Important: These procedures require at least 20 cm (8 in.) of liquid helium and no more than 57 cm (22.5 in.) of liquid helium in the bottom of the dewar.

4.2.5.1 VERIFYING THE HELIUM-LEVEL METER CALIBRATION

You will use a liquid-helium thumper tube to check the helium-level meter calibration. The liquid-helium thumper tube is usually a long, thin tube with a balloon or membrane attached to one end. You lower the open end into the helium dewar, which sets up pressure oscillations in the tube that you can feel by placing a finger on the balloon or membrane. The tube must be long enough to reach all the way to the bottom of the dewar (1.1 m or 43 in.). You will be able to feel dramatic changes in the frequency of the pressure oscillations when you raise the end of the tube out of the surface of the liquid. This change is used to determine the height of liquid helium in the vessel.

WARNING!

Wear cryogenic safety gloves to protect your bare skin from the cold gas when you perform the following procedures. Work very carefully to prevent the gas burning your bare skin.

We strongly recommend that you review the instructions before you begin—that will facilitate the process and help you avoid injury.

1. Prepare a liquid helium thumper tube.
2. Use the **EverCool System** dialog box (Figure 4-4) to disable the cold head.
   a. Select **Instrument** >> **EverCool** to open the **EverCool System** dialog box.
   b. Click on the **Disable Cold Head** button.
3. Vent one of the transfer-port fittings by using a small blunt object (e.g., finger nail, round end of paper clip) to open the relief valve on the transfer-port fitting. *Do not* use a sharp object to open the relief valve, because it could tear the O-ring and damage the seal.
4. Unlatch the lock to a transfer-port fitting and quickly pull the fitting out of the dewar, moving your hand away from the transfer port to avoid cold burns. When you pull it out, the overpressure in the dewar will initially force a lot of cold gas out of the dewar.
5. Dry the transfer-port fitting and put it to the side where you can reach it.
6. Lower the thumper tube all the way to the bottom of the dewar, avoiding the cold gas that will flow from the transfer port as you lower the warm thumper tube into the dewar.
7. Use a piece of tape or a clip or similar object to mark the location where the tube enters the transfer port. Verify that the thumper tube has reached the bottom of the dewar (1.1 m or 43 in.) and is not resting on the edge of the dewar belly or on the magnet.

8. Lightly press on the balloon or membrane with your finger(s) so that you can sense the pressure oscillations in the liquid helium.
9. Slowly raise the thumper tube out of the dewar until you feel the oscillations change frequency. When you feel the change in frequency, mark the location where the tube enters the transfer port.
10. Remove the thumper tube from the dewar, re-insert the *dry* EverCool transfer-port fitting, and latch the fitting in place. You might need to push down quite hard on the fitting to get it to seat all the way in the port.
11. Measure the distance between the two markings you made on the thumper tube. Call this distance *T* (for thumped), which represents the height of liquid helium in the dewar.
12. Use one of the following standard formulas to translate *T* into the correct percent helium-level reading, *PH*:
    - in centimeters: $PH = 100\% \times (T - 9.1\text{ cm}) / 53\text{ cm}$
    - in inches: $PH = 100\% \times (T - 3.6\text{ in.}) / 21\text{ in.}$

    Important: If *PH* is less than 20%, you cannot recalibrate the level meter. The actual helium level in the dewar must be greater than 20 cm (8 in.) to change the calibration of the level meter. Likewise, if *PH* is greater than 90%, you cannot recalibrate the level meter because its resistance is too low. The helium level in the dewar must be less than 57 cm (22.5 inches) for you to change the helium-level meter calibration.
13. Compare the number calculated above in Step 12 to the helium level displayed in PPMS MultiVu or on the front panel of the Model 6000 PPMS Controller. If the values differ by more than about 2%, you should change the calibration stored in the Model 6000, as described below in Section 4.2.5.2. Otherwise, you have completed the verification.

4.2.5.2 RESETTING THE HELIUM-LEVEL METER CALIBRATION

1. Before you make any changes to the configuration files, back up the current level configuration and the other components of the PPMS system configuration by using the `Romcfg32` utility. This will ensure that you have the original files in the event your changes cause a problem. Refer to Quantum Design *Service Note 1070-803, Rev. B-0*, "Configuration Download Instructions," for instructions on backing up the system configuration.
2. Follow the steps below to set the correct percent helium reading in the Model 6000.
    a. On the front panel of the Model 6000, press on the **CONFIG** button, then select **4. Level Sensor**.
    b. Select **Current Level** with the arrow keys.
    c. Enter the value for percent helium that you calculated in Step 12 and press **ENTER**.
    d. Verify that the **Hourly Update** setting is set to **Yes**.
    e. Do *not* change the **Preheat Time** (10 seconds is the normal preheat time).
    f. Press **ALT + ENTER** to save the entry. The PPMS will immediately read the level meter to get a new voltage reading. You now have completed the recalibration procedure.
3. Back up the new level configuration and the other components of the PPMS system configuration by using the `Romcfg32` utility.

4.2.6 Shutting Down the System

If you will not be using the PPMS for an extended period of time or you have to shut it down for building maintenance such as power or water outages, follow this procedure to shut down the PPMS EverCool.

WARNING!

Before following this procedure, verify that the room is well ventilated. The helium that escapes from the EverCool dewar will displace air in an enclosed space.

1. Remove any sample or option probe from the sample chamber, clamp the blank flange on the chamber, and purge and seal the chamber.
2. Close the PPMS MultiVu software and any other PPMS software.
3. Turn off the main power switch on the front of the Sumitomo compressor. If you have a water-cooled compressor, shut off the flow of cooling water to the compressor.
4. Turn off the power to the PPMS electronics according to the cabinet design:

   Newer cabinets: Turn off the power by using the switch on the power distribution unit on the back of the cabinet.

   Older cabinets: Turn off the power by using the switch on the power strip mounted inside the back of the cabinet.
5. Remove the power to any other PPMS pumps or electronics that have plugs to an outlet.
6. **Optional Step: Saving the Helium for Future Use**

CAUTION!

Do not attempt this procedure unless you are experienced at transferring liquid helium.

a. Relieve the pressure in the EverCool dewar by using a small blunt object (e.g., finger nail, round end of paper clip) to open the relief valve on the transfer-port fitting. *Do not* use a sharp object to open the relief valve, because it could tear the O-ring and damage the seal.

b. Using the procedures given in the *PPMS Hardware Manual*, transfer the liquid helium from the EverCool dewar into another vessel.

   Important: If you empty the dewar or the helium level drops below 15%, you will need to use the **Startup Wizard** to restart the system (see Chapter 2). If you do not empty the dewar, you can restart the system by restoring power to the components in the reverse of the order given in these instructions, *so long as the helium level in the dewar is still greater than 15%* when you restart the system. If the helium level drops below 15%, you must warm the system to room temperature and use **Startup Wizard** to restart the system. The **Startup Wizard** is designed to start with the EverCool only at room temperature.

7. Remove the transfer-port fittings on the dewar and plug the transfer ports with the standard 1 psi (7 kPa) relief-valve fitting that is used for standard (non-EverCool) PPMS units (Figure 4-9). This fitting prevents high pressures from building up in the dewar while the EverCool is not being used. (As the inside of the EverCool dewar warms up, the liquid helium boils off more and more rapidly.)

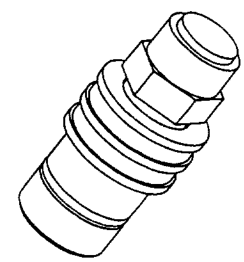


Figure 4-9. Dewar relief-valve fitting

4.3 Troubleshooting

4.3.1 Cold Head

The condensing of the helium inside of the EverCool dewar maintains the dewar pressure between two set points that are both above atmospheric pressure. A dewar overpressure is maintained to optimize helium condensation inside the dewar and to help prevent contamination of the dewar with gases other than helium. The cold head is turned on-and-off based on the pressure in the dewar. When the cold head is off, the pressure rises. If the pressure gets too high, helium will be lost, but relief valves throughout the system prevent any risk of equipment damage or injury to personnel.

If the pressure gets too low, the dewar can draw in contaminants from the atmosphere. These contaminants can plug the condenser or impedance assemblies, causing critical system failures. A pressure switch in the system shuts off the cold head if the pressure ever drops too close to atmospheric pressure.

WARNING!

If helium does not escape from the relief valves or relief disk when they are briefly pulled open, immediately contact your Quantum Design service representative. It is possible that there is a dangerous ice blockage.

The system will turn off the cold head under certain types of "failure modes" (see Section 4.3.2). Whenever the cold head is turned off, the cold head and dewar radiation shield slowly begin to warm to 300 K, causing the liquid helium in the dewar to boil and increasing the dewar pressure. If the cold head does not come on at the proper pressure set point, the dewar will begin to lose helium. The longer the cold head is left off, the warmer the cold head and radiation shield get, and the faster helium escapes.

Remember that the compressor and related parts require critical maintenance after approximately 20,000 hours of normal operation. If you see reduced cold-head performance before that time, check the timer on the bypass unit to see if the cold head has operated more than 10,000 hours. Symptoms of cold-head breakdown include a deterioration of the seal, increased noise during operation, longer times to liquefy helium, or difficulty maintaining a constant level of liquid helium.

Helium Loss

If cold-head operation is interrupted for several hours, the system will recover with only a slight loss of liquid helium (perhaps two liters of liquid helium lost for an interruption of six hours). The lost helium should be replaced automatically from the helium-gas supply cylinder within a day or two after the system resumes normal operation. However, if cold head operation is interrupted for several days to many weeks, the dewar will lose most of its liquid helium. The loss will begin gradually and should not pose a safety threat to laboratory personnel, but in a small laboratory it is important to keep the room well ventilated, because this large volume of helium will escape into the room and displace the air.

Conserving Liquid Helium

In the event you know that the cold head will be off for an extended time, you can conserve the liquid helium in the EverCool dewar by transferring it into a dedicated liquid-helium storage dewar that has lower static evaporation rates (see Section 4.2.6, "Optional Step"). Note that you will perform this procedure only if you expect the interruption to last significantly longer than one day and the dewar and PPMS will be warmed to room temperature, because several liters of liquid are typically lost during the transfer.

Important: Only personnel who are experienced at transferring liquid helium between dewars should perform this task.

4.3.2 Failure Modes

Different types of failures are described below in relation to their effect on operations of the PPMS EverCool system.

4.3.2.1 POWER INTERRUPTIONS

Loss of electricity should not cause damage to the equipment. In the event of a power loss, the EverCool system will recover automatically (without your intervention) as soon as power to the Model 6000 is restored, because the Model 6000 PPMS Controller performs the critical control operations.

If the system does not appear to be operating normally after a power loss, it could be due to associated events, such as tripping of a local breaker or fuse or power surges that damaged the equipment. Contact your Quantum Design service representative if you believe the system has not returned to normal operation after a power outage.

Three-Phase Power Loss

The cold head shuts off if the compressor *or* the Model 6000 loses power. If PPMS MultiVu is running and only the three-phase power to the compressor is lost, MultiVu will report the power loss and log it into the PPMS MultiVu event log. However, the power loss can be detected and reported only if the compressor does not receive any power. MultiVu does not issue a power-loss message if you turn off the power switch at the front of the compressor. When three-phase power is restored, the system should resume normal operation.

Important: It causes undue wear on the equipment when you often restart the compressor (i.e., turn it off and immediately back on). If your facility frequently switches between a public power grid and a private generator, consider installing an uninterruptible power supply (UPS) and/or delay circuitry to avoid undue wear on the compressor. Contact your Quantum Design representative for the specific requirements of such an arrangement.

Single-Phase Power Loss

The cold head shuts down when the Model 6000 loses only single-phase power. If PPMS MultiVu is running, it will report a communication error, because it will not be able to communicate with the Model 6000. When power is restored to the Model 6000, the EverCool should resume normal operations, but the system will default to the recirculating liquefaction state. You might need to restart PPMS MultiVu to re-establish communications between MultiVu and the Model 6000. To restart MultiVu, select **File** >> **Exit** from the main dropdown menus at the top of the MultiVu window. After MultiVu has closed, start it in your usual fashion.

24 V Power Loss

If only the +24 V power to the diaphragm-pump control unit is lost, the solenoid valves on the manifold will not operate. The system enters the recirculating state when these valves have no power, so helium should not be lost as long as the compressor has three-phase power and the Model 6000 has single-phase power.

Very brief power interruptions and brown-outs should not cause a significant loss of helium, but they might cause error messages from MultiVu or an interruption of sequence execution. They also might cause the PC and Model 6000 to reboot.

4.3.2.2 COMPRESSOR

Cooling Water Loss/Temperature Alarm

A temperature alarm in the Sumitomo compressor indicates that the flow of cooling water or air is inadequate to cool the compressor. If this alarm is tripped, PPMS MultiVu reports the alarm in a pop-up message and logs the error condition in the PPMS MultiVu event log. The temperature alarm automatically shuts off the compressor and cold head.

In the event that the compressor temperature alarm is tripped and the compressor shuts itself off, it will not resume operation until you have reset the compressor. You should wait to do this until you are certain that adequate cooling has been restored. To reset the compressor, cycle the main power switch on the front of the compressor unit off and back on. Refer to the Sumitomo *Operation Manual* for your compressor for further information regarding the temperature alarm.

Compressor Pressure Alarm

A pressure alarm in the Sumitomo compressor indicates that the charge of high-pressure helium gas used to cool the cold head has reached an unacceptable level. If this alarm is tripped, PPMS MultiVu reports the alarm in a pop-up message and logs the error condition in the PPMS MultiVu event log. The pressure alarm automatically shuts off the compressor.

The helium pressure in the compressor can drop if the compressor has a leak, if helium leaked out of the fittings on the large hoses when they were connected, or if the fittings on these hoses are dirty. The helium in the compressor should be recharged by a qualified Quantum Design or Sumitomo representative. Refer to the Sumitomo *Operation Manual* for your compressor for further information regarding the pressure alarm.

Dewar Underpressure Alarm

The EverCool manifold contains a pressure switch that is set to open if the gauge pressure in the dewar drops below approximately 0.5 psi (3.5 kPa). This is a hardware fail-safe that prevents the cold head from cryopumping contaminants from the atmosphere into the dewar. If this switch opens, the system immediately turns off the cold head and PPMS MultiVu reports the underpressure state in a pop-up message. The underpressure event will be logged to the PPMS MultiVu event log.

The EverCool dewar always operates above atmospheric pressure so that contaminants from the atmosphere are not drawn into the dewar. However, certain normal operating procedures cause pressure in the dewar to drop to atmospheric pressure. For example, you must remove a transfer-port fitting from the probe if you transfer liquid helium into the EverCool dewar. The transfer-port fitting seals the dewar, so removing it will cause the pressure to drop below the set point of the pressure switch and trip the underpressure alarm.

In addition, if you leave the sample chamber venting continuously for a long time, the dewar pressure can drop below the pressure set point because the sample chamber is vented with the helium gas in the EverCool dewar.

While the system is operating, you must *never* allow the EverCool dewar to remain in an underpressure condition for a long time. If it is necessary to open the dewar to atmosphere, maintain a positive flow of helium *out* of the dewar to help keep contaminants out of the dewar. Then you should seal the dewar again as soon as possible. Only vent the sample chamber for the time required to insert or remove a sample—continuous venting will prevent the dewar pressure from reaching the upper set point that turns on the cold head, so it will stay off.

The underpressure alarm could indicate that there is a leak (perhaps a gross leak) into the system, which can cause a critical system failure if it is not corrected quickly. Even if the leak is not significant, a persistent underpressure state (for example, due to continuous sample chamber venting), can cause the dewar to lose helium as the cold head and radiation shield warm to 300 K. If an underpressure alarm occurs for a known reason, it is important to reseal the system and verify that it resumes normal operation within a few minutes. If an underpressure alarm occurs for an unknown reason, it is important to determine and treat the cause immediately.

4.4 Required Maintenance and Log

The following maintenance procedures should be performed regularly. Some of the services must be performed by a qualified Quantum Design representative and you will need to schedule the maintenance visit with them. Chapter 1 contains a list of our service representatives in different locations around the world.

The cryocooler system can be seriously damaged if it is not serviced properly. Other system components must be serviced at the same time as the compressor. For example, the compressor requires servicing after approximately 20,000 hours of normal operation—a timer on the front tracks the amount of time it has been operating. The cold head will operate at optimal efficiency for less than 20,000 hours, but because it does not operate continuously, it will require servicing at about the same time as the compressor.

You will need to shut down the system about one week before the maintenance is performed, because the cold head can be serviced only when it is at room temperature.

Section 4.2 of this manual and Chapter 4 of the *PPMS Hardware Manual* have instructions for services that you and other onsite personnel can perform.

Table 4-1. Maintenance procedures required for the EverCool system

PART	SERVICE	FREQUENCY	WHO PERFORMS
Compressor	Replace compressor adsorber	20,000 hours	QD service personnel
Cold head	Replace cold-head seals	20,000 hours	QD service personnel
Scroll pump*	Replace tip seals	4,300 hours	QD service personnel
Diaphragm pump valve-control	Replace diaphragms	20,000 hours or as needed	QD service personnel
	Replace charcoal filter	20,000 hours	QD service personnel
Compressor: Air-cooling unit	Clean air intake, exhaust vents, fins of cooling units	See operating manual	Site personnel
Compressor: Water-cooling unit	Service the water filter per manufacturer manual	See operating manual	Site personnel
Rotary-vane pump*	Replace coalescing filter element	When saturated with oil	QD service personnel
	Oil-mist cartridge	When saturated with oil	Site personnel
	Change pump oil	Yearly or sooner	Site personnel
	Check seals	20,000 hours	QD service personnel

*Most PPMS EverCool systems are equipped with the scroll pump illustrated in Figure 1-6, but some use a rotary-vane pump. If you are uncertain which type of pump is being used on your system, contact Customer Service at Quantum Design.

Maintenance Log

Make additional copies of the following maintenance log as necessary.

DATE	COMPRESSOR HOURS	BYPASS UNIT HOURS	WORK PERFORMED BY/AFFILIATION

WORK COMPLETED

[ ] Replace compressor adsorber

[ ] Replace cold head seals

[ ] Replace coalescing-filter element (rotary vane pump)

[ ] Change rotary-vane pump oil (rotary vane pump)

[ ] Replace scroll-pump tip seals (scroll pump)

[ ] Replace diaphragm pump diaphragms

[ ] Other (explain)

COMMENTS

Maintenance Log

DATE	COMPRESSOR HOURS	BYPASS UNIT HOURS	WORK PERFORMED BY/AFFILIATION

WORK COMPLETED

[ ] Replace compressor adsorber
[ ] Replace cold head seals
[ ] Replace coalescing-filter element (rotary vane pump)
[ ] Change rotary-vane pump oil (rotary vane pump)
[ ] Replace scroll-pump tip seals (scroll pump)
[ ] Replace diaphragm pump diaphragms
[ ] Other (explain)

COMMENTS

Maintenance Log

DATE	COMPRESSOR HOURS	BYPASS UNIT HOURS	WORK PERFORMED BY/AFFILIATION

WORK COMPLETED

[ ] Replace compressor adsorber

[ ] Replace cold head seals

[ ] Replace coalescing-filter element (rotary vane pump)

[ ] Change rotary-vane pump oil (rotary vane pump)

[ ] Replace scroll-pump tip seals (scroll pump)

[ ] Replace diaphragm pump diaphragms

[ ] Other (explain)

COMMENTS

Maintenance Log

DATE	COMPRESSOR HOURS	BYPASS UNIT HOURS	WORK PERFORMED BY/AFFILIATION

WORK COMPLETED

[ ] Replace compressor adsorber

[ ] Replace cold head seals

[ ] Replace coalescing-filter element (rotary vane pump)

[ ] Change rotary-vane pump oil (rotary vane pump)

[ ] Replace scroll-pump tip seals (scroll pump)

[ ] Replace diaphragm pump diaphragms

[ ] Other (explain)

COMMENTS

Maintenance Log

DATE	COMPRESSOR HOURS	BYPASS UNIT HOURS	WORK PERFORMED BY/AFFILIATION

WORK COMPLETED

[ ] Replace compressor adsorber

[ ] Replace cold head seals

[ ] Replace coalescing-filter element (rotary vane pump)

[ ] Change rotary-vane pump oil (rotary vane pump)

[ ] Replace scroll-pump tip seals (scroll pump)

[ ] Replace diaphragm pump diaphragms

[ ] Other (explain)

COMMENTS

Maintenance Log

DATE	COMPRESSOR HOURS	BYPASS UNIT HOURS	WORK PERFORMED BY/AFFILIATION

WORK COMPLETED

[ ] Replace compressor adsorber

[ ] Replace cold head seals

[ ] Replace coalescing-filter element (rotary vane pump)

[ ] Change rotary-vane pump oil (rotary vane pump)

[ ] Replace scroll-pump tip seals (scroll pump)

[ ] Replace diaphragm pump diaphragms

[ ] Other (explain)

COMMENTS

A P P E N D I X A

Electrical Connections and Ports

A.1 Introduction

- Section A.2 contains the EverCool system electrical connection diagram.
- Section A.3 illustrates the ports on the diaphragm-pump control unit.
- Section A.4 discusses the compressor bypass unit.
- Section A.5 illustrates the EverCool system connector cables.

A.2 Electrical Interconnect Diagram

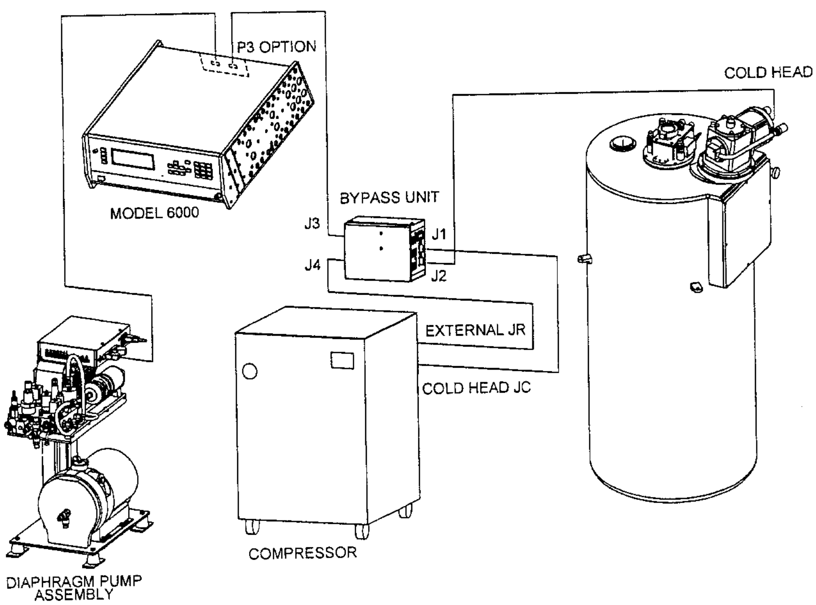
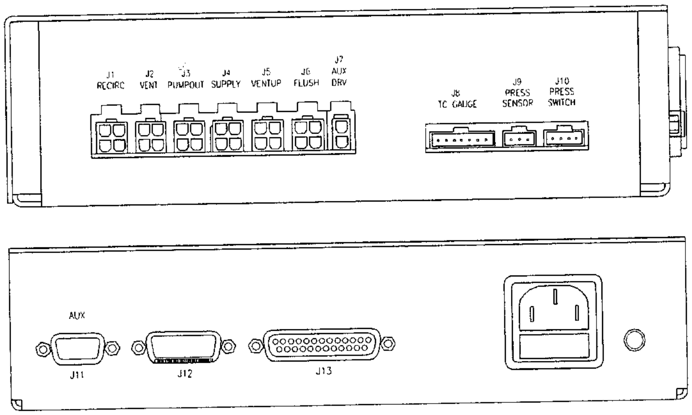


Figure A-1. Electrical interconnect diagram for the PPMS EverCool system

A.3 Diaphragm-Pump Control Unit

One electrical port on the diaphragm-pump control unit connects the diaphragm-pump assembly to the Model 6000 PPMS Controller. Sensors carry gas-pressure status information to the EverCool controller card in the Model 6000. Molex connectors energize the plumbing valves. LEDs inside the diaphragm-pump control unit light up when the corresponding valves are energized and are visible only when the cover of the control unit is removed.



A. Electrical ports

B. Sensors and molex connector

Figure A-2. Connectors and electrical ports on diaphragm- pump control unit

A.4 Compressor Bypass Unit

The compressor bypass unit interrupts cold-head operation so that the system can maintain overpressure in the EverCool dewar. The compressor bypass unit intercepts the logic signals between the EverCool controller card and the compressor and interrupts the power lines between the compressor and the cold head. For water-cooled systems, the bypass unit also contains a solenoid valve that opens when the cold head is shut off. This solenoid valve opens to shunt the high-pressure helium around the cold head. For air-cooled systems, this valve is inside the compressor.

A.5 EverCool System Cables

The diaphragm-pump cable connects the diaphragm-pump assembly to the Model 6000. The Model 6000 uses this cable to read the state of the plumbing valves and the dewar-pressure signal so that it can regulate the duty cycle of the cold head. The diaphragm-pump cable plugs into the P12 or J12 port on the diaphragm-pump control unit and into the P3–Option port on the Model 6000.

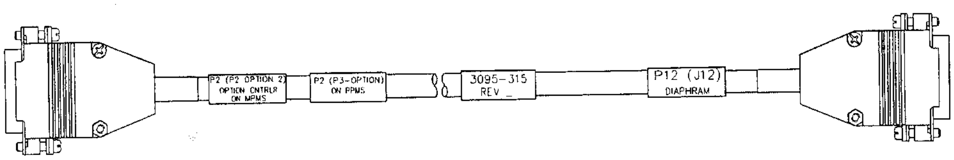


Figure A-3. Diaphragm-pump cable

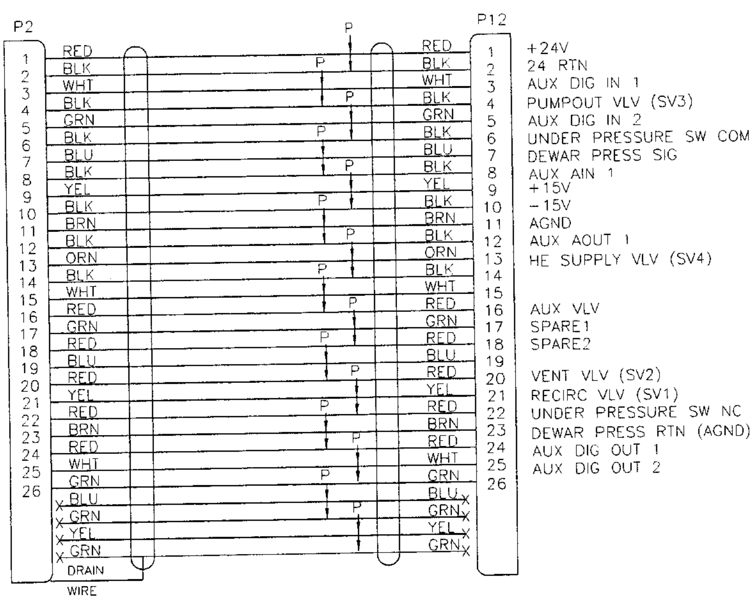
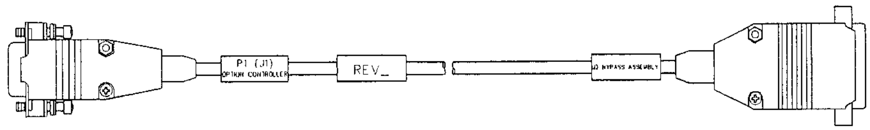


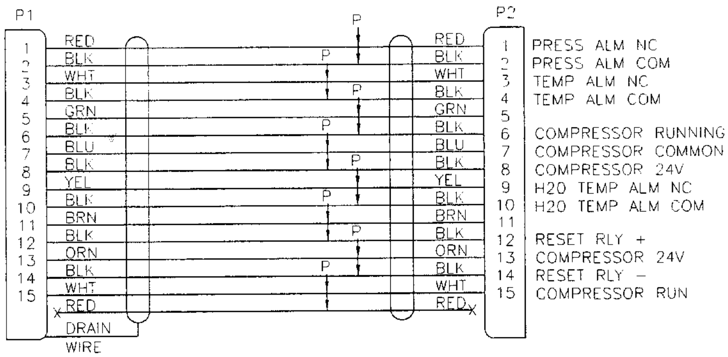
Figure A-4. Wiring diagram for diaphragm-pump cable

A.5.1 Sumitomo Compressor Cable

The Sumitomo compressor cable (Model CSW-71 Series) connects the compressor bypass unit to the Model 6000. The option controller uses the cable to manage the duty cycles of the cold head and receive compressor-alarm signals. The Sumitomo compressor cable plugs into the P2 port on the compressor bypass unit and into the P1 port on the Model 6000.



A. Sumitomo compressor cable

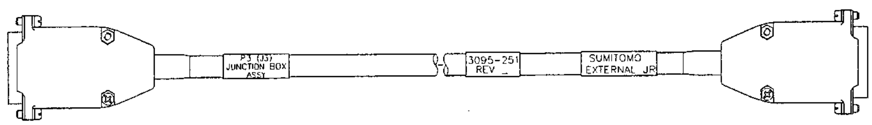


B. Wiring diagram for Sumitomo compressor cable

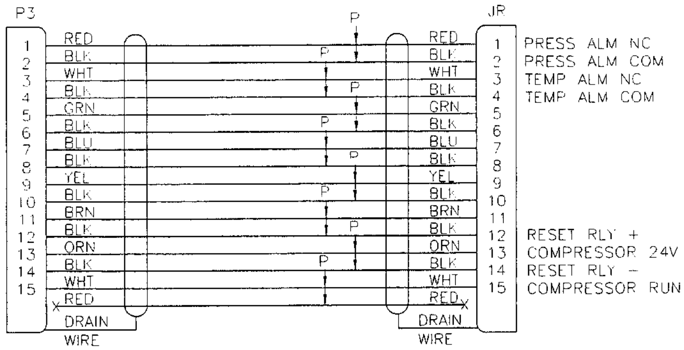
Figure A-5. Sumitomo compressor cable and wiring diagram

A.5.2 Bypass Compressor Cable

The bypass compressor cable connects the compressor bypass unit to the Sumitomo compressor. This cable is used to control the cold head without interrupting the compressor. The bypass compressor cable plugs into the P3 or J3 port on the compressor bypass unit and into the External JR port on the compressor.



A. Bypass compressor cable



B. Wiring diagram for bypass compressor cable

Figure A-6. Bypass compressor cable and wiring diagram

A P P E N D I X B

Evercool.ini File

B.1 Introduction

- Section B.2 presents an overview of the `Evercool.ini` file.
- Section B.3 presents the contents of the Evercool section.
- Section B.4 presents an overview of the He_Level_Control section.
- Section B.5 presents an overview of the Dewar_Pressure section.
- Section B.6 presents an overview of the Startup_Wizard section.
- Section B.7 presents an overview of the Dewar_Thermometers section.

B.2 Contents of the Evercool.ini File

The values in the `Evercool.ini` file are read out of the appropriate section when the PPMS MultiVu software is started. The values are used to initialize certain variables in the software.

In this appendix, default settings are in brackets, and the names of the major sections of the file are identified with square brackets.

The `Evercool.ini` file is in the `C:\QdPpms\Evercool` directory.

User modification of the values in the `Evercool.ini` file is generally unnecessary.

B.3 Section: [Evercool]

`Pump_Startup_Vent_Time (integer) {28800}`

This value sets the time in seconds that the **Evercool System Start-up Wizard** should exhaust the pump output to atmosphere after it completes the dewar purge sequence, which ensures that the pump exhaust is clean before the pump output is recirculated back into the dewar.

`Vane_Pump_Output_Clean (boolean) {1}`

This flag indicates whether the software should consider the exhaust of the scroll pump (or rotary-vane pump) clean. If the output is not clean, the software may exhaust the pump output to atmosphere depending on the values found in `Pump_Clean_Timer` and `Shutdown_Time`.

`Pump_Clean_Timer (double) {0}`

This is the time remaining in seconds on the pump start-up vent timer when PPMS MultiVu was last shut down. The EverCool option generates this field—***do not*** change it.

`Shutdown_Time (double) {present Model 6000 time stamp}`

This is the absolute time stamp (in seconds) when PPMS MultiVu was last shut down. This value is used to calculate any remaining time that needs to be set on the pump start-up vent timer if the EverCool was venting the pump output to atmosphere for cleaning when PPMS MultiVu was last shut down. The EverCool option generates this field—***do not*** change it.

`Enable_Pressure_Ctrl_Dlg (boolean) {0}`

This value provides access to the pressure set points dialog, which is used to change the EverCool dewar-pressure set points from within PPMS MultiVu. Typically, these set points should not be changed, so this window is not usually enabled.

B.4 Section: [He_Level_Control]

`He4_Level_Control_Enabled (boolean) {0}`

This flag indicates whether automatic helium-level control was enabled the last time PPMS MultiVu was shut down. When PPMS MultiVu starts again, it enables or disables automatic helium-level control based on this setting in the `Evercool.ini` file.

`Zero_Percent_Voltage (float) {18.0}`

This value approximates the level-meter calibration. The **Evercool System Start-up Wizard** will not proceed beyond the system verification step if it reads a level-meter voltage lower than this value. When the system is being filled, this value is only an approximate helium level until the voltage drops below 80% of this value. This technique guards against faulty level-meter calibrations stored in the Model 6000.

`High_He4_Level (float) {70}`

This is the maximum percent helium level allowed in the dewar during filling mode when automatic helium-level control is enabled. When the percent helium level has risen to this value, the system closes the **Supply** valve.

`Low_He4_Level (float) {65}`

This is the minimum percent of helium level allowed in the dewar when automatic helium-level control is enabled. When the percent helium level drops to this value, the system opens the **Supply** valve.

B.5 Section: [Dewar_Pressure]

`High_Pressure_Limit (float) {14}`

If the EverCool is under automatic (system) control, this is the maximum pressure (kPa) the system allows in the dewar before it turns on the cold head.

`Low_Pressure_Limit (float) {7}`

If the EverCool is under automatic (system) control, this is the minimum pressure (kPa) the system allows in the dewar before it turns off the cold head.

`MapDat_Channel (integer) {59}`

This value sets the mappable channel used as the default for mapping the dewar pressure sensor reading in the **EverCool Dewar Diagnostics** dialog box (Figure 3-5). You can select another channel before you perform the mapping in this dialog.

`Table_File (string) {}`

This is the name of the file that contains the calibration for the dewar pressure sensor. The file should reside in the `C:\QdPpms\Evercool` directory.

B.6 Section: [Startup_Wizard]

`Zero_Pressure_Timeout (float) {30.0}`

This is the time in seconds that the **Evercool System Start-up Wizard** waits for the pressure reading to reach zero during the dewar pump-out procedure. If it does not reach zero in that time, the wizard will display an error message.

`Back_Fill_Time (float) {600.0}`

This is the time in seconds that the **Evercool System Start-up Wizard** waits for the pressure reading to rise above the `Filling_Pressure` setting during the dewar-backfill procedure. If the pressure reading has not risen above the `Filling_Pressure` setting in that time, the wizard will display an error message.

`Pump_Out_Time (float) {415.0}`

This is the time in seconds that the **Evercool System Start-up Wizard** pumps on the dewar after the pressure reading has dropped to zero during the dewar pump-out procedure .

`Filling_Pressure (float) {7.0}`

This is the target pressure (kPa) during the dewar-backfill procedure. When the dewar pressure reaches this value, the **Evercool System Start-up Wizard** will close the **Supply** valve and proceed to the next step.

B.7 Section: [Dewar_Thermometers]

`2nd_Stage_Bridge_Channel (integer) {1}`

This is the Model 6000 user-bridge channel that is used to read the cold-head second-stage thermometer. This channel is configured when you select **Load Dewar Bridge Config** in the **EverCool Dewar Diagnostics** dialog (see Section 3.3.5).

`Condenser_Bridge_Channel (integer) {3}`

This is the Model 6000 user-bridge channel that is used to read the thermometer on the EverCool condenser. This channel is also configured when you select **Load Dewar Bridge Config** in the **EverCool Dewar Diagnostics** dialog.

`2nd_Stage_MapDat_Channel (integer) {60}`

This is the GetDat channel that is used to map the calibrated readings of the cold-head second-stage thermometer so that they can be logged to a file. This is the default channel for the second-stage thermometer in the **EverCool Dewar Diagnostics** dialog—you can select a different channel.

`Condenser_MapDat_Channel (integer) {61}`

This is the GetDat channel that is used to map the calibrated readings of the EverCool condenser thermometer so that they can be logged to a file. This is the default channel for the condenser thermometer in the **EverCool Dewar Diagnostics** dialog—you can select a different channel.

`2nd_Stage_Table_File (string) {}`

This is the name of the calibration file for the cold-head second-stage thermometer. The file should reside in the `C:\QdPpms\Evercool` directory, and it normally follows the naming convention `MEC***.tab`, where `***` is a thermometer serial number.

`Condenser_Table_File (string) {}`

This is the name of the file that contains the calibration for the EverCool condenser thermometer. The file should reside in the `C:\QdPpms\Evercool` directory, and it normally follows the naming convention `MEC***.tab`, where `***` is a thermometer serial number.

References

Quantum Design. 2004. *Physical property measurement system: Hardware manual.*

———. 2000. *Physical property measurement system: Heat Capacity option user's manual.*

———. 2000. *Physical property measurement system: PPMS MultiVu application user's manual.*

———. 2004. *Service note 1070-803*, Configuration download instructions.

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Quantum Design

Physical Property Measurement System

Ultra Low Field Option User's Manual

Part Number 1077-150A

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Second edition of manual completed February 1999.

Trademarks

U.S. Patents

4,791,788	Method for Obtaining Improved Temperature Regulation When Using Liquid Helium Cooling
4,848,093	Apparatus and Method for Regulating Temperature in a Cryogenic Test Chamber
5,311,125	Magnetic Property Characterization System Employing a Single Sensing Coil Arrangement to Measure AC Susceptibility and DC Moment of a Sample (patent licensed from Lakeshore)
5,647,228	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber
5,798,641	Torque Magnetometer Utilizing Integrated Piezoresistive Levers

Foreign Patents

U.K.	9713380.5	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber

C O N T E N T S

Table of Contents

CHAPTER 3
System Operation

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P R E F A C E

Contents and Conventions

P.1 Introduction

This preface contains the following information:

- Section P.2 discusses the overall scope of the manual.
- Section P.3 briefly summarizes the contents of the manual.
- Section P.4 illustrates and describes conventions that appear in the manual.

P.2 Scope of the Manual

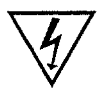
This manual describes the PPMS Ultra Low Field option. This manual describes how you install the Ultra Low Field option, how you use the fluxgate magnetometer that enables low-field operations, and how you perform low-field operations.

PPMS MultiVu is the software application controlling the Ultra Low Field system. PPMS MultiVu runs on Windows 95. This manual assumes you are familiar with Windows 95.

P.3 Contents of the Manual

- Chapter 1 introduces the PPMS Ultra Low Field option and explains how to install the option.
- Chapter 2 describes the operation of the fluxgate magnetometer.
- Chapter 3 explains how to perform low-field operations.

P.4 Conventions in the Manual

File menu	Bold text distinguishes menus, options, buttons, and panels appearing on the PC monitor or on the Model 6000 PPMS Controller LCD screen.
File➢Open	The ➢ symbol indicates that you select multiple, nested software options.
STATUS	Bold text and all capital letters distinguish the names of keys located on the front panel of the Model 6000 PPMS Controller.
`.cal`	The Courier font distinguishes characters you enter from the PC keyboard or from the Model 6000 PPMS Controller front panel. The Courier font also distinguishes code and the names of files and directories.
<Enter>	Angle brackets distinguish the names of keys located on the PC keyboard.
<Alt+Enter>	A plus sign connecting the names of two or more keys distinguishes keys you press simultaneously.
	A pointing hand introduces a supplementary note.
	An exclamation point inside an inverted triangle introduces a cautionary note.
	A lightning bolt inside an inverted triangle introduces a warning.

C H A P T E R 1

Introduction and Installation

1.1 Introduction

This chapter contains the following information:

- Section 1.2 presents an overview of the PPMS Ultra Low Field option.
- Section 1.3 explains how to install the PPMS Ultra Low Field option.

1.2 Overview of the Ultra Low Field Option

The PPMS Ultra Low Field option performs two functions: (1) it profiles the magnetic field that is in the sample chamber and (2) it nulls, or *zeroes*, the magnetic field at a specific position in the sample chamber. To perform each function, the Ultra Low Field option uses the 5-G fluxgate magnetometer, the low-field magnet coil, the magnet reset heater, and the ACMS insert, ACMS sample transport, and ACMS board. The fluxgate magnetometer, which measures the field, fits inside the ACMS insert and has its movement controlled by the ACMS sample transport. The PPMS AC Measurement System (ACMS) option must be installed in the PPMS unit in order for the Ultra Low Field option to operate.

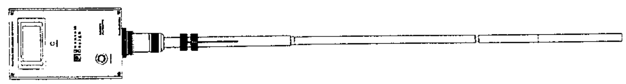
The Ultra Low Field option zeroes the magnetic field at a specific position in the sample chamber by iteratively applying a compensation field with the low-field magnet coil while quenching the 7-T or 9-T PPMS superconducting magnet. The low-field magnet coil is a unique superconducting coil wound directly on a specially designed coil form that fits between the outer vacuum jacket and the superconducting magnet. The ACMS board in the Model 6000 PPMS Controller provides the drive current that runs the low-field magnet coil. The compensation field the low-field magnet coil applies is used to adjust the flux trapped in the superconducting magnet. Fields of less than 0.05 G can be achieved at a user-specified location in the sample chamber.

1.2.1 Overview of Software

PPMS MultiVu is the software application controlling and monitoring the operation of the Ultra Low Field option and the PPMS hardware. When you install the Ultra Low Field option, you install a software module into PPMS MultiVu. The software module enables all low-field operations. The Ultra Low Field software module effectively becomes part of PPMS MultiVu.

1.2.2 Overview of Hardware

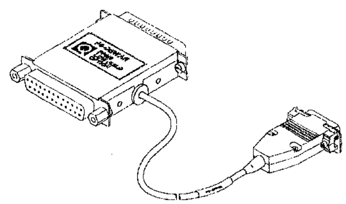
1.2.2.1 FLUXGATE MAGNETOMETER



The 5-G fluxgate magnetometer is used for all low-field functions.

The fluxgate magnetometer assembly includes a wall bracket and a fluxgate cable. The wall bracket holds the fluxgate magnetometer when the fluxgate magnetometer is not in the sample chamber. The wall bracket also provides a magnetic shield. The fluxgate cable connects the fluxgate magnetometer to the Model 6000 PPMS Controller.

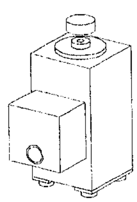
1.2.2.2 ULTRA LOW FIELD OPTION INTERFACE CABLE



The Ultra Low Field option interface cable reroutes the signal from the ACMS board and sends the signal to the low-field magnet coil.

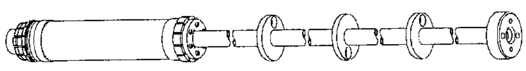
The Ultra Low Field option interface cable assembly has three connectors. The J1 and J2 connectors are on opposite ends of the large, silver-colored box that is labeled "P6–Dewar PPMS Low Field Option." The low-field coil connector is at the end of the cable that is attached to the silver-colored box.

1.2.2.3 PPMS ACMS OPTION HARDWARE



ACMS Sample Transport

The ACMS sample transport controls the movement of the fluxgate magnetometer when the fluxgate magnetometer is installed in the sample chamber. The ACMS insert guides the fluxgate magnetometer while the fluxgate magnetometer is inside the sample chamber. The ACMS board sends the signal that controls the nulling function.



ACMS Insert

The *Physical Property Measurement System: ACMS User's Manual* (Quantum Design 1996) discusses the ACMS hardware in detail.

1.3 Installing the Ultra Low Field Option

The following installation procedure assumes the ACMS board, the ACMS sample transport, and the ACMS insert are installed in the PPMS unit. The *Physical Property Measurement System: ACMS User's Manual* (Quantum Design 1996) explains how you install the ACMS hardware.

1.3.1 Install the Option Software

1. Load the installation disk into the control PC.
2. Run `setup.exe`, and then follow the on-screen instructions. The Ultra Low Field software module is copied to the PC hard drive and will run as part of PPMS MultiVu. The Low Field configuration file, `LowField.cfg`, is also copied to the hard drive.

1.3.2 Install the Wall Bracket

1. Choose a location to hang the fluxgate wall bracket. You should hang the wall bracket relatively close to the PPMS dewar.
2. Hold the wall bracket so that the permalloy fluxgate shield is at the bottom of the wall bracket and the wall bracket just rests on the floor. Figure 2-3 illustrates the wall bracket.
3. Use the four flathead screws included with the wall bracket assembly to attach the wall bracket to the wall.

1.3.3 Install the Option Cable

1. Disconnect the dewar cable from the "P6–Dewar" port on the back of the Model 6000. Keep the opposite end of the cable plugged into the blue Lemo port on the PPMS probe head.
2. Plug the J1 connector on the Ultra Low Field option interface cable into the "P6–Dewar" port. Let the low-field coil connector that is on the Ultra Low Field option interface cable remain dangling.
3. Plug the free end of the dewar cable into the J2 connector on the Ultra Low Field option interface cable.

1.3.4 Activate the Option

1. Open the PPMS MultiVu application.
2. Select **Utilities➢Activate Option**. The **Option Manager** dialog box opens.

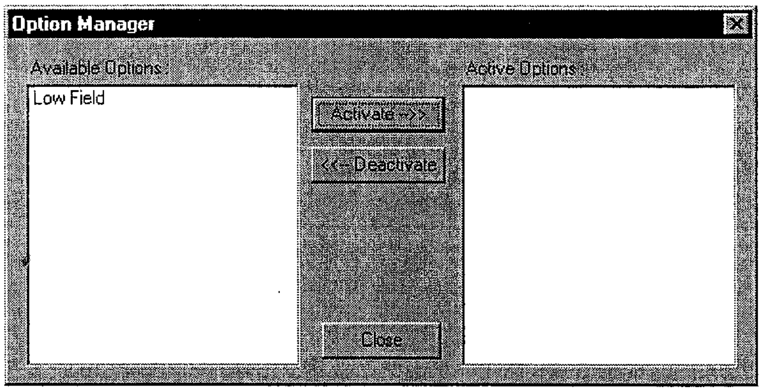


Figure 1-1. **Option Manager** Dialog Box

3. Click once on **Low Field** in the **Available Options** panel.
4. Select **Activate**. The Ultra Low Field option is activated. The **Option Manager** dialog box automatically closes.

To deactivate the Ultra Low Field option, click once on **Low Field** in the **Active Options** panel that is in the **Option Manager** dialog box, and then select **Deactivate**.

C H A P T E R 2

Fluxgate Magnetometer

2.1 Introduction

This chapter contains the following information:

- Section 2.2 presents an overview of the fluxgate magnetometer.
- Section 2.3 explains how to determine whether the fluxgate magnetometer is operating properly.
- Section 2.4 explains how to adjust the zero offset of the fluxgate magnetometer.
- Section 2.5 explains how to replace the battery that provides power to the fluxgate magnetometer.

2.2 Overview of the Fluxgate Magnetometer

The 5-G fluxgate magnetometer is a vector instrument that reads the magnetic field parallel to the long axis of the fluxgate probe. The 5-G fluxgate magnetometer must be installed in the sample chamber in order for the Ultra Low Field option to zero the magnetic field at a specific position or plot the field profile. The fluxgate is specifically designed to fit inside the ACMS insert and to have its movement controlled by the ACMS sample transport.

The fluxgate sensor in the fluxgate magnetometer measures the field inside the sample chamber. The sensor, which is 1.1 cm above the bottom of the fluxgate probe, is embedded in the G-10 fiberglass tube that comprises the lower part of the fluxgate probe. The fiberglass housing prevents the fluxgate sensor from contacting anything magnetic. The ACMS sample transport moves the fluxgate probe up and down within the sample chamber so that the fluxgate sensor can measure the field at any number of locations. PPMS MultiVu reads the field measurements and can plot them or instruct the system to apply a compensation field that nulls the measured remnant.

CAUTION

Handle the fluxgate magnetometer carefully to avoid damaging the fiberglass tube and the fluxgate sensor that are at the bottom of the fluxgate probe. Use only the stainless steel portion of the fluxgate probe to hold the probe. Never use the fiberglass tube to hold the probe.

The fluxgate is designed for operation only at low fields and should not be exposed to DC fields over 100 G. The performance of the fluxgate sensor has not been characterized at cryogenic temperatures.

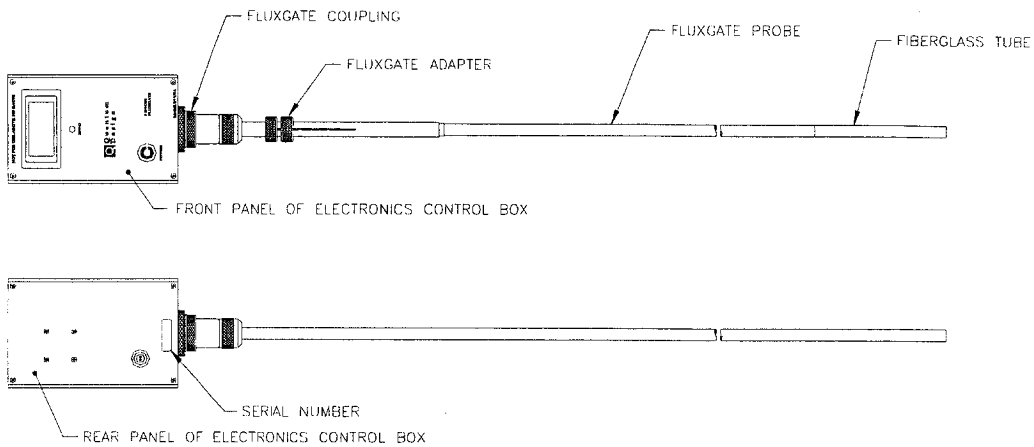


Figure 2-1. Front and Rear View of 5-G Fluxgate Magnetometer

Section 3.3.1 explains how you install the fluxgate magnetometer in the sample chamber. Section 3.3.2 explains how you remove the fluxgate magnetometer from the chamber.

2.2.1 Electronics Control Box

The electronics control box, which mounts on top of the fluxgate probe, houses the electronics that operate the fluxgate sensor. The digital display on the front panel of the electronics control box shows the field, in gauss, as measured by the sensor. The "Power" button turns on or off the power to the fluxgate. The zero-adjustment screw adjusts the zero offset of the fluxgate. The fluxgate cable plugs into the port on the rear panel of the electronics control box.

The electronics control box may be detached from the fluxgate probe. To detach the box, loosen the fluxgate coupling, which is at the top of the fluxgate probe, and then pull the box off the probe. Figures 2-1 and 2-4 illustrate the fluxgate coupling.

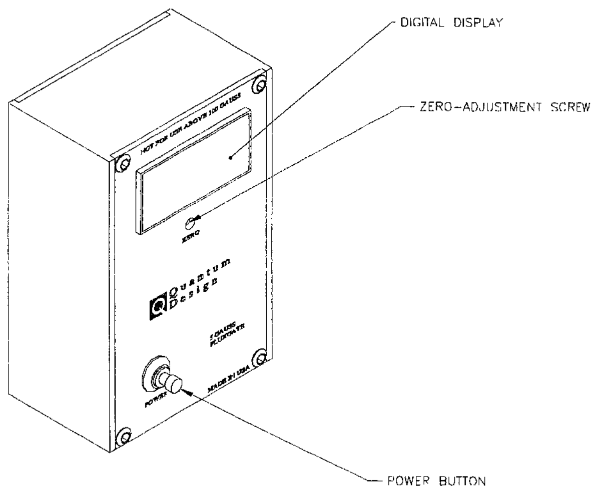


Figure 2-2. Front Panel on Electronics Control Box

NOTE

Quantum Design assigns a serial number to the electronics control box and to the fluxgate probe to ensure that the electronics control box is used with the correct probe. You should verify that the serial numbers on the electronics control box and the fluxgate probe match.

2.2.2 Wall Bracket

The fluxgate magnetometer assembly includes a wall bracket. The wall bracket holds the fluxgate when the fluxgate is not installed in the sample chamber. The wall bracket mounts vertically on any wall.

Near the base of the wall bracket is a two-layer permalloy fluxgate shield. When the fluxgate is in the wall bracket, the fluxgate shield protects the fiberglass tube and fluxgate sensor that are at the bottom of the fluxgate probe. The fluxgate shield is also a magnetic shield providing more than 60-dB attenuation of the earth's magnetic field. Within the shield there is thus a remnant field of less than 0.5 mG.

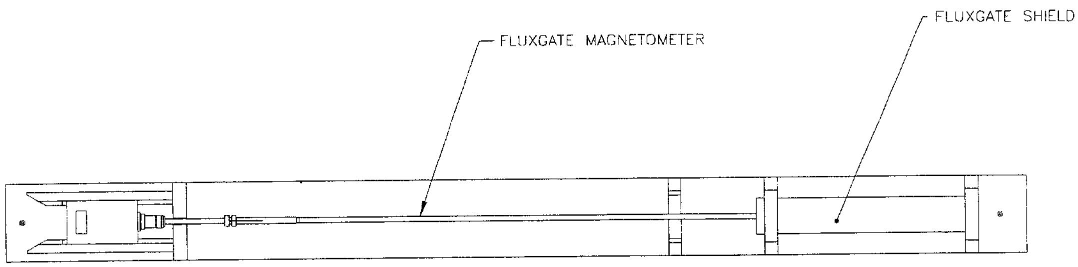


Figure 2-3. Fluxgate Magnetometer in Wall Bracket

The wall bracket is designed so that the lower part of the fluxgate probe must clear the fluxgate shield before the fluxgate magnetometer can be removed from the wall bracket.

2.2.3 Power Requirements

One standard 9-V transistor battery provides sufficient power to continuously operate the fluxgate magnetometer for 8 to 10 hours.

The fluxgate's control unit includes an automatic shut-off feature that turns off power to the fluxgate after approximately 15 minutes. The automatic shut-off prevents the battery from being discharged. Fifteen minutes is usually enough time to run a field-zeroing operation and plot the residual field. If the fluxgate turns off while it is in use, you press the "Power" button to activate it again.

When the battery must be replaced, a small icon of a battery appears in the upper left corner of the digital display that is on the electronics control box. This icon is the low-battery indicator. Section 2.5 explains how you replace the battery.

2.3 Verifying Proper Operation

1. Remove the fluxgate magnetometer from the wall bracket. Lift the fluxgate magnetometer upward until it clears the fluxgate shield, and then pull the fluxgate magnetometer out of the wall bracket.
2. Activate the fluxgate magnetometer by pressing the "Power" button on the electronics control box. The digital display should immediately begin showing the ambient field.
3. Test the fluxgate magnetometer. Alter its orientation with respect to the ambient field of the earth, and watch the fluxgate output change.

2.4 Adjusting the Zero Offset

1. Verify that the fluxgate magnetometer is in the wall bracket. If necessary, place the fluxgate magnetometer in the wall bracket. The two-layer permalloy fluxgate shield in the wall bracket is a magnetic shield that lets a true zero field be obtained.
2. Activate the fluxgate magnetometer by pressing the "Power" button on the electronics control box. The digital display should indicate the field is zero.
3. Adjust the fluxgate's zero offset only if the field is not zero. Use the flathead screwdriver included with the fluxgate magnetometer assembly to turn the zero-adjustment screw until the digital display indicates a zero field.

2.5 Replacing the Battery

You must replace the battery in the electronics control box whenever you see a small icon of a battery in the digital display that is on the front of the box. The icon is the low-battery indicator.

Complete the following steps to replace the battery:

1. Remove the fluxgate magnetometer from the sample chamber if it is in the sample chamber. Refer to section 3.3.2.
2. Lay the fluxgate magnetometer on a flat surface.

   You may detach the electronics control box from the fluxgate probe. To detach the box, loosen the fluxgate coupling, and then pull the box off the probe. Figure 2-4 illustrates the fluxgate coupling.
3. Use the Phillips-head screwdriver included with the fluxgate magnetometer assembly to remove each of the four screws located in a corner of the rear panel of the electronics control box. Refer to figure 2-4.

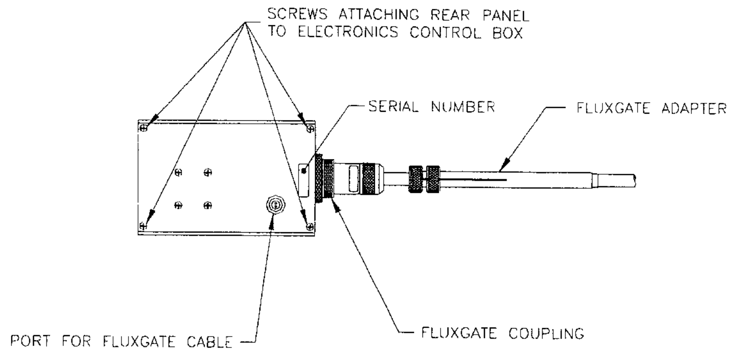


Figure 2-4. Fluxgate Coupling and Fluxgate Adapter

4. Remove the rear panel from the electronics control box.
5. Remove the battery from its holder. Work carefully to avoid pulling the wires connecting the battery and rear panel receptacle to the electronics that are inside the control box.
6. Place a new 9-V transistor battery into the battery holder.
7. Reattach the rear panel to the electronics control box.

C H A P T E R 3

System Operation

3.1 Introduction

This chapter contains the following information:

- Section 3.2 presents an overview of all low-field operations.
- Section 3.3 explains how to install and remove the fluxgate magnetometer.
- Section 3.4 explains how to plot the magnetic field profile.
- Section 3.5 explains how to zero the magnetic field.

3.2 Overview of Low-Field Operations

The 5-G fluxgate magnetometer must be installed in the sample chamber in order for the Ultra Low Field option to zero the magnetic field at a specific position or plot the field profile. The fluxgate sensor, which is housed in the fiberglass tube at the bottom of the fluxgate probe, measures the field. PPMS MultiVu reads the field measurements and can plot them or instruct the system to apply a compensation field that nulls the measured remnant.

You initiate all low-field operations, including installing and removing the fluxgate, from the **Low Field Operations** dialog box. The **Utilities➤Low Field** menu option opens the **Low Field Operations** dialog box. The **Status** panel at the top of the dialog box displays the current field, in gauss, as measured by the fluxgate sensor. The **Control** panel contains the command buttons that access the fluxgate installation instructions and the procedures for obtaining field profiles or zeroing the field.

- The **Install Fluxgate** button initiates fluxgate installation.
- The **Remove Fluxgate** button initiates fluxgate removal.
- The **Zero Magnetic Field** button initiates field nulling.
- The **Magnetic Field Profile** button initiates field profiling.

If the fluxgate is not connected to the Model 6000 or is not turned on, the **Status** panel in the **Low Field Operations** dialog box displays an extremely small number such as .0049.

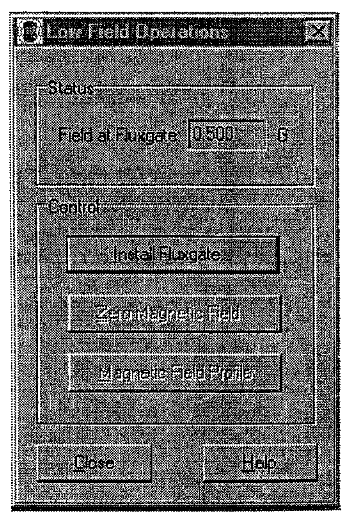


Figure 3-1. **Low Field Operations** Dialog Box

3.3 Installing and Removing the Fluxgate Magnetometer

3.3.1 Installing the Fluxgate Magnetometer

You may install the fluxgate magnetometer in the sample chamber only when the field is discharged to zero and the temperature is at least 295 K. If you try to install the fluxgate when the field is greater than zero or the temperature is less than 295 K, PPMS MultiVu displays a message, requesting you to correctly set the field and temperature. PPMS MultiVu will not let you continue with the installation until the field and temperature are correctly set.

Complete the following steps to install the fluxgate magnetometer:

1. Verify that the field is zero. If necessary, set the field to zero and instruct the PPMS to use the oscillate mode to approach the field set point. Best results are achieved when the PPMS approaches zero field from a field that is at least 1 T.
2. Verify that the temperature is at least 295 K. If necessary, set the temperature to 295 K.
3. Verify that the ACMS insert and ACMS sample transport are installed. If necessary, install these two items. Refer to the *Physical Property Measurement System: ACMS User's Manual* (Quantum Design 1996).
4. Verify that the fluxgate magnetometer reads a zero field when the fluxgate sensor is protected by the fluxgate shield, and if necessary, adjust the fluxgate's zero offset. Refer to section 2.4 and complete steps 1 through 3.

NOTE

If a small icon of a battery appears in the digital display, you must replace the battery providing power to the fluxgate before you install the fluxgate. Refer to section 2.5.

5. Remove the fluxgate from the wall bracket. Lift the fluxgate upward until it clears the fluxgate shield, and then pull the fluxgate out of the wall bracket.
6. Select **Utilities➢Low Field**. The **Low Field Operations** dialog box opens.
7. Select **Install Fluxgate**. The **Installing Fluxgate** dialog box opens. Procedures in the dialog box guide you through the installation process.

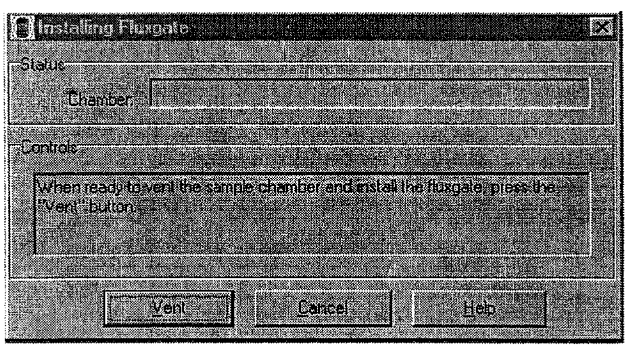


Figure 3-2. **Installing Fluxgate** Dialog Box

8. Select **Vent**. The system vents the sample chamber with helium.
9. Remove the black cap from the top of the ACMS sample transport. Place the black cap on the cap holder that is on top of the transport's back component.
10. Lower the fluxgate probe into the sample chamber until the fluxgate adapter that is near the top of the fluxgate probe prevents you from lowering the probe further, or until the bottom end of the fluxgate rests on the bottom of the ACMS insert. The fluxgate adapter is slightly larger than the opening to the sample chamber.

CAUTION

Handle the fluxgate magnetometer carefully to avoid damaging the fiberglass tube and the fluxgate sensor that are at the bottom of the fluxgate probe. Use only the stainless steel portion of the fluxgate probe to hold the probe. Never use the fiberglass tube to hold the probe.

11. Adjust the position of the fluxgate adapter until the adapter just touches the top of the moving sample transport mechanism. When the adapter just touches the top of the transport and the fluxgate probe rests on the bottom of the ACMS insert, the fluxgate is correctly positioned to ensure accurate field-versus-position measurements. Figures 2-1 and 2-4 illustrate the fluxgate adapter.
12. Tighten the fluxgate adapter so that the fluxgate probe is locked into position. If tightening the adapter is difficult, you may place a piece of tape on the fluxgate probe and then slide the adapter over the tape.
13. Activate the fluxgate by pressing the "Power" button on the electronics control box.
14. Plug the right-angle Lemo connector that is on the fluxgate cable into the port on the rear panel of the electronics control box. A red dot on the connector marks the top of the connector. The cable near the connector is labeled "Fluxgate."

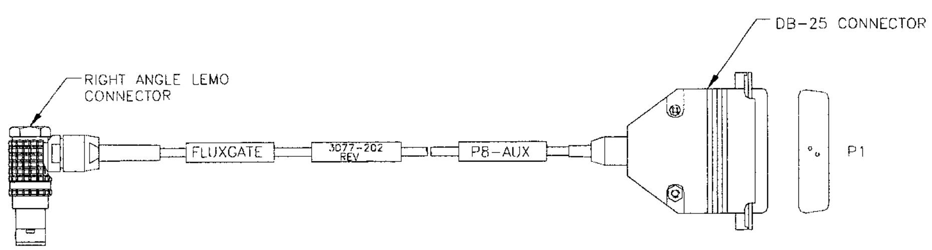


Figure 3-3. Fluxgate Cable

15. Plug the DB-25 connector that is on the fluxgate cable into the "P8–Auxiliary" port on the back of the Model 6000. The cable near the connector is labeled "P8–Aux."
16. Verify that the Ultra Low Field option interface cable is plugged into the "P6–Dewar" port on the back of the Model 6000. If necessary, plug in the cable. Refer to section 1.3.3.
17. Disconnect the ACMS preamp/controller cable from the 15-pin "P3–Option" port on the back of the Model 6000.
18. Plug the low-field coil connector on the Ultra Low Field option interface cable assembly into the 15-pin "P3–Option" port. The low-field coil connector is at the end of the cable that is attached to the silver-colored box housing the J1 and J2 Low Field connectors.
19. Select **Continue**. The **Zero Magnetic Field** and **Magnetic Field Profile** options in the **Low Field Operations** dialog box are enabled.

3.3.2 Removing the Fluxgate Magnetometer

1. Deactivate the fluxgate by pressing the "Power" button on the electronics control box.
2. Disconnect the low-field coil connector from the Model 6000.
3. Plug the ACMS preamp/controller cable into the 15-pin "P3–Option" port on the back of the Model 6000.
4. Disconnect the right-angle Lemo connector from the electronics control box.
5. Select **Utilities➢Low Field**. The **Low Field Operations** dialog box opens.
6. Select **Remove Fluxgate**. The **Removing Fluxgate** dialog box opens. Procedures in the dialog box guide you through the removal process.

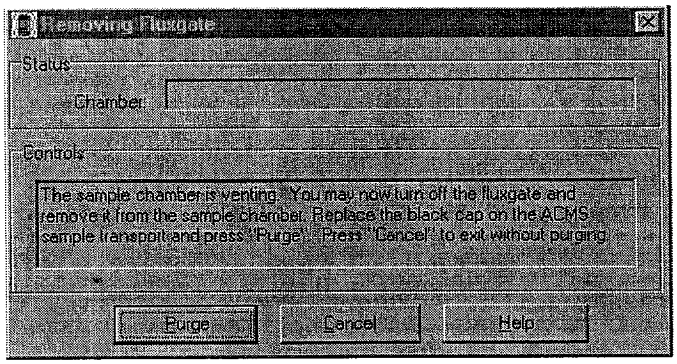


Figure 3-4. **Removing Fluxgate** Dialog Box

7. Remove the fluxgate from the sample chamber, and place the fluxgate in the wall bracket.
8. Place the black cap over the opening to the sample chamber.
9. Select **Purge** to purge and seal the sample chamber *or* select **Cancel** if you do not want to purge the chamber.
10. Select **Continue**. The **Zero Magnetic Field** and **Magnetic Field Profile** options are disabled.

3.4 Plotting the Magnetic Field Profile

1. Select **Utilities➢Low Field**. The **Low Field Operations** dialog box opens.
2. Select **Magnetic Field Profile**. The option is available only if the fluxgate magnetometer is installed. Refer to section 3.3.1 to install the fluxgate.

   When you select **Magnetic Field Profile**, the ACMS sample transport raises the fluxgate probe approximately 7 cm and then slowly lowers it. While the probe lowers, the fluxgate sensor measures the field versus the position. PPMS MultiVu reads the field measurements and saves them to the `LowFieldProfile.dat` file. The `LowFieldProfile.dat` file automatically opens as a graph that plots each field measurement against the position of the fluxgate sensor.

   Notice that after you select **Magnetic Field Profile**, the command button reads **Abort**. You may select **Abort** at any time to cancel the field profile.

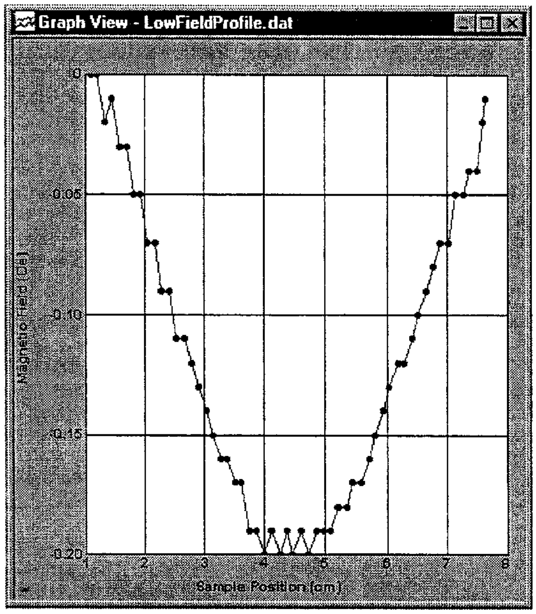


Figure 3-5. Example of Field Plot

In the graph view of the `LowFieldProfile.dat` file, the position of the fluxgate sensor indicates the height, in centimeters, above the surface of a standard puck. The lowest position indicated in the graph corresponds to the fluxgate probe touching the puck surface. The lowest position is not zero because the sensitive region of the fluxgate is 1.1 cm above the bottom of the fluxgate probe.

The graph view of the `LowFieldProfile.dat` file remains open when the field profile is done. You may use any of the data-viewing formats available in PPMS MultiVu to examine the data in the file. You may also use any available graph format to change the default graph format. Data-viewing formats are listed in the **View** menu and the **Graph** pop-up menu. Graph-formatting options are listed in the **Graph** menu and the **Graph** pop-up menu.

The `LowFieldProfile.dat` file is overwritten each time you run a field profile.

3.5 Zeroing the Magnetic Field

You may minimize, or *zero*, the field at a specific position in the sample chamber only when the field in the chamber is discharged to zero. If you attempt to zero the field at one location when the overall field is greater than zero, PPMS MultiVu displays a message, requesting you to correctly set the field. PPMS MultiVu will not let you continue with the field-zeroing operation until the field is zero.

Complete the following steps to zero the field at a specific position:

1. Verify that the field is zero. If necessary, set the field to zero and instruct the PPMS to use the oscillate mode to approach the field set point. If you require small field gradients in the sample chamber, instruct the PPMS to use oscillate mode to approach zero field from at least 2 T.
2. Select **Utilities➢Low Field**. The **Low Field Operations** dialog box opens.
3. Select **Zero Magnetic Field**. The option is available only if the fluxgate magnetometer is installed. Refer to section 3.3.1 to install the fluxgate.
4. Use the **Zero Magnetic Field** dialog box to specify the position at which the field will be minimized. Select one of the three system-defined positions or specify any other position from 1.1 to 7.97 cm. The field-zeroing position is the specified number of centimeters above the surface of a standard puck.
5. Select **Zero Field**. The field-zeroing operation begins. The ACMS sample transport moves the fluxgate probe so that the fluxgate sensor is at the position you have specified. The superconducting magnet and various heaters cycle through a sequence of operations to minimize the field at the position of the sensor. The **Status** panel at the top of the **Zero Magnetic Field** dialog box shows a scrolling list of operations completed by the zero field algorithm.

   When the field-zeroing operation is complete, the message "Done" appears in the **Status** panel in the **Zero Magnetic Field** dialog box. PPMS MultiVu also turns off the compensation field.

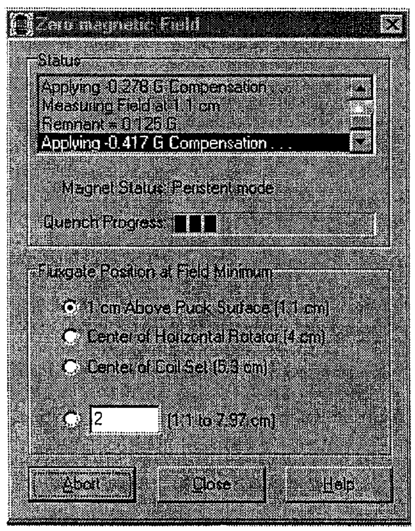


Figure 3-6. **Zero Magnetic Field** Dialog Box during Field-Zeroing Operation

Notice that after you select **Zero Field,** the command button reads **Abort**. You may select **Abort** at any time to cancel the field-zeroing operation.

The field-zeroing operation consists of the following steps:

(a) The system performs a zero-field quench of the magnet. The quench releases the trapped flux that remains in the magnet.

(b) PPMS MultiVu reads the remnant field at the location of the fluxgate sensor.

(c) PPMS MultiVu applies a compensation field by driving a current in the low-field magnet coil. The compensation field is opposite in direction to the remnant field and therefore cancels the remnant field in the magnet.

Quantum Design has determined the coil compensation value that works best in your Ultra Low Field system. *You should not change the coil compensation value.*

(d) While the low-field magnet coil holds the compensation field, the system quenches the magnet.

(e) PPMS MultiVu removes the compensation field and then reads the remnant field at the location of the fluxgate sensor.

(f) PPMS MultiVu applies the compensation field again and adjusts the current in the low-field magnet coil to further null the field.

This process is repeated for the maximum number of iterations or until the remnant field is less than the specified lowest field. The default maximum number of iterations is three. The default lowest field is +.05 G to -.05 G. You may use the `LowField.cfg` file to change the maximum number of iterations or the value of the lowest field.

After the field has been set to zero, you may want to plot the field profile over the length of the magnet. Refer to section 3.4. Plotting the field profile is particularly useful if you will subsequently take measurements in which you want to know the field variations seen by the sample during a normal sample scan.

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Quantum Design

Physical Property Measurement System

VSM Ultra-Low Field Option User's Manual

Part Number 1096-500

Quantum Design

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First edition of manual completed January 2005.

Trademarks

U.S. Patents

4,791,788	Method for Obtaining Improved Temperature Regulation When Using Liquid Helium Cooling
4,848,093	Apparatus and Method for Regulating Temperature in a Cryogenic Test Chamber
5,311,125	Magnetic Property Characterization System Employing a Single Sensing Coil Arrangement to Measure AC Susceptibility and DC Moment of a Sample (patent licensed from Lakeshore)
5,647,228	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber
5,798,641	Torque Magnetometer Utilizing Integrated Piezoresistive Levers

Foreign Patents

U.K.	9713380.5	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber

CE

Safety Instructions

⚠ No operator-serviceable parts are inside. Refer servicing to qualified personnel.	⚠ For continued protection against fire hazard, replace fuses only with same type and rating of fuses for selected line voltage.

Observe the following safety guidelines when you use your system:

- To avoid damaging the system, verify that the system power requirements match the alternating current (AC) power available at your location. If the system has not been configured for the correct power available at your location, contact your local service representative before you proceed with the system installation.
- To prevent electrical shock, verify that the equipment is properly grounded with three-wire grounded plugs.
- To prevent electrical shock, unplug the system before you install it, adjust it, or service it.
- Do not spill food or liquids on the system or its cables.
- Refer to the section titled "Safety Precautions" before you install or operate this system. Direct contact with cryogenic liquids, materials recently removed from cryogenic liquids, or exposure to the boil-off gas, can freeze skin or eyes almost instantly, causing serious injuries similar to frostbite or burns.
- Wear protective gear, including clothing, insulated gloves, and safety eye protection, when you handle cryogenic liquids.
- Transfer liquid helium only in areas that have adequate ventilation and a supply of fresh air. Helium gas can displace the air in a confined space or room, resulting in asphyxiation, dizziness, unconsciousness, or death.
- Keep this system away from radiators and heat sources. Provide adequate ventilation to allow for cooling around the cabinet and computer equipment.
- Refer to the manuals for the supplied computer and monitor for additional safety warnings and notices before you operate the system.

Regulatory Information

- This apparatus has been tested to the requirements of the EMC Directive 89/336/EEC.
- This apparatus is defined as ISM Group 1, Class A and B equipment per EN 50011:1991 (industrial and light industrial environment limits of radio frequency emission).
- This apparatus has been tested to the requirement of the Low Voltage Directive 73/23/EEC.
- See the EU Declaration of Conformity for additional regulatory information regarding your PPMS.

C O N T E N T S

Table of Contents

Figures

Tables

P R E F A C E

Contents and Conventions

P.1 Introduction

This preface contains the following information:

- Section P.2 discusses the overall scope of the manual.
- Section P.3 briefly summarizes the contents of the manual.
- Section P.4 illustrates and describes conventions that appear in the manual.

P.2 Scope of the Manual

This manual contains background information about the PPMS VSM Ultra-Low Field (ULF) option and instructions for installing the option, using the software and hardware, and performing field-zeroing and profiling operations with it.

P.3 Contents of the Manual

- Chapter 1 provides an overview of the VSM ULF option, its notable features, our safety recommendations, and information for contacting Quantum Design.
- Chapter 2 provides instructions for the initial installation of the VSM ULF option as well as for connecting and removing it from the PPMS and VSM.
- Chapter 3 explains VSM ultra-low-field operations.
- Chapter 4 describes the VSM Ultra-Low Field hardware.

P.4 Conventions in the Manual

File menu	Bold text identifies the names of menus, dialogs, options, buttons, and panels used in the PPMS MultiVu and VSM software.
File >> Open	The >> symbol indicates that you select multiple, nested software options.
`.dat`	The Courier font indicates file and directory names and computer code.
Important	Text is set off in this manner to signal essential information that is directly related to the completion of a task.
Note	Text is set off in this manner to signal supplementary information about the current task; the information may primarily apply in special circumstances.

CAUTION!

Text is set off in this manner to signal conditions that could result in loss of information or damage to equipment.

WARNING!

Text is set off in this manner to signal conditions that could result in bodily harm or loss of life.

WARNING!

Text is set off in this manner to signal electrical hazards that could result in bodily harm or loss of life.

C H A P T E R 1

Introduction to the VSM Ultra-Low Field Option

1.1 Introduction

This chapter contains the following information:

- Section 1.2 presents an overview of the PPMS VSM Ultra-Low Field (ULF) option.
- Section 1.3 describes notable features of the VSM ULF option.
- Section 1.4 outlines safety considerations for working with the VSM ULF option.
- Section 1.5 provides information on Quantum Design service centers and how to contact your customer service representative.

1.2 Overview

The PPMS VSM Ultra-Low Field (ULF) option performs two functions: it profiles the magnetic field that is in the sample chamber and it nulls, or *zeroes*, the residual magnetic field at a specific position in the sample chamber. The VSM ULF option is offered with systems that have standard and EverCool dewars and 7- and 9-tesla magnets, and is designed to operate at room temperature (295–315 K). The VSM ULF option measures the magnetic field using a fluxgate magnetometer that has its movement controlled by the VSM linear motor transport. The VSM option, the AC Measurement System (ACMS) board, the low-field magnet coil, and the magnet reset heater option are required in order to operate the VSM ULF.

The ULF option adjusts the magnetic field at a given position based on readings from the fluxgate sensor, embedded at 1.1 cm from the bottom of the fluxgate probe. Zeroing of the field (field nulling) consists of iteratively using the magnet reset option to quench the magnet while simultaneously using the ACMS board to apply a compensation current to the low-field magnet coil.

1.3 Notable Features of the VSM ULF Option

The Model CM-A motor module plugs into the Model 1000 Modular Control System, which communicates with the PC via the CAN network cable. The Model CM-A motor module controls the VSM Linear Motor Transport that moves the Fluxgate Magnetometer. The PC also communicates with the ACMS board installed in the Model 6000 controller (or the Model 6500 controller if the PPMS is an EverCool system).[1]

The ACMS board in the Model 6000 (or Model 6500)[2] controller provides the drive current that runs the low-field magnet coil, which is a superconducting coil wound directly on a coil form that fits between the outer vacuum jacket and the main PPMS superconducting magnet. The low-field magnet coil applies a compensation field that is used to adjust the flux trapped in the superconducting magnet. Fields of less than 0.1 G can be achieved at a user-specified location in the sample chamber.

Inside the dewar are installed the VSM coilset, the VSM sample tube, the low-field magnet coil, and the magnet reset heater.

Figure 1-1 illustrates the hardware and functional connections for the VSM ULF option.

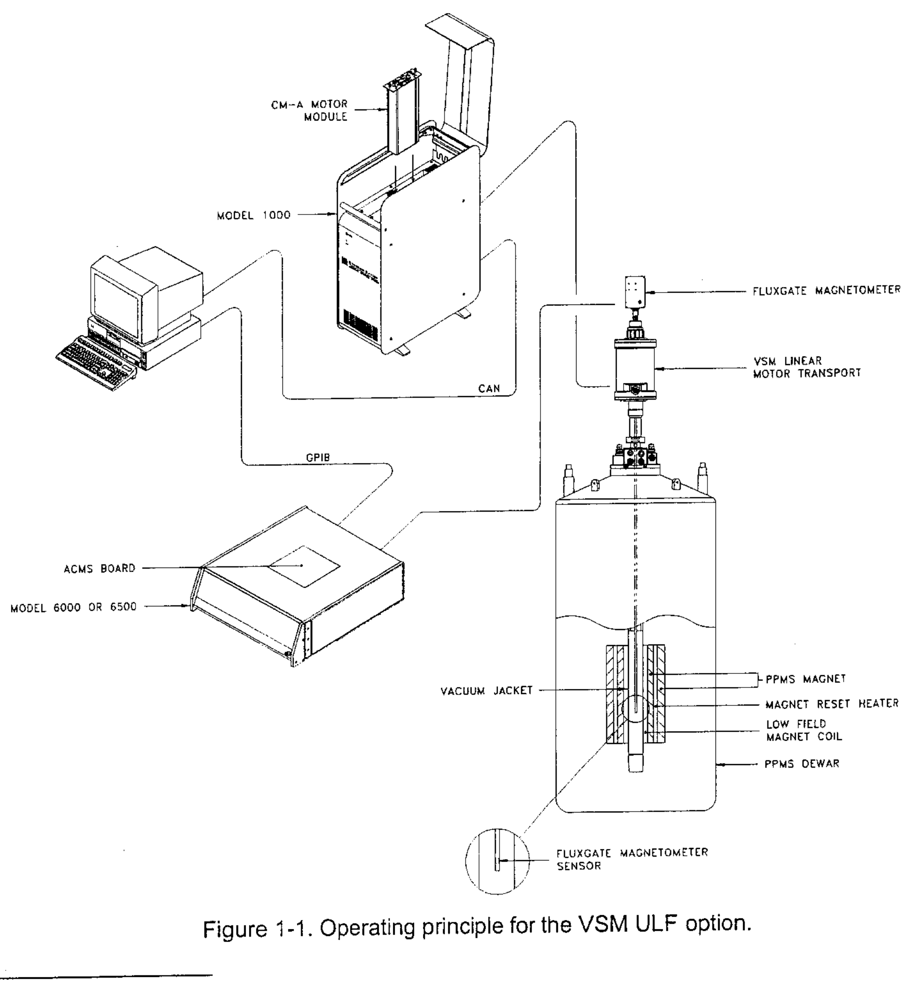

Figure 1-1. Operating principle for the VSM ULF option.

[1] EverCool systems use the Model 6000 controller and the Model 6500 controller.
[2] The Model 6000 and Model 6500 controllers are often referred to simply as the Model 6000 or Model 6500.

1.4 Safety Precautions

WARNING!

The VSM and ULF options are used in conjunction with the Physical Property Measurement System (PPMS), so you should be aware of the safety considerations for all the equipment. PPMS-related safety precautions include those for the use of superconducting magnets and for the use of cryogenic liquids, as is reviewed below and in the *Physical Property Measurement System: Hardware Manual.*

Above all, Quantum Design and its staff ask that you use standard safe laboratory procedures.

- Use common sense.
- Pay attention to the state of the system and to your surroundings.
- If the system appears to be behaving abnormally, investigate to see if there is a malfunction. If necessary, take the appropriate action (e.g., troubleshoot, shut down the system, contact Quantum Design).
- Supervise inexperienced users and train them in general electrical safety procedures.

The VSM and PPMS have safety features to prevent accidents from causing injury or serious equipment damage. *If you use the equipment in a manner that is not specified by Quantum Design, the protection afforded by the equipment may be impaired.*

1.4.1 Magnets

WARNING!

Any person who wears a pacemaker, electrical medical device, or metallic implant must stay at least 5 m (16.5 ft.)[3] from the PPMS dewar. In addition, personnel should keep all ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar. Verify that all magnetic fields are at zero (0) before you handle the VSM linear motor transport in any way.

The following precautions should be followed to ensure the safety of personnel who work with or around a PPMS with a superconducting magnet. This material is covered in more depth in Chapter 1 of the *Physical Property Measurement System: Hardware Manual.*

[3] At the current time (January 2005), 5 m should be a large enough distance to protect wearers of metallic implants or medical devices from most magnetic fields produced by Quantum Design magnets. However, the safe distance from newer magnets (in development) could be greater. Hence, personnel who work with and around the superconducting magnets should review thoroughly documentation for new equipment.

- Verify that any person who has a metallic implant or is wearing a pacemaker or electrical or mechanical medical device stays at least 5 m (16.5 ft.) from the PPMS dewar. Large magnetic fields are dangerous to anyone who has a metallic implant or is wearing a pacemaker or other electrical or mechanical medical device.

  Important: The automated control system can turn on the magnet while the system is unattended. Furthermore, the three-dimensional magnetic field of the PPMS will penetrate nearby walls, the ceiling, and the floor. Therefore, your safety considerations should include such adjacent spaces.

- Keep all iron, nickel, and other ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar. Large magnets, such as the PPMS superconducting magnets, can attract iron and other ferromagnetic materials with great force. The observable effects of magnetic fields are listed in Chapter 1 of the *Physical Property Measurement System: Hardware Manual.*
- Never attempt to install, remove, or handle the VSM linear motor transport (4096-400) when there is a field set in the PPMS or in any other nearby equipment. In addition, the VSM linear motor transport must be secured when it is stored within 5 m (16.5 ft.) of the PPMS or any other large field source. The VSM linear motor transport contains nearly 9 kg of iron, which presents a considerable hazard in a large magnetic field such as that produced by the PPMS or other laboratory equipment such as an NMR magnet.

1.4.2 Cryogens

WARNING!

Always wear protective clothing and ensure that the room has good ventilation when you work with cryogenic materials such as liquid helium and liquid nitrogen. These precautions will protect you against cryogenic material hazards: (1) they can expand explosively when exposed to room temperature; (2) they can cause serious burns.

- Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium, liquid nitrogen, or other cryogens.
- Avoid loose clothing or loose fitting gloves that could collect cryogenic liquids next to the skin. The extreme cold of liquid and gaseous cryogens can cause serious burns and has the potential to cause loss of limbs.
- Use cryogens only in well-ventilated areas. In the event a helium container ruptures or there is a helium spill, vent the room immediately and evacuate all personnel. In a poorly ventilated area, helium can displace the air, leading to asphyxiation. Because helium rises, well-vented rooms with high ceilings generally provide the safest setting for working with it.

1.4.3 Electricity

WARNING!

The VSM and the PPMS are powered by nominal voltages between 100 V to 240 V AC. These voltages are potentially lethal, so you should exercise appropriate care before opening any of the electronics units, including turning off the equipment and disconnecting it from its power source.

- Turn off and unplug all electronic equipment before removing any equipment covers.
- Keep electrical cords in good working condition and replace frayed and damaged cords.
- Keep liquids away from the workstations.

1.4.4 Lifting and Handling

The VSM linear motor transport (4096-400) should be handled with care, as it is very heavy (about 10 kg or 22 lb) and could cause crushing injuries.

1.5 Contacting Quantum Design

If you have questions or problems related to your Quantum Design equipment, contact your local Quantum Design service representative at one of the offices listed below. When you call, please be able to give the representative a full description of the problem, including the circumstances involved and the recent history of your system.

United States

Quantum Design World Headquarters
6325 Lusk Boulevard
San Diego, CA 92121

Tel: 1-858-481-4400
1-800-289-6996
Fax: 1-858-481-7410

Email: service@qdusa.com
Web: http://www.qdusa.com

Service for Canada, Mexico, the United States, and other countries not listed below

Europe

L.O.T.—Gmbh & Co KG
Im Tiefen See 58
D-64293 Darmstadt, Germany

Tel: 49-6151-880631
Fax: 49-6151-896667

Email: qd.euroservice@lot-oriel.de
Web: http://www.lot-oriel.com

Service for Austria, Belgium, Crete, Croatia, Czech Republic, Denmark, England, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and Yugoslavia

Japan

Quantum Design Japan
Sanpo Ikebukuro Building Annex
4-32-8 Ikebukuro
Toshima-ku, Tokyo
171-0014, Japan

Tel: 81-3-5954-8570
Fax: 81-3-5954-6570

Email: qdjapan@tkb.att.ne.jp
Web: http://www.qd-japan.com

Service for Japan

Korea

Quantum Design Korea
Kyungbin Building, Fourth Floor
517-18 Dogok-dong, Kangnam-gu
Seoul, 135-270, Korea

Tel: 82-2-2057-2710
Fax: 82-2-2057-2712

Web: http://www.qdkorea.com

Service for Korea

People's Republic of China

Quantum Design Instrumentation (Bejing) Co., Ltd
Room 502-04, Tower B, COFCO Plaza
No.8 Jianguomennei Avenue
Dong Cheng District,
Beijing 100005
P.R. China

Tel: 8610-8512-0277/80
Fax: 8610-8512-0276

Email: quantum-design@163.com

Service for People's Republic of China

Taiwan

Omega Scientific Taiwan Ltd.
13F-3, No. 415, Sec. 4
Hsin Yi Road
Taipei City 110, Taiwan R.O.C.

Tel: 886-2-8780-5228
Fax: 886-2-8780-5225

Email: lonson.lin@omega-cana.com.tw

Service for Taiwan, Hong Kong, Singapore

C H A P T E R 2

Installing and Removing the VSM ULF Option

2.1 Introduction

This chapter contains the following information:

- Section 2.2 includes definitions and a list of the VSM ULF components.
- Section 2.3 describes the procedures for the initial installation of the VSM ULF option and its software.
- Section 2.4 describes how to connect the fluxgate magnetometer to the PPMS.
- Section 2.5 explains how to remove the VSM ULF option so that the PPMS can be used to perform a zero-field measurement.
- Section 2.6 describes how to reconfigure the PPMS for the VSM ULF option.

2.2 Overview of VSM ULF Option Installation

This chapter describes the procedures you will use to install the hardware and software for the VSM Ultra-Low Field (ULF) option. Note that the procedures for the *initial* installation of the ULF option are different from those for subsequent installations (i.e., when you re-install the ULF after having used a non-VSM option). The initial installation procedures vary according to the options with which the PPMS is equipped. However, if you purchased the VSM ULF option as part of a complete Quantum Design system, many of the installation procedures will have been performed before you receive the equipment.

2.2.1 Terminology

The following usages and definitions will help distinguish among the various activities that are involved in installing and operating the VSM ULF option:

Activate option refers to the **Utilities >> Activate Option** command in PPMS MultiVu. When an option is activated, the program incorporates option-specific commands into MultiVu.

Install hardware refers to activities involved in setting up equipment, such as installing the VSM linear motor transport, the VSM sample tube or the VSM coilset, connecting cables, and so on.

Install the fluxgate magnetometer refers to the procedures for inserting the VSM fluxgate probe into the PPMS. You will perform these operations by using the **VSM ULF Operations** dialog, which is available after you have activated the VSM ULF option within MultiVu.

Load position refers to the position of the slider tube in the VSM linear motor transport when the indicator pin is at the top of the window. Use the load position to install the fluxgate magnetometer.

Oscillating the field refers to using the oscillating mode to charge and discharge the superconducting magnet.

PPMS VSM User's Manual refers to the *Physical Property Measurement System: Vibrating Sample Magnetometer (VSM) Option User's Manual.*

Quenching the magnet refers to the act of expelling trapped magnetic flux by using the magnet reset heater to warm the superconducting magnet.

Remnant field (also ***Residual field***) refers to the residual magnetic field in the superconducting magnet after the magnetic field has been zeroed.

Touchdown operation refers to the act of slowly lowering the motor position until there is no more levitation force, indicating that the bottom of the fluxgate probe is resting on the puck surface.

Touchdown position refers to the position (motor-encoder value) where there is zero levitation force as measured by the touchdown operation.

2.2.2 VSM ULF Option Components

To operate the VSM ULF option on a PPMS with a 7- or 9-tesla magnet and a standard dewar, the system must be equipped with the ACMS board, low-field magnet coil, magnet-reset heater, Model 1000 modular control system, standard VSM option, Model 6000 Firmware ROM (version 1.912 or later), and the VSM–MultiVu application software (rev 1.3.2 or later). If the ULF option will be installed on an existing PPMS that does not have one or more of the necessary components, those items will be shipped with the VSM ULF option.[1] Table 2-1 lists the basic components of the Quantum Design VSM ULF option.

Table 2-1. Components of the PPMS VSM ULF option

COMPONENT	PART NUMBER	ILLUSTRATION
VSM ULF option interface cable (also called the low-field option interface cable)	3077-203	Pages 2-10, 4-4
Fluxgate cable assembly	3077-202	Pages 2-10, 4-5
VSM fluxgate magnetometer (5 gauss)	4096-521	Pages 2-9, 4-1
Fluxgate wall bracket	4049-025	Pages 2-9, 4-4
VSM fluxgate adapter assembly	4096-530	Page 4-2
VSM ULF User's Kit	4096-510	
VSM ULF option software (shipping disk)	4096-544	
VSM ULF Option User's Manual	1096-500	

[1] You will need to ship your probe to Quantum Design for installation of the low-field magnet coil and the magnet reset heater.

Before you begin the installation, we recommend that you use your order form to verify that you have received every item necessary for a complete installation of the VSM ULF.

2.3 Initial Installation of the VSM ULF Option

Important: The instructions in this section only apply to the *initial* installation of the VSM ULF option. If you subsequently reconfigure the PPMS to use a non-VSM option, you must reconfigure the PPMS for the standard VSM before you can begin using any of the VSM options. For complete instructions on reconfiguring the PPMS for the standard VSM, see the *PPMS VSM User's Manual*. After the PPMS has been reconfigured for the VSM, you only will need to activate the VSM ULF option and install the hardware to start using it again.

The procedures for the initial installation of the VSM ULF option will depend on whether it was purchased as part of a complete Quantum Design (QD) system (e.g., PPMS with VSM options) or as an upgrade to an operating PPMS.

If you purchased the VSM ULF option along with a new PPMS, you can go to Step 3 of Section 2.3.3, "Install the VSM ULF Software." If you purchased the VSM ULF option as an upgrade, please review the support materials and the procedures below as a guide to installation.

VSM ULF Requirements

Operation of the VSM ULF option requires a PPMS with a 7- or 9-tesla magnet and the standard VSM option, the Model 1000 modular control tower, a Quantum Design AC Measurement System (ACMS) board, the low-field magnet coil, and the magnet-reset heater. To insert the fluxgate magnetometer into the sample chamber, a vertical clearance of 10 feet is required between the floor and ceiling of the room in which the VSM ULF option is used.[2]

If your PPMS does not have the low-field magnet coil and the magnet reset heater, you must send the probe to Quantum Design so that these components can be installed.

Altogether, the procedures for installing the VSM ULF option in an operational PPMS will depend on the pre-existing equipment. Below are the procedures that will be required if you are missing all or part of the requirements at the time that you purchase the VSM ULF option:

1. Install the ACMS board in the Model 6000 (systems with standard dewars) or Model 6500 (systems with EverCool dewars).
2. Install and verify the operation of any components required for the VSM ULF: the Model 1000 modular control tower and CAN network adapter, the Model CM-A and CM-B[3] modules (required for the standard VSM), and the standard VSM option, including the necessary software.
3. Install the VSM ULF software.

Some or most of these procedures might have been performed at the factory. Please review the instructions before you begin, and call Customer Service at Quantum Design if you have any questions.

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[2] This is the standard recommendation for the PPMS.

[3] The Model CM-B module is not part of the VSM ULF option or required for it, but it is needed for the standard VSM option.

2.3.1 Install the ACMS Board

You will use the instructions in this section only if the ACMS board has not been installed on the PPMS. First, you will place the PPMS in **Shutdown** (standby) mode to stabilize it and conserve helium (see Section 2.3.1.1).

Important: The magnet must be in **Persistent** mode and the **Field** must be at zero (0) Oe *before* you place the system in **Shutdown** mode.

The next steps for installing the ACMS board will vary for standard systems (Section 2.3.1.2) and EverCool systems (Section 2.3.1.3).

2.3.1.1 PPMS SHUTDOWN PROCEDURES

Use the instructions below to put the PPMS in **Shutdown** mode. For more information about **Shutdown** mode, see Chapter 4 of the *PPMS Hardware Manual.*

1. If the magnetic field is not in **Persistent** mode *and* at zero (0) Oe, reset it by using the **Field** dialog box.
   a. Select **Instrument** >> **Field** from the dropdown menus at the top of the MultiVu window.
   b. When the **Field** dialog box opens (Figure 2-1), set the **Mode** to **Persistent** and the **Set Point** to zero (0) Oe.
   c. Click on the **Set** button.
   d. Leave the dialog box open so that you can monitor the field until it is within 1000 Oe of zero (do not continue until the field is within 1000 Oe of zero).
   e. In the **Field** dialog box, click on the **Close** button.

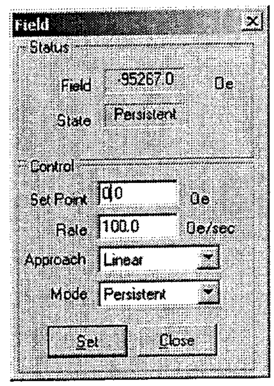

Figure 2-1. Field dialog box

2. Start **Shutdown** mode.
   - To use the Model 6000, select **CTRL** >> **Interactive Control** >> **8. Shutdown Mode.**
   - To use MultiVu, select **Instrument** >> **Shutdown** from the dropdown menus at the top of the MultiVu window.

2.3.1.2 INSTALLATION ON A PPMS THAT HAS A STANDARD DEWAR

If you have a PPMS with a standard type of dewar, you will install the ACMS board into the Model 6000 controller. Use Figure 2-2 as a guide for the installation procedures.

1. Verify that the PPMS is in **Shutdown** (standby) mode (see Section 2.3.1.1).
2. At the front of the cabinet, turn off the power switch to the Model 6000.
3. Open the PPMS cabinet by removing the top wooden cover and the metal cover.
4. Looking at the Model 6000 from the front of the cabinet, find the panel at the back of the second slot from the left, corresponding to port P3. Remove the screws and panel and install the ACMS board in this slot.
5. Connect the daughter ribbon cable from the J15 connector on the Model 6000 mother board to the J3 connector on the ACMS board.

6. Connect the power cable (black and red wires from the Model 6000) to the J4 connector on the ACMS board.
7. Slide the metal cover back onto the top of the Model 6000.
8. Replace the wooden cover on the top of the PPMS cabinet.
9. Turn on the power switch to the Model 6000.

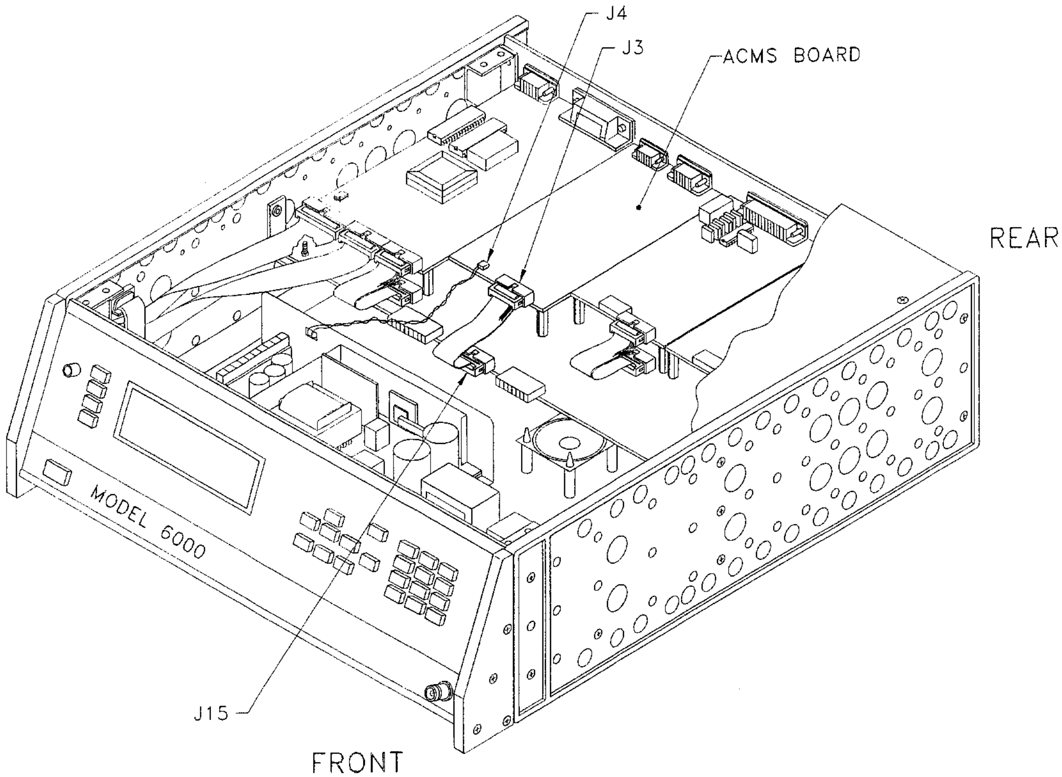

Figure 2-2. Illustration of Model 6000 controller (from the front), with the ACMS board inserted and J3 and J4 connectors in place

2.3.1.3 INSTALLATION ON A PPMS THAT HAS AN EVERCOOL DEWAR

If you have an EverCool system, you will install the ACMS board into the Model 6500 controller. Use Figure 2-3 as a guide for the installation procedures.

1. Verify that the PPMS is in **Shutdown** (standby) mode (see Section 2.3.1.1).
2. Turn off the power switch to the Model 6500 at the front of the cabinet.
3. Unplug the cables from the back of the Model 6500 so that you can slide it out of the cabinet.
4. Remove the Model 6500 from the rack by sliding it out from the front of the cabinet. Place the Model 6500 on a flat surface at a comfortable working height.
5. Looking at the Model 6500 from the front (cabinet end), locate the panel that covers the second slot from the right. The slot is labeled P2-Option2. Remove the screws and panel.
6. Install the ACMS board.

7. Connect the end of the ribbon cable supplied with the Model 6500 (labeled P2 (J3) Option2 daughter board) to the J3 connector of the ACMS board. Connect the other end of the ribbon cable to the Option2 connector on the daughter board.
8. Connect the black and red wires from the power supply to the J4 connector on the ACMS board.
9. Slide the Model 6500 back into the cabinet rack.
10. Reconnect the cables at the back of the Model 6500.
11. Turn on the power to the Model 6500.

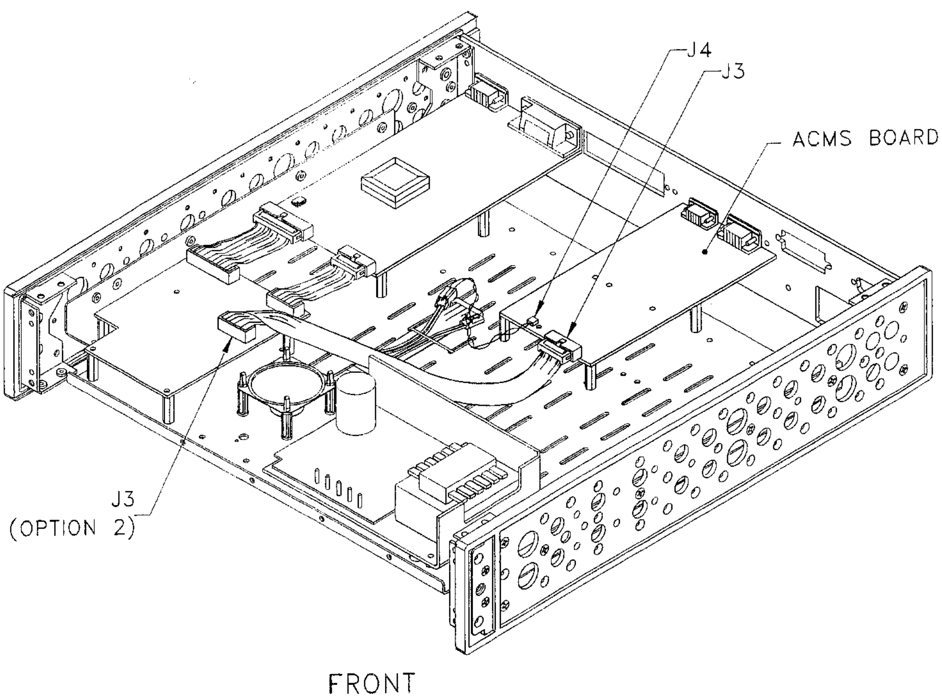

Figure 2-3. Illustration of Model 6500 controller in electronics cabinet, with ACMS board inserted and J3 and J4 connectors in place

2.3.2 Install the Model 1000, Standard VSM Option, and Application Software

You will use the instructions in this section only if you have an operational PPMS (and computer) without the Model 1000 modular control tower and standard VSM option. If the Model 1000 and standard VSM option have been installed already, go to Section 2.3.3.

1. Install the Model 1000, CAN Network Adapter, and CAN Manager driver software, using the instructions in the *Model 1000 Modular Control System User's Manual*. Remember to verify the software installation and the hardware connections.
2. Install the CM-A and CM-B control modules and the standard VSM option, including the VSM linear motor transport, sample tube, and coilset puck, using the instructions in Chapter 2 of the *PPMS VSM User's Manual*.

3. Using Figure 2-4 for guidance, verify that you have attached all the connectors and the connections are firm.

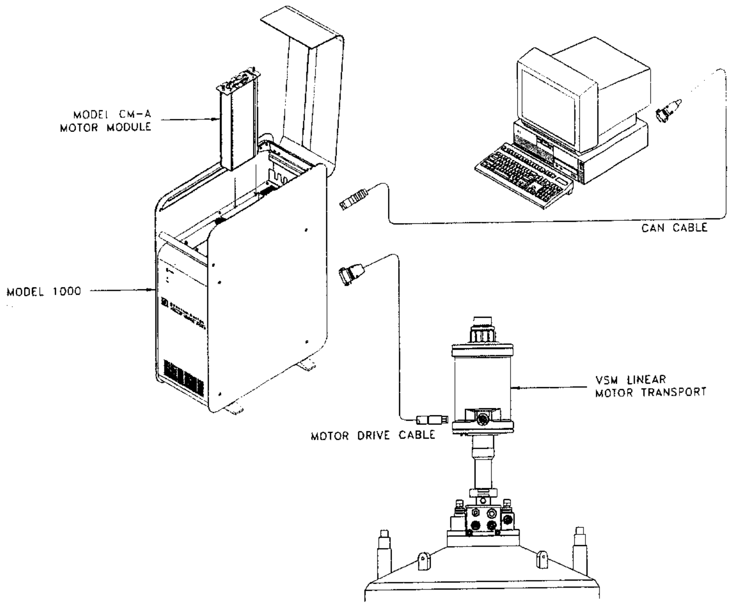

Figure 2-4. PPMS—VSM option components and interconnections

4. Install or update the software (MultiVu, VSM), as necessary. Any required software will be included with the ULF option shipment, along with detailed instructions for installation. Remember to verify that the software is operating properly.

2.3.3 Install the VSM ULF Software

The following instructions presume that you have already installed PPMS MultiVu (Version 1.3.2. or later) and the standard VSM software (refer to Section 2.3.2 for further information).

If you purchased your VSM ULF option as part of a new PPMS, go to Step 3 below—you only need to verify that the software is operating properly.

1. Insert into the computer the media (CD or floppy diskette) that contains the software.
2. On the media, open the DISK1 folder and double-click on the file named `Setup.exe`. A wizard (an automated program) will start and guide you through the installation process. Continue through the `Setup` program until it indicates that it has finished.
3. Verify that the program is properly installed by activating it from within MultiVu.
   a. Start PPMS MultiVu.
   b. Open the **Option Manager** by selecting **Utilities >> Activate Option** from the dropdown menus at the top of the MultiVu window.
   c. When the **Option Manager** dialog box (Figure 2-5) appears with a list of the **Available Options**, click on **VSM Ultra Low Field** under the **Available Options** heading.

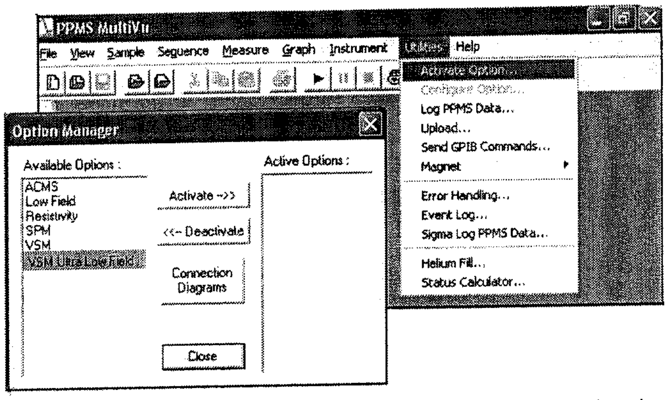

Figure 2-5. Using MultiVu to activate the VSM Ultra Low Field option

d. Click on the **Activate** button.

e. **VSM Ultra Low Field** will move to the **Active Options** area of the **Option Manager**.

f. A control dialog, a log window, and an information popup will open (Figure 2-6a–2-6c) when you activate the VSM ULF option. If these items appear, it indicates that the software is operating properly. If one or more of these software components does not appear, contact Customer Service at Quantum Design.

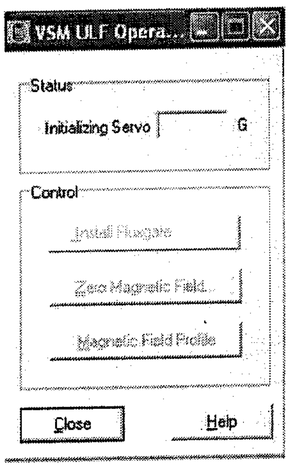

Figure 2-6a. VSM ULF Operations dialog at activation

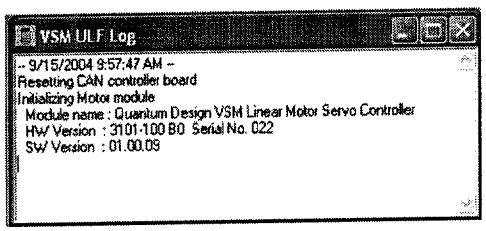

Figure 2-6b. VSM ULF Log dialog

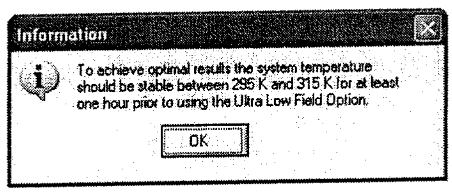

Figure 2-6c. VSM ULF Information popup with PPMS temperature instructions

2.3.4 Attach the Fluxgate Storage Bracket

The final part of the initial installation process is to attach the magnetometer storage bracket to the wall and place the fluxgate magnetometer in it.

1. Select a location for the fluxgate storage (wall) bracket that is relatively close to the PPMS dewar.
2. Hold the storage bracket so that the permalloy fluxgate shield is at the bottom and the bracket just rests on the floor. Figure 2-7 shows the bracket after it has been attached to the wall and the fluxgate magnetometer has been placed in it.

3. Attach the bracket to the wall with the four bronze screws and screwdriver that are included in the VSM ULF Option User's Kit.

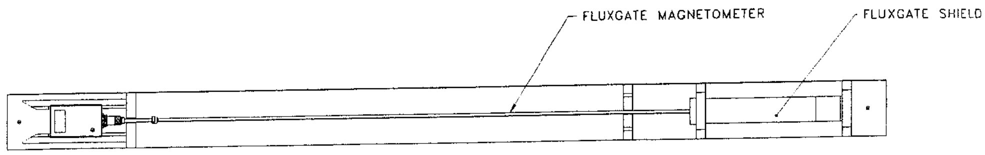

Figure 2-7. VSM ULF storage (wall) bracket and fluxgate magnetometer

4. Verify that the same serial number is used on the electronics control box and the fluxgate probe. If the two components do not have the same serial number, contact Customer Service at Quantum Design.
5. The initial installation is now complete.
6. Place the fluxgate magnetometer in the wall bracket until later in the installation procedures, when you will install it into the VSM linear motor transport.

You will probably never perform the *initial* installation of the ULF option again. However, several additional (but brief) steps are required before you can use the VSM ULF option for zeroing and field profiling, such as connecting the fluxgate magnetometer cables, preparing the sample chamber, and inserting the probe. These steps will be necessary each time you use the VSM ULF option, so they have been separated from the initial installation procedures. Begin the final steps by connecting the fluxgate magnetometer cables (Section 2.4).

2.4 Connecting the Fluxgate Magnetometer Cables

The VSM ULF option uses specific connections to the PPMS, as explained below. After you have connected the cables, you will use the instructions in Sections 3.4–3.5 to stabilize the system, insert the fluxgate, and perform the field-nulling and field-profiling operations.

Figures 2-8 and 2-9 show the VSM ULF cables, and Figures 2-10 and 2-11 show the connection diagrams for the VSM ULF option on systems with standard or EverCool dewars. Use the screwdrivers provided in the VSM ULF User's Kit to connect the cables.

1. Disconnect the dewar cable from the “P6–Dewar” port on the back of the Model 6000. Do *not* disconnect the other end of the cable, which is plugged into the blue Lemo port on the PPMS probe head.
2. Plug the J1 connector on the VSM ULF option interface cable assembly into the “P6–Dewar” port. Let the low-field coil connector on the option interface cable remain unattached. As is shown in Figure 2-8, the low-field coil connector is at the end of the cable that is attached to the silver-colored box.

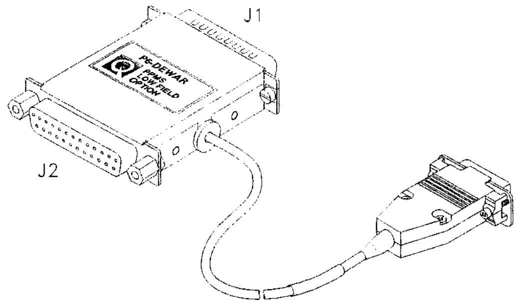

Figure 2-8. VSM ULF option interface cable assembly

3. Plug the free end of the dewar cable into the J2 connector on the option interface cable assembly.
4. Plug in the low-field coil connector on the option interface cable assembly as follows:
   - PPMS system with standard dewar: Attach the low-field coil connector to the 15-pin P3–Option port on the back of the Model 6000.
   - PPMS system with EverCool dewar: Attach the low-field coil connector to the P2–Option2 port on the back of the Model 6500.
5. Plug the fluxgate cable DB-25 connector into the "P8–Auxiliary" port on the back of the Model 6000. As is shown in Figure 2-9, the section of the cable near the DB-25 connector is labeled "P8–Aux." Let the right-angle Lemo connector remain unattached for the moment.[4]

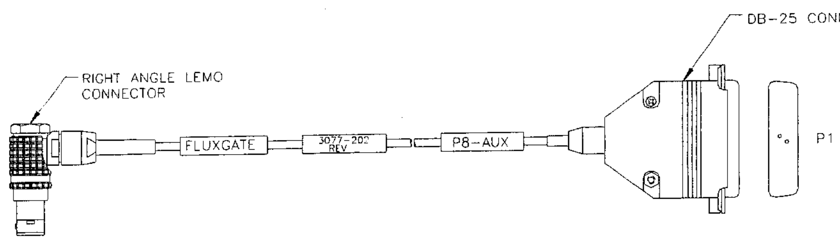

Figure 2-9. Fluxgate cable assembly

6. Chapter 3 has the instructions for completing the ULF–PPMS connections and for using the VSM ULF software to insert the fluxgate magnetometer and zero and profile the field. Because ultra-low field measurements should be performed immediately following the field-nulling operation(s), we recommend that you review the instructions for removing the fluxgate magnetometer (Section 2.5) before you start Chapter 3.

---

[4] When you complete the connections, you will plug the right-angle Lemo connector on the fluxgate cable into the electronics control box of the magnetometer.

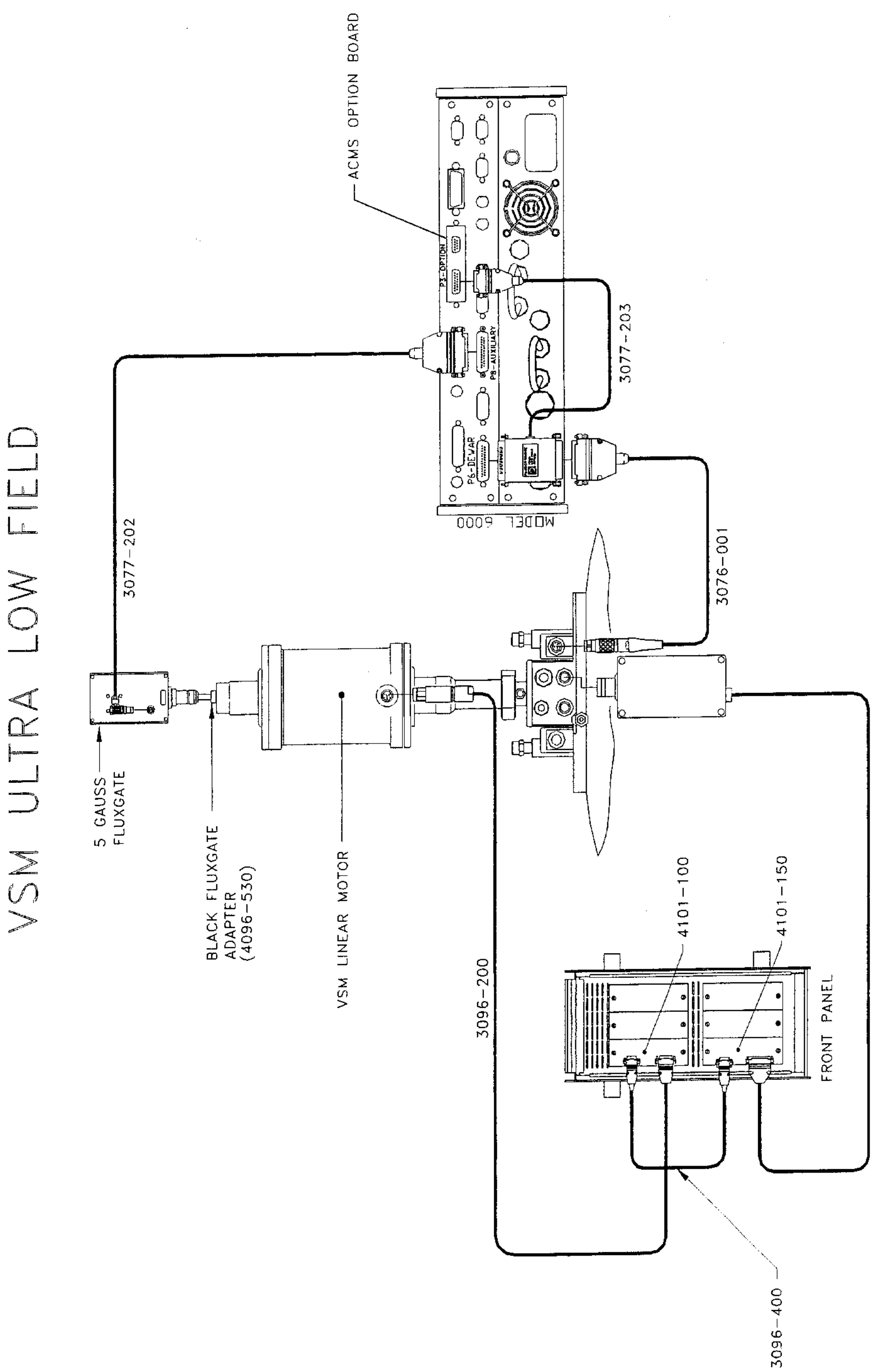

Figure 2-10. Connections for the VSM ULF option on a PPMS VSM system that uses a standard dewar

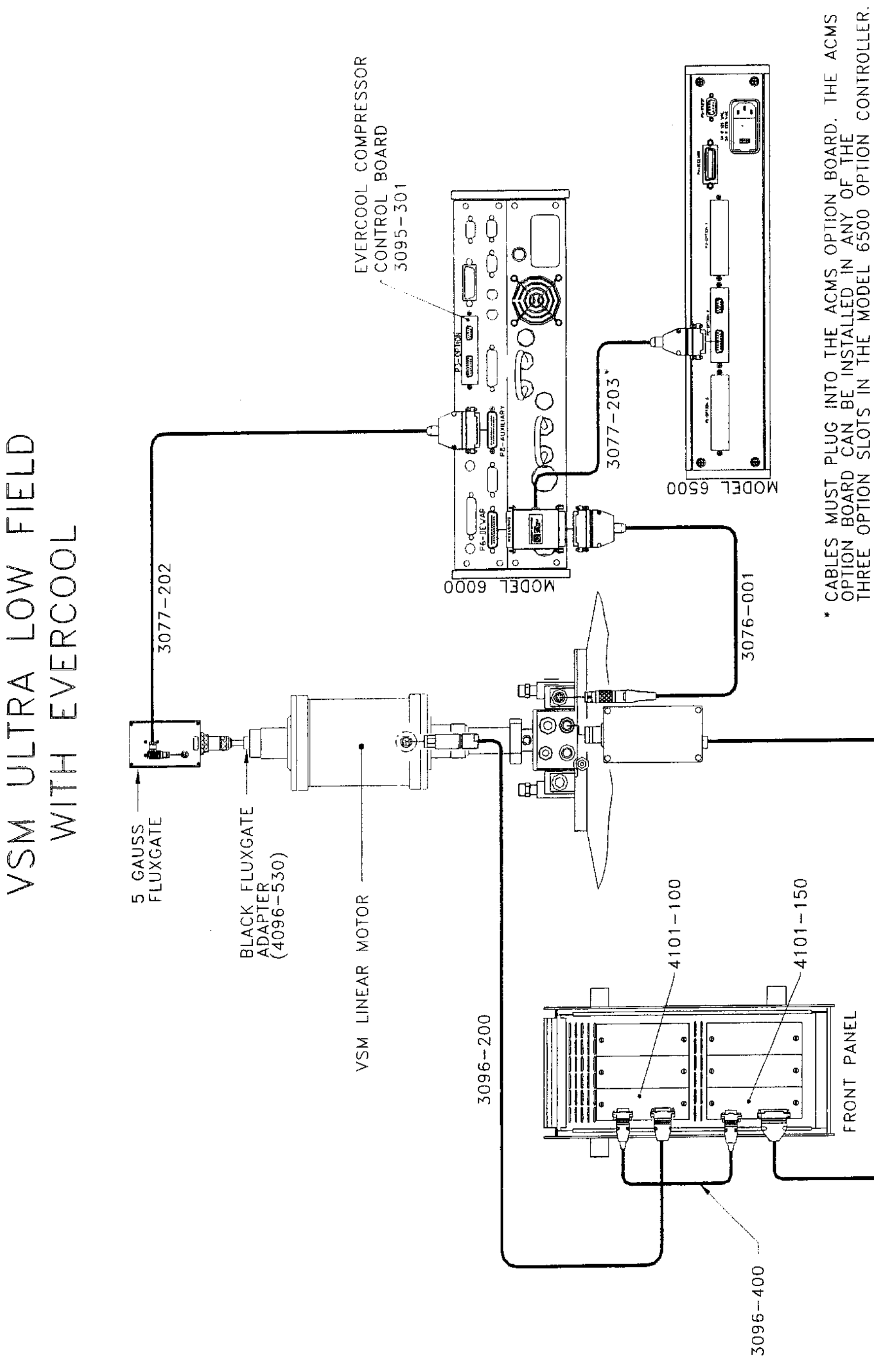

Figure 2-11. Connections for the VSM ULF option on a PPMS VSM system that uses an EverCool dewar

2.5 Preparing for Zero-Field Measurements

After you complete the field-nulling and profiling operation(s), you must remove the VSM ULF fluxgate magnetometer,[5] deactivate the VSM ULF option, and install the option that you intend to use for zero-field measurements. For the best results, perform ultra-low field measurements immediately after you finish performing the field-nulling and profiling, because relaxation effects in the magnet could result in small field changes over hours or days. This section describes the procedures for removing the VSM ULF hardware in preparation for an ultra-low field measurement. Please review all the removal instructions before you begin the procedure, as the dialog boxes only summarize the steps.

2.5.1 Remove the VSM ULF Hardware

1. Turn off the fluxgate by pressing the "Power" button on the electronics control box.
2. If necessary, open the **VSM ULF Operations** dialog box (Figure 2-12) by selecting **Utilities >> VSM Ultra Low Field** from the MultiVu dropdown menus.
3. In the **VSM ULF Operations** dialog, click on the **Remove Fluxgate** button. This button starts the **Removing Fluxgate** wizard and its dialog box (Figure 2-13).

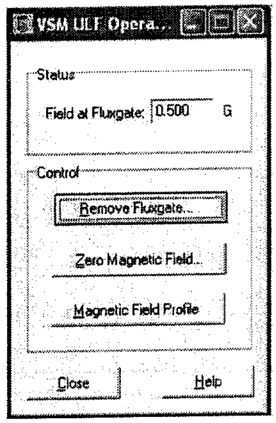

Figure 2-12. VSM ULF Operations dialog box

4. Remove the electronics control box from the fluxgate probe by loosening the fluxgate coupling and pulling the box off the probe.
5. In the **Removing Fluxgate** dialog box, click on the **Remove** button to move the transport into the load position. The **Controls** area will report on the process (Figure 2-14).

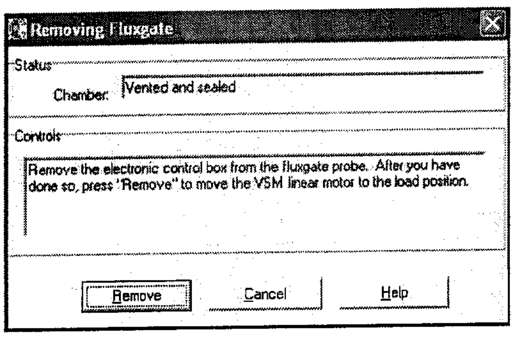

Figure 2-13. Removing Fluxgate dialog: Ready to move linear motor to load position

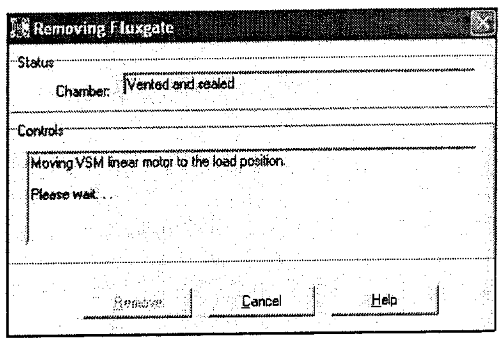

Figure 2-14. Removing Fluxgate dialog: Moving the linear motor transport into the load position

6. When the instructions indicate that the VSM linear motor is in the load position (Figure 2-15), remove the fluxgate probe from the sample chamber.

[5] You might also remove the standard VSM hardware.

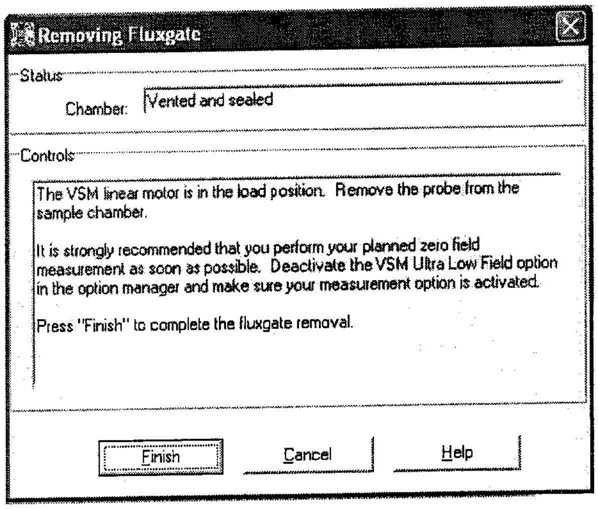

Figure 2-15. Removing Fluxgate dialog: Ready to remove fluxgate probe

7. Disconnect the right-angle Lemo connector on the fluxgate cable (Figure 2-9) from the electronics control box.
8. Re-attach the electronics box to the probe and place the fluxgate magnetometer in the storage (wall) bracket.
9. Disconnect the J1 connector on the VSM ULF option interface cable assembly (Figure 2-8) from the P6–Dewar port.
10. Disconnect the low-field coil connector from the P3–Option port on the back of the Model 6000 (systems with a standard dewar) or from the P2–Option2 port on the back of the Model 6500 (systems with an EverCool dewar).
11. Disconnect the DB-25 connector on the fluxgate cable from the P8–Auxiliary port on the back of the Model 6000.
12. Click on the **Finish** button at the bottom of the **Removing Fluxgate** dialog box to complete the removal process.
13. The **Removing Fluxgate** wizard will close its dialogs and you will be returned to the **VSM ULF Operations** dialog.
14. Next, you will deactivate the VSM ULF option.

2.5.2 Deactivate the VSM ULF Option

Using the **Option Manager** dialog box (Figure 2-16), deactivate the VSM ULF option:

1. Open the **Option Manager** dialog box by selecting **Utilities >> Activate Option** from the main MultiVu dropdown menus.
2. Click on **VSM Ultra Low Field** in the **Active Options** panel.
3. Click on the **Deactivate** button. **VSM Ultra Low Field** will move from the **Active Options** panel to the **Available Options** panel.

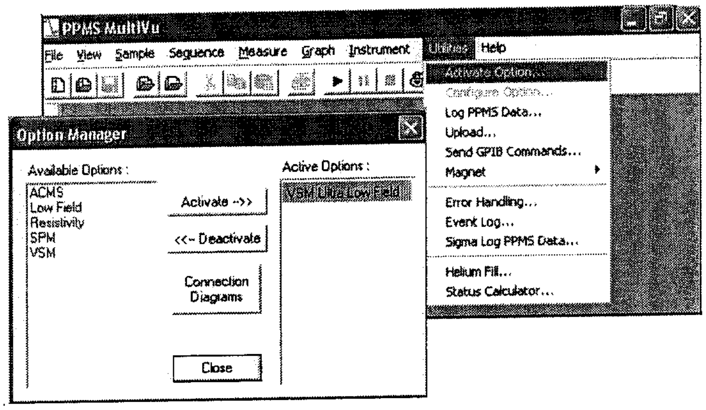

Figure 2-16. Using MultiVu to deactivate the VSM Ultra Low Field option

4. If you will be using the standard VSM option to perform zero-field measurements, you now can activate it and begin the usual procedures for taking these types of measurements. If you will be using a non-VSM option to perform zero-field measurements, you will remove the standard VSM option (see Section 2.5.3).

2.5.3 Remove the Standard VSM Hardware

If you will not be using the VSM for the zero-field measurements, use the instructions in this section to remove the VSM linear motor transport, sample tube, and coilset puck.

CAUTION!

Quantum Design recommends that you have another person help you remove the VSM linear motor transport, which is fragile, bulky, and moderately heavy (about 10 kg or 22 lb).

2.5.3.1 REMOVE THE VSM LINEAR MOTOR TRANSPORT

1. Unplug the electrical connector from the back of the VSM linear motor transport (see Figures 2-10, 2-11, and 2-17). You can leave the other end of the cable connected to the Model 1000 modular control system.

   Important: Never attempt to move the linear motor transport when it has a cable connected to it.

2. Remove the flange clamp from the top flange of the PPMS (see Figure 2-17).
3. Slowly lift the linear motor transport until it has cleared the stabilizer post, as is illustrated in Figure 2-17.
4. Place the linear motor transport back in the storage case.

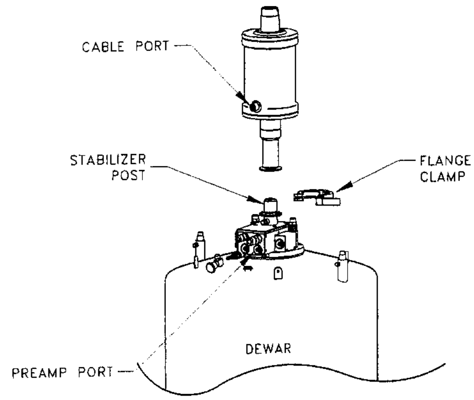

Figure 2-17. Removing the VSM linear motor transport

> **WARNING!**
>
> Store the VSM linear motor transport in a secure location to prevent it from being attracted to magnetic fields in the laboratory, including those produced by the PPMS, as explained in Section 1.4.1.

2.5.3.2 REMOVE THE VSM SAMPLE TUBE AND COILSET PUCK

1. Remove the VSM sample tube from the PPMS sample chamber.
2. Remove the VSM coilset puck from the sample chamber by using the puck insertion/extraction (or sample insertion) tool. Refer to the *Physical Property Measurement System: Hardware Manual* for a detailed description of puck insertion and extraction.
3. Unplug the VSM preamp from the probe head and set it aside. You do not need to disconnect the other end of the cable from the Model 1000.
4. Return the blank flange to the top of the probe head or install another of the Quantum Design measurement options.
5. Once the sample chamber has been closed, you can purge and seal it by using the **Chamber** dialog box.
   - Select **Instrument** >> **Chamber** from the dropdown menus at the top of the MultiVu window.
   - In the **Chamber** dialog box, click on the **Purge/Seal** button.
6. The base measurement system is now ready for you to install a different option.

2.5.4 Install the Option for Performing Zero-Field Measurements

Install the hardware for the option that you intend to use for zero-field measurements. Remember, for optimal data, perform the zero-field measurements immediately after you have removed and deactivated the ULF hardware.

2.6 Reconfiguring the PPMS for the VSM ULF Option

If you reconfigure the PPMS in order to install and use a non-VSM option, you will not be able to use any of the VSM options until you have reconfigured the PPMS for the standard VSM option. For complete instructions on reconfiguring the PPMS for the standard VSM, see the *PPMS VSM Option User's Manual*. After the PPMS has been reconfigured for the VSM, you can use the VSM ULF option again by activating it and installing the fluxgate magnetometer with its connections.

C H A P T E R 3

VSM ULF Operations

3.1 Introduction

This chapter contains the following information:

- Section 3.2 summarizes VSM ULF option operations.
- Section 3.3 describes how to prepare the system for installation of the VSM ULF option.
- Section 3.4 describes how to activate the VSM ULF option and install the option hardware.
- Section 3.5 describes how to perform zeroing and field-profiling operations with the VSM ULF option.

3.2 Overview of VSM ULF Operations

VSM ULF operations involve zeroing the magnetic field at a fixed position and profiling the field. These operations are organized through the **VSM ULF Operations** dialog (Figure 3-1), which has automated procedures (wizards) for installing the fluxgate and setting up the system to perform the zeroing and field-profiling operations.

The overall process of using the VSM ULF includes activating the VSM ULF option and installing the fluxgate magnetometer in the sample chamber. The next steps include locating the sensor, quenching the magnet, and compensating for the residual field as well as monitoring the field profile. The following sections explain these steps.

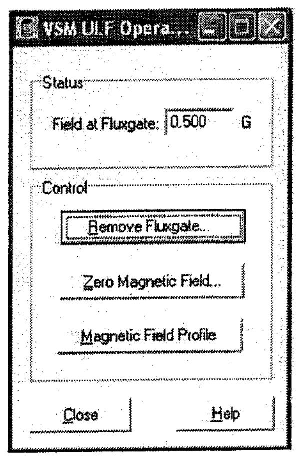

Figure 3-1. The VSM ULF Operations dialog

3.3 Verify System Readiness

We recommend the following preliminary steps before you start to install the fluxgate magnetometer. Subsequent to the initial installation and use of the fluxgate, Step 1 will be unnecessary, but Steps 2–5 will serve as a reminder of the installation procedures.

1. *(First use only)* Verify that any initial installation procedures that are required (see Section 2.3) have been completed. Such procedures might include installing the ACMS board, the VSM option, the appropriate application software, and the fluxgate storage bracket.
2. Verify that the ULF option interface and fluxgate cables are connected properly and firmly (see Section 2.4 and Figures 2-8–2-11):
   a. ULF option interface cable (Figures 2-8, 2-10, 2-11):
      - Standard, non-EverCool systems: Attach the low-field coil connector to the P3–Option port on the back of the Model 6000 controller; attach the J1 connector to the P6-Dewar port on the back of the Model 6000; and attach the dewar cable to the J2 connector.
      - EverCool systems: Attach the low-field coil connector to the P2–Option2 port on the back of the Model 6500 controller. Connections to-and-from the J1 and J2 connectors are the same as for non-EverCool systems.

   b. Fluxgate cable (Figures 2-9–2-11): Attach the DB-25 connector to the P8–Auxiliary port in the back of the Model 6000 controller. Let the right-angle Lemo connector remain free until later.
3. Verify that the magnet is in the **Persistent** mode and the **Field** is at zero (0) Oe.
4. Bring the system to a temperature between 295 K and 315 K and let it sit for at least 20 minutes before beginning the fluxgate installation.
5. Review the fluxgate magnetometer removal instructions (Section 2.5) before you perform the field-nulling and field-profiling operations.
6. Verify that the fluxgate adapter assembly (Figure 4-2) is located 48.8–49.2 inches from the bottom of the fluxgate probe (see Section 4.2.2.3).

3.4 Installing the Fluxgate Magnetometer

The final procedures for installing the fluxgate magnetometer include activating the VSM ULF option, preparing the PPMS sample chamber for VSM ULF operations, inserting the fluxgate magnetometer, and completing the system connections.

First, the VSM ULF option must be activated to start the VSM ULF software and open the **VSM ULF Operations** dialog box.

3.4.1 Activate the VSM ULF Option

1. If necessary, start the MultiVu software program.
2. Select **Utilities** >> **Activate Option** from the dropdown menus at the top of the MultiVu window. The **Option Manager** dialog box will open (Figure 3-2).
3. If another option is active, select it and click on the **Deactivate** button.

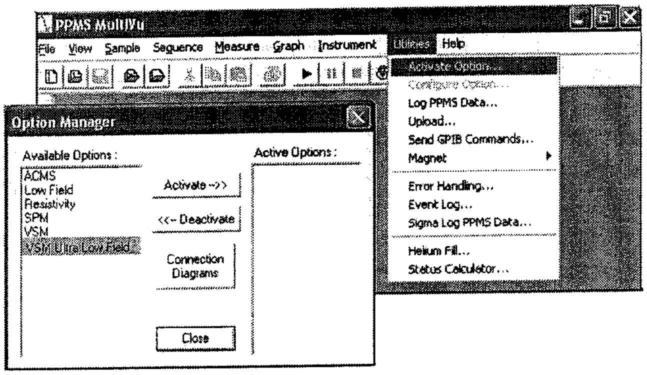

Figure 3-2. Using MultiVu to activate the VSM option

4. Select "VSM Ultra Low Field" and click on the **Activate** button. The **VSM ULF Operations** dialog box, the **VSM ULF Log** dialog, and the **Information** dialog will appear as soon as you activate the VSM ULF option (Figures 3-3a–3-3c). The **VSM ULF Operations** dialog box coordinates operations with the VSM ULF option, the **VSM ULF Log** dialog records system activities during the current session, and the **Information** popup explains that optimal VSM ULF results are obtained when the system temperature has been stable and at 295–315 K for at least one hour before you use the ULF. Note that 20 minutes is an adequate wait time.

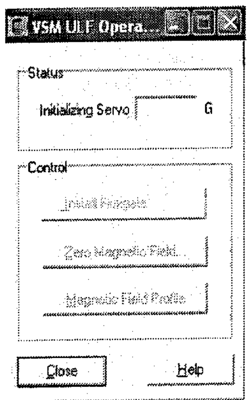

Figure 3-3a. Initial appearance of the VSM ULF Operations dialog box

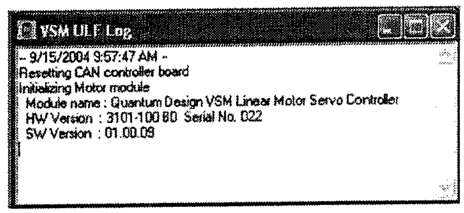

Figure 3-3b. VSM ULF Log dialog

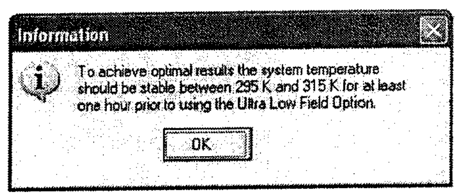

Figure 3-3c. Information popup

5. When the **VSM ULF Operations** dialog box opens, the **Control** buttons will be inactive (e.g., Figure 3-3a). To activate them so that you can proceed with the installation, click on the **OK** button in the **Information** popup. When the **Information** popup closes, the **Install Fluxgate** button will be available for use (Figure 3-4).

   Note that there will be fluctuations in the **Field at Fluxgate** reading until you have installed the fluxgate.

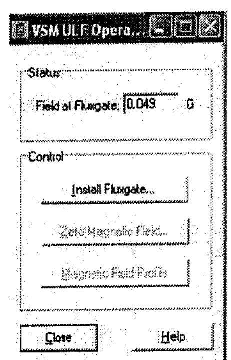

Figure 3-4. VSM ULF Operations dialog: Install Fluxgate button active

3.4.2 Prepare the PPMS for the Fluxgate

During this phase of the installation, you will use the **Installing Fluxgate** dialog box to quench the magnet and prepare the sample chamber.

1. Click on the **Install Fluxgate** button in the **VSM ULF Operations** dialog box (Figure 3-4).
2. The **Installing Fluxgate** dialog box will open (Figure 3-5) at Page 1. This dialog has a **Status** area and a **Controls** area, as well as **Quench**, **Skip Quench**, **Cancel**, and **Help** buttons for starting and stopping the processes.

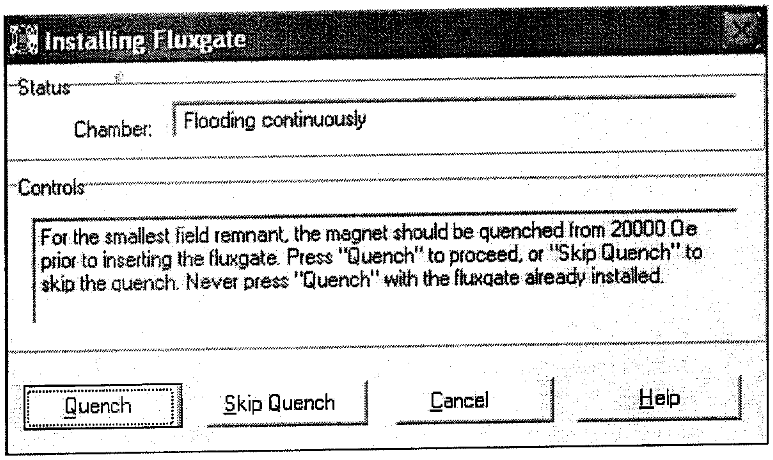

Figure 3-5. Page 1 of the Installing Fluxgate wizard

- The **Status** area will display the status of the sample chamber. For example, in Figure 3-5 the **Chamber** status is "Flooding continuously" because the chamber is continuously flooding.
- The **Controls** area will instruct you to quench the magnet from 20000 Oe, which is the recommended starting field value when you are performing a quench to expel the remnant field from the magnet. Note that you would ***never*** perform a quench when the fluxgate has been installed in the VSM.

CAUTION!

Never attempt to quench the magnet when the VSM ULF fluxgate magnetometer is installed in the VSM.

3. Click on the **Quench** button at the bottom left of the dialog box. Page 2 of the **Installing Fluxgate** wizard will open, where the **Controls** area will indicate that the field is being set to 20000 Oe (Figure 3-6a) and then that the magnet is being quenched (Figure 3-6b). (If you click on the **Skip the Quench** button, the wizard will open the dialog shown in Figure 3-7.)

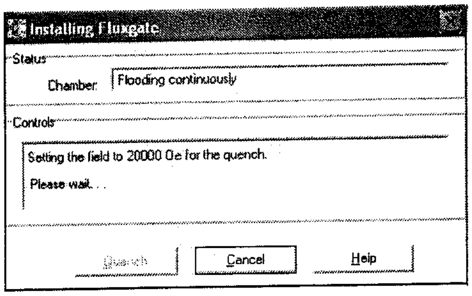

Figure 3-6a. Installing Fluxgate dialog: Setting the field to 20000 Oe

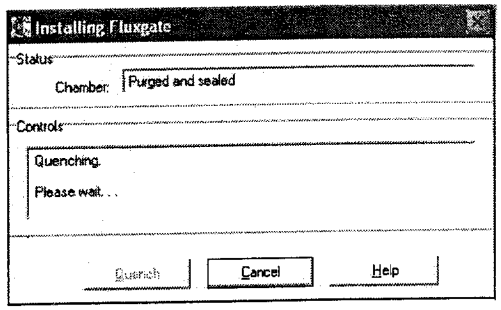

Figure 3-6b. Installing Fluxgate dialog: Quenching the magnet

4. When the magnet has been quenched, Page 3 of the **Installing Fluxgate** wizard will appear (Figure 3-7), indicating the status of the sample chamber (in this case it is purged and sealed).
5. Click on the **Vent** button to prepare the sample chamber for installing the fluxgate probe.
6. The **Status** area of the **Installing Fluxgate** dialog will indicate that the chamber is being vented and sealed, and the **Controls** area of the dialog will display the process (Figures 3-8a and 3-8b).

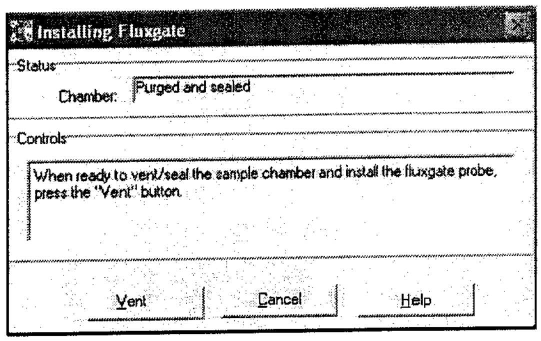

Figure 3-7. Installing Fluxgate dialog: Ready to vent/seal

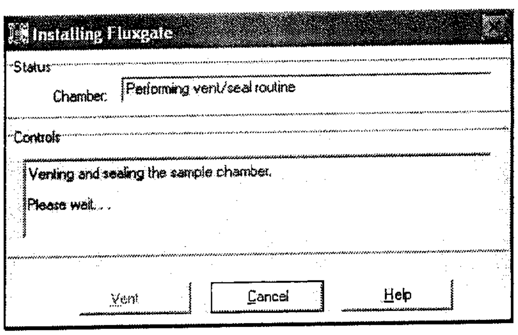

Figure 3-8a. Installing Fluxgate dialog: Venting and sealing the sample chamber

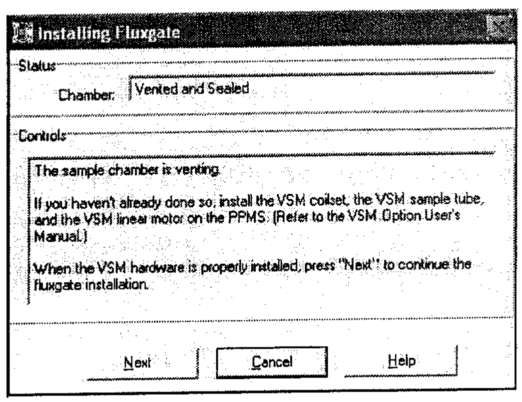

Figure 3-8b. Installing Fluxgate dialog: Reminder to install standard VSM

7. If you have not already done so, install the components of the standard VSM—the VSM coilset, the VSM sample tube, and the VSM linear motor—on the PPMS, as noted in the **Controls** area of the dialog (Figure 3-8b).

8. When the chamber has been vented and you have installed any necessary VSM components, click on the **Next** button at the bottom left of the dialog.
9. Page 4 of the **Installing Fluxgate** dialog (Figure 3-9) will open to start the final instructions for installing the VSM ULF fluxgate magnetometer into the sample chamber.
10. Please read the instructions in Section 3.4.3 before you start the installation, as the dialog boxes only provide a summary of the next steps.

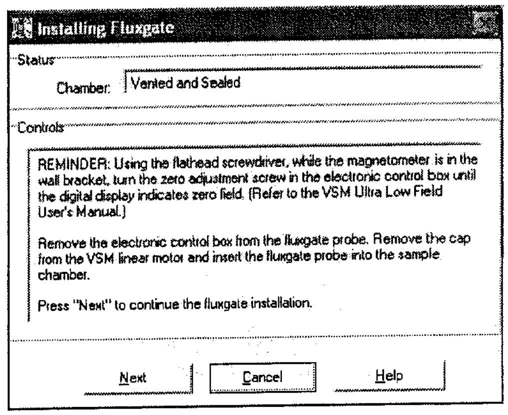

Figure 3-9. Installing Fluxgate dialog: Starting the final installation instructions

3.4.3 Prepare and Install the Fluxgate

1. Verify that the digital display on the fluxgate magnetometer reads zero (0) Oe while it is in the wall bracket:
   - Press the power button on the fluxgate magnetometer.
   - If the reading is more than zero (0) Oe, use the flat head screwdriver provided in the ULF Option User's Kit to reset it, turning the zero-adjustment screw in the electronics control box until the reading is at zero (0) Oe.
2. Remove the cap from the VSM linear motor transport so that you can insert the fluxgate probe.
3. Remove the fluxgate magnetometer from the wall bracket by lifting it upward until it clears the fluxgate shield and then pulling it out of the bracket.
4. Lay the fluxgate magnetometer on a flat surface and detach the electronics control box by loosening the fluxgate coupling until you can pull the box off the probe. Figure 3-10 illustrates the location of the fluxgate coupling.

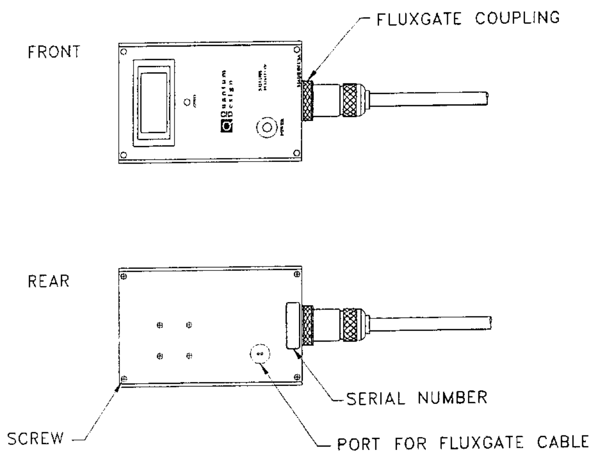

Figure 3-10. Electronics control box for the magnetometer

5. Insert the probe into the sample-access port until the magnetic lock at the base of the fluxgate adapter assembly engages the magnetic lock ring in the linear motor transport. Tug on the probe to verify that the magnetic lock has engaged the magnetic lock ring.

6. Plug the right-angle Lemo connector on the fluxgate cable (Figure 3-11) into the port on the rear panel of the electronics control box of the magnetometer (Figure 3-10). The top of the connector is marked by a red dot.

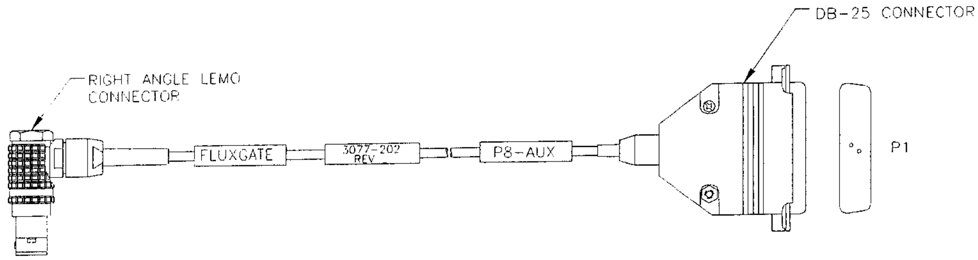

Figure 3-11. Fluxgate cable

7. Verify the cable connections: The option interface cable and the fluxgate cable attach to the back of the Model 6000 (and Model 6500 for EverCool systems), as explained in Sections 2.4 and 3.3.
8. Click on the **Next** button at the bottom of the **Installing Fluxgate** dialog (Figure 3-9) to continue the installation process. Page 5 of the **Installing Fluxgate** dialog (Figure 3-12) will open, with the final instructions for installing the VSM ULF fluxgate magnetometer.
9. Using minimal force, attach the electronics control box to the fluxgate probe in the sample chamber. Work with care so that you do not damage the armature of the VSM linear motor transport.

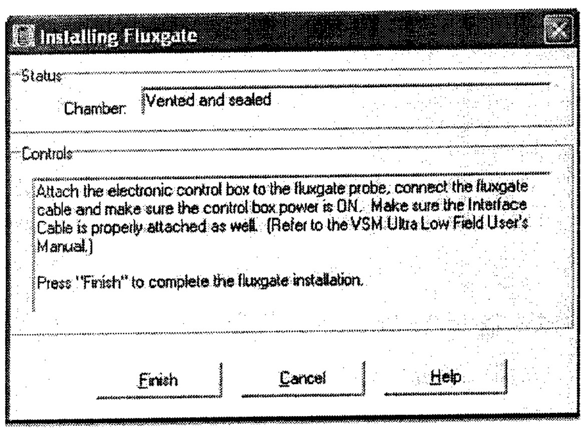

Figure 3-12. Installing Fluxgate dialog: Completing the fluxgate installation

CAUTION!

Avoid applying excessive force when you attach the electronics box to the fluxgate probe. Otherwise, you could damage the armature of the VSM linear motor transport.

10. Verify that the electronics control box power is turned on (it automatically turns off after 15 minutes). If it is not, press the power button.
11. Click on the **Finish** button at the bottom of the dialog box to complete the fluxgate installation. The system will now perform a **Homing** operation and the process will be shown in the **Installing Fluxgate** dialog (Figure 3-13).

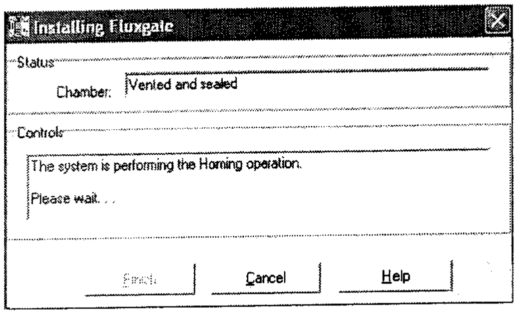

Figure 3-13. Installing Fluxgate dialog: Performing a Homing operation

During the **Homing** operation the software finds the minimum and maximum positions for the magnetic field sensor, which is embedded 1.1 cm from the bottom of the G-10 portion of the fluxgate probe. These two values define the range of positions at which the remnant field can be zeroed during the next phase. The range depends on where the adapter assembly is clamped and is the basis for the recommendation to clamp it 48.8–49.2 inches from the bottom of the probe (see Section 4.2.2.3).

12. When the **Homing** operation finishes you will have completed the fluxgate installation.
13. The **Installing Fluxgate** dialog will close and the **VSM ULF Operations** dialog will have three active **Control** buttons, indicating that you can now perform any of the three operations: remove the fluxgate, zero the magnetic field, or perform a magnetic field profile (Figure 3-14).

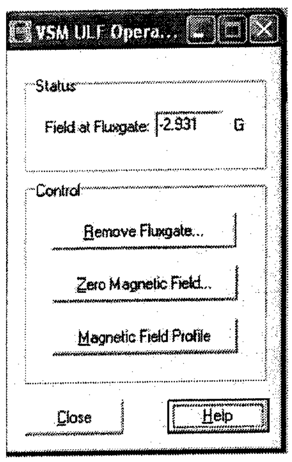

Figure 3-14. VSM ULF Operations dialog with active Control buttons

The next section (Section 3.5) explains how to perform zeroing and field-profiling operations with the VSM ULF fluxgate magnetometer.

Important: Before you begin zeroing or field-profiling operations, verify that the **Field at Fluxgate** value in the **VSM ULF Operations** dialog box is the same as the value that is displayed in the electronics control box. If these two displays do not show the same value, please contact Customer Service at Quantum Design.

3.5 Using the VSM ULF Option

Zeroing procedures are organized by the **VSM ULF Zero Magnetic Field** dialog box (Figure 3-15), which has two options for the fluxgate position. After introducing the dialog box (Section 3.5.1), we explain how to use the **Center of the VSM Coil (4.1 cm)** option (Sections 3.5.2 and 3.5.3). The second, "off-center" option is explained in Section 3.5.4.

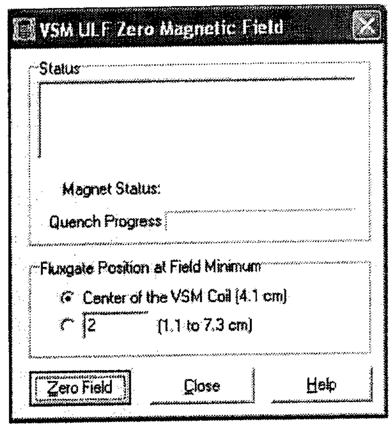

Figure 3-15. VSM ULF Zero Magnetic Field dialog (Zero Field dialog)

3.5.1 VSM ULF Zero Magnetic Field Dialog

1. To open the **VSM ULF Zero Magnetic Field** dialog box (**Zero Field** dialog for short), click on the **Zero Magnetic Field** button in the **VSM ULF Operations** dialog box (Figure 3-14).

2. When the **Zero Field** dialog box opens (Figure 3-15), you will see **Status and Fluxgate Position ...** sections and **Zero Field, Close,** and **Help** buttons.
   - The **Status** area will display the status of the magnet and any magnet quench in progress.
   - Options in the **Fluxgate Position at Field Minimum** allow you to zero the field at the **Center of the VSM Coil (4.1 cm)** or at an "off-center" location, which is any other location between the two limits that were found during the **Homing** operation (see Section 3.4.3, Step 11). Note that the off-center limits will vary according to the distance between the magnetic lock and the bottom of the probe (see Section 4.2.2).
   - The **Zero Field** button is used to start the zeroing process. After you have started it, the label of this button changes to **Abort** (see Figure 3-16). You can stop the zeroing operation at any time by clicking on this button.
   - The **Close** button closes the **Zero Field** dialog.

3.5.2 Example: Zeroing the Field at 4.1 Centimeters

1. If necessary, open the **Zero Field** dialog box (Figure 3-15) by clicking on the **Zero Magnetic Field** button in the **VSM ULF Operations** dialog box (Figure 3-14).
2. In the **Zero Field** dialog box, click in the check box next to **Center of the VSM Coil (4.1 cm).**
3. Click on the **Zero Field** button at the bottom of that dialog box.
4. The program will automatically perform an initial quench to expel the remnant field (Figure 3-16).

   Note that the button at the lower left of the **Zero Field** dialog box is now labeled **Abort**.

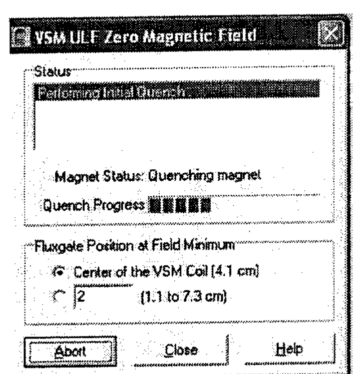

Figure 3-16. Zero Field dialog: Zeroing the field at 4.1 cm

5. The program will move the fluxgate magnetometer to 4.1 cm and measure the field. These procedures will be reported in the **Zero Field** dialog box (Figure 3-17) and in the **VSM ULF Log** (Figure 3-18), which will report that the system is performing a touchdown.

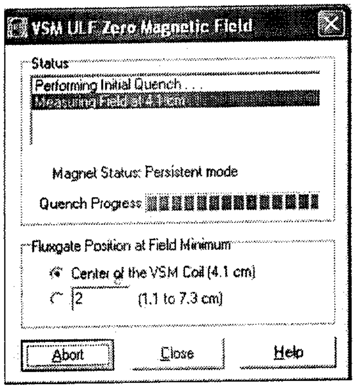

Figure 3-17. Zero Field dialog: Measuring the field at 4.1 cm

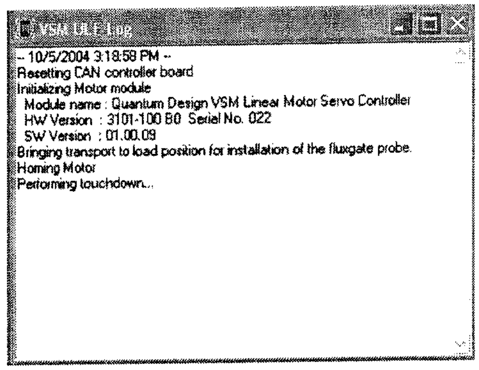

Figure 3-18. VSM ULF Log: Logging the zero-field operation

7. Next, the program will automatically apply a compensation field and quench the magnet to reduce the measured remnant (Figure 3-19), and the **VLM ULF Log** will show that the magnetic sensor was moved to 4.1 cm (Figure 3-20). After the remnant field measurement, the transport will move the fluxgate magnetometer to the bottom of the travel range that was determined during the **Homing** operation. This repositioning prevents the CAN module from being overheated.

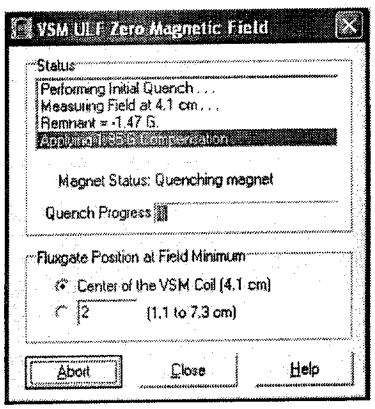

Figure 3-19. Zero Field dialog: Compensating for the remnant field

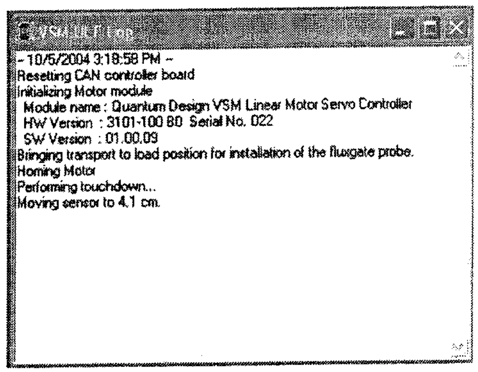

Figure 3-20. VSM ULF Log: Logging the sensor movement

Important: If the adapter assembly was installed less than 48.8 inches from the bottom of the probe, the system will not be able to perform a touchdown and a **Warning** message will be issued (Figure 3-21).

You will not be able to proceed further until you have repositioned the adapter assembly by using the sequence given below.

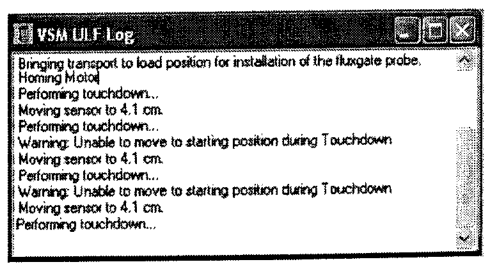

Figure 3-21. VSM ULF Log: Warning message

a. Stop the current procedure by clicking on the **Abort** button at the bottom left of the **Zero Field** dialog box (Figure 3-19).
b. Bring the fluxgate probe to the load position as explained in Section 2.5.1, Steps 1–5.

c. When the **Removing Fluxgate** dialog indicates that the VSM linear motor is in the load position, loosen the knurled nut on the fluxgate adapter assembly and reposition it (see Section 4.2.2).

d. Click on the **Cancel** button at the bottom left of the **Removing Fluxgate** dialog (see Figure 2-15). Now you will be returned to the **VSM ULF Operations** dialog box (e.g., Figure 3-24).

e. Re-attach the electronic control box to the fluxgate probe.

f. In the **VSM ULF Operations** dialog box, click on the **Zero Field** button to open the **Zero Field** dialog box and return to zeroing the magnetic field (e.g., at Step 1 of Section 3.5.2).

8. As shown in Figures 3-22 and 3-23, the system will automatically continue to reduce the field and perform magnet quenches until the field remnant is under 0.1 G.
9. When the remnant has been reduced to 0.1 G, the status area of the **Zero Field** dialog box will display "Done" (Figure 3-23). Note that the button that was labeled **Abort** has changed back to **Zero Field.**
10. Click on the **Close** button.
11. Now you will be returned to the **VSM ULF Operations** dialog box (Figure 3-24). Note that the value in the **Field at Fluxgate** text box now reads 0.098 G, by comparison with the value of –2.931 G at the start of the field-zeroing operation (Figure 3-14).

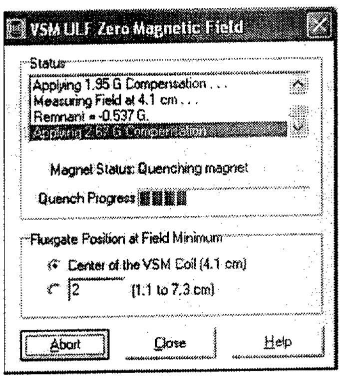

Figure 3-22. Zero Field dialog: Reducing the field remnant

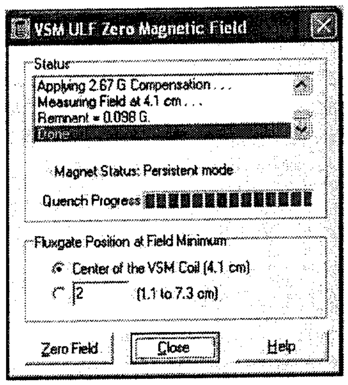

Figure 3-23. Zero Field dialog: Field remnant under 0.1 G

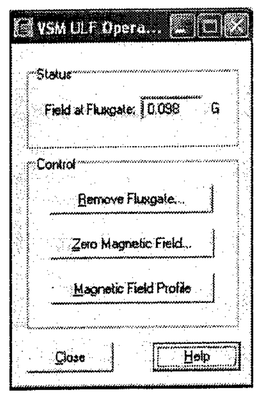

Figure 3-24. VSM ULF Operations dialog box after field zeroing

3.5.3 Profiling the Magnetic Field

1. Click on the **Magnetic Field Profile** button in the **VSM ULF Operations** dialog box.
2. The **VSM ULF Log Data** dialog box (Figure 3-25) will open so that you can save the profile data to a file.

   "`VSMUlfProfile.dat`" is the default name for the field profile data file, but you can choose another name by clicking on the **Browse** button and designating another file name and/or directory, as is shown in Figure 3-26.

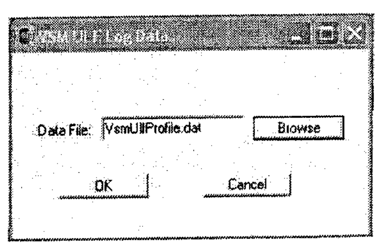

Figure 3-25. VSM ULF Log Data dialog box for saving field profile data

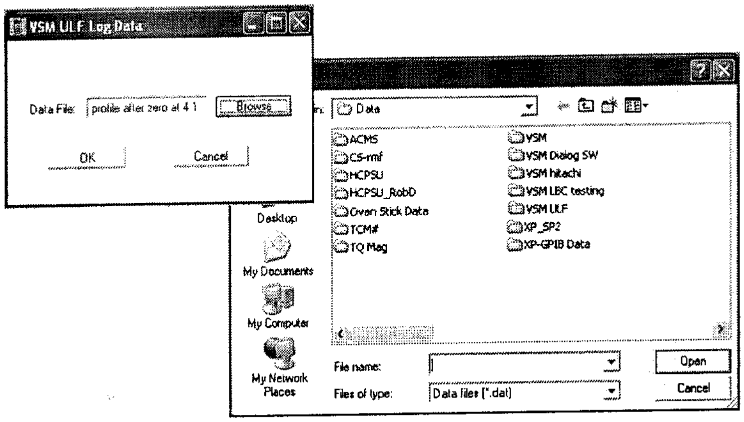

Figure 3-26. Changing the name of the field profile data file

3. After designating a name for your profile data file, click on the **OK** button at the bottom of the **VSM ULF Log Data** dialog box. The program will begin the field profile, and the only active button in the **VSM ULF Operations** dialog box will be one that allows you to **Abort** the field-profiling operation (Figure 3-27).
4. During the field profile, the program will move the fluxgate magnetometer to the top of the travel range determined during the **Homing** operation, then it will slowly lower it down. At the same time, it will log the data (Figure 3-28). In the **VSM ULF Operations** dialog box, the **Field at Fluxgate** reading (in the **Status** section) will change during the movement, reflecting the field that remains in the magnet, and the only active control button will be labeled **Abort**.

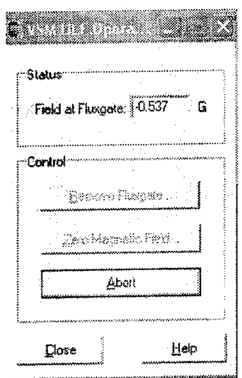

Figure 3-27. VSM ULF Operations dialog box during field profiling

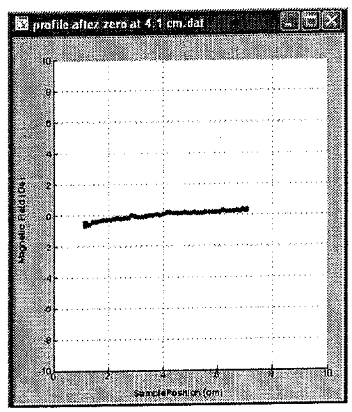

Figure 3-28. Plotting the field profile data

3.5.4 Example: Zeroing the Field at 5 Centimeters

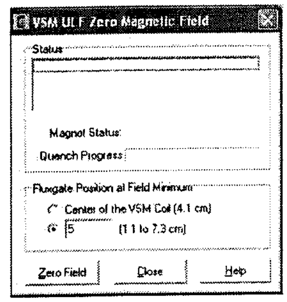

Figure 3-29. Zero Field dialog: Zeroing the field at 5 cm

As is explained in Section 3.5.1, you can zero the field at a fluxgate position other than the center of the VSM coilset. Use this "off-center" option as follows:

1. If necessary, open the **Zero Field** dialog box (Figure 3-29) by clicking on the **Zero Magnetic Field** button in the **VSM ULF Operations** dialog box (e.g., Figure 3-24).
2. In the **Zero Field** dialog, select the second option, which is shown in Figure 3-29 as **(1.1 to 7.3 cm)**, and enter your value in the option text box. For example, in Figure 3-29 we used 5 cm.

   Important: Remember that the limits for the off-center option depend on where you placed the adapter assembly, as is explained in Section 4.2.2.
3. Click on the **Zero Field** button at the bottom of the **Zero Field** dialog box.
4. The remainder of the process will proceed the same as when you use the center of the VSM coil to zero the field (see Section 3.5.2).

   Important: If the adapter assembly was installed less than 48.8 inches from the bottom of the probe, the **VSM ULF Log** will not be able to perform a touchdown at the position you designated, and a **Warning** message will be issued (Figure 3-30).

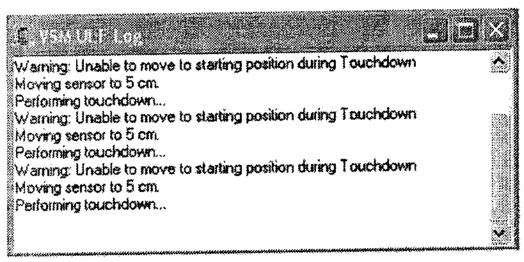

Figure 3-30. VSM ULF Log: Warning message

If this type of warning message appears, you will not be able to proceed further until you have repositioned the adapter assembly by using the sequence given below.

a. Stop the current procedure by clicking on the **Abort** button at the bottom left of the **Zero Field** dialog box (e.g., Figure 3-22).
b. Bring the fluxgate probe to the load position as explained in Section 2.5.1, Steps 1–5.
c. When the **Removing Fluxgate** dialog indicates that the VSM linear motor is in the load position, loosen the knurled nut on the fluxgate adapter assembly and reposition it (see Section 4.2.2).
d. Click on the **Cancel** button at the bottom left of the **Removing Fluxgate** dialog (see Figure 2-15). Now you will be returned to the **VSM ULF Operations** dialog box (e.g., see Figure 3-24).
e. Re-attach the electronic control box to the fluxgate probe.
f. In the **VSM ULF Operations** dialog box, click on the **Zero Magnetic Field** button to open the **VSM ULF Zero Magnetic Field** dialog box and return to zeroing the magnetic field (e.g., at Step 1 of Section 3.5.4).

C H A P T E R 4

VSM ULF Hardware

4.1 Introduction

This chapter contains the following information:

- Section 4.2 describes hardware components of the VSM ULF option.
- Section 4.3 describes maintenance and use of the fluxgate magnetometer.

4.2 VSM ULF Hardware Components

The hardware components of the VSM Ultra-Low Field (ULF) option include a fluxgate magnetometer, a magnetometer storage (wall) bracket, a fluxgate cable, and an interface cable.

4.2.1 Fluxgate Magnetometer

The fluxgate magnetometer is used to measure the magnetic field in the sample chamber. As is shown in Figure 4-1, the fluxgate magnetometer consists of an electronic control box and a probe. The fluxgate probe includes a coupling, a fluxgate adapter assembly, a stainless-steel tube, a fiberglass tube, and the field sensor.

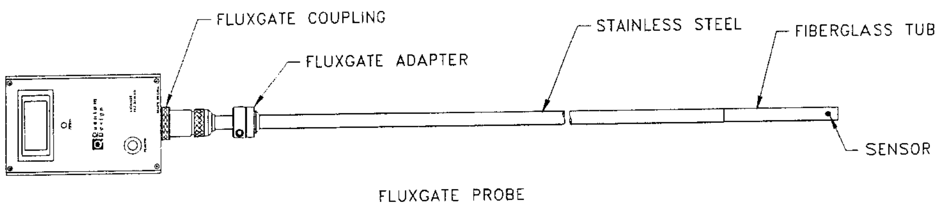

Figure 4-1. VSM fluxgate magnetometer assembly

The fluxgate magnetometer is a precision instrument that must be handled with care. When you are working with it, hold it by the stainless steel section of the probe to avoid damaging the fiberglass tube and sensor.

> **CAUTION!**
>
> Handle the fluxgate magnetometer carefully to avoid damaging the fiberglass tube and the fluxgate sensor that are located at the bottom of the fluxgate probe. Only hold the fluxgate probe by the stainless-steel portion, ***never*** by the fiberglass tube.

The fluxgate magnetometer is a vector instrument that reads the magnetic field parallel to the longitudinal axis of the fluxgate probe. The VSM ULF option requires the fluxgate magnetometer in order to zero the magnetic field at a specific position or plot the field profile. This fluxgate magnetometer is specifically designed to fit inside the VSM linear motor transport, sample tube, and VSM coilset. Its movement is controlled by the VSM linear motor transport.

The fluxgate sensor in the fluxgate magnetometer measures the magnetic field inside the sample chamber. The sensor, which is 1.1 cm above the bottom of the fluxgate probe, is embedded in the G-10 fiberglass tube, which is the lower part of the fluxgate probe. The fiberglass housing prevents the fluxgate sensor from contacting anything magnetic. The VSM linear motor transport moves the fluxgate probe up and down within the sample chamber so that the fluxgate sensor can measure the field at any number of locations. PPMS MultiVu reads the field measurements and can plot them or instruct the system to apply a compensation field that nulls the measured remnant field.

Important: The performance of the fluxgate sensor has not been characterized at cryogenic temperatures. Thermal cycling can cause serous damage to the magnetometer.

> **CAUTION!**
>
> Always wait to use the magnetometer until the temperature of the system has been stable for at least 20 minutes. This is to prevent thermal shocking, which can seriously damage the magnetometer.

4.2.2 Fluxgate Adapter Assembly

The fluxgate adapter assembly (Figure 4-2) holds the fluxgate probe in place in the VSM linear motor transport. The adapter is constructed of anodized aluminum and has two components: an adjustable clamp and a magnetic lock. The adjustable clamp allows you to move the adapter up and down on the fluxgate probe to change the zeroing and profiling range, and the magnetic lock sticks to the magnetic lock ring, which is a thin steel ring at the top of the VSM sample access port.

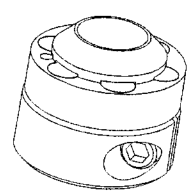

Figure 4-2. Fluxgate adapter assembly (upside down)

4.2.2.1 ADJUSTABLE CLAMP

The adjustable clamp is closed around the fluxgate probe by tightening the horizontal screw. Two vertical screws hold the clamp in place on top of the magnetic lock. If you need to loosen or tighten the adjustable clamp, you can use the Allen wrench provided in the VSM ULF Option User's Kit to turn the horizontal screw.

4.2.2.2 MAGNETIC LOCK.

The magnetic lock contains six small, very strong magnets that attach the fluxgate probe to the armature of the linear motor transport during zeroing and field-profiling operations. Keep the magnets clean and prevent them from contacting any magnetic object.

Important: Keep the magnet surfaces clean, as the strength of the lock depends on the magnets being flush in contact with the mating part in the linear motor transport. Also, avoid bringing the magnets into contact with magnetic objects. Although small, the magnets are extremely strong.

4.2.2.3 POSITIONING THE FLUXGATE ADAPTER ASSEMBLY

The VSM ULF option is shipped with an assembled fluxgate magnetometer (Figure 4-1). Note that the fluxgate adapter assembly (Figure 4-2) is located 48.8 inches from the bottom of the probe. If you adjust the fluxgate adapter assembly, attach it 48.8–49.2 inches from the bottom of the fluxgate probe. A distance of 48.8 inches is the minimum that will allow the bottom of the fluxgate probe to touch the surface of the puck at the VSM coilset. This contact is necessary for touchdown operations. A distance of 49.2 inches will allow the magnetometer to profile the magnetic field over 2 cm around the center of the VSM coilset. Distances greater than 49.2 inches reduce the profiling capability below 2 cm.

Important: Verify that there is 48.8–49.2 inches between the fluxgate adapter assembly and probe bottom. At this location, the magnets of the adapter assembly will engage the armature of the linear motor transport. If there is less than 48.8 inches between the adapter assembly and the bottom of the fluxgate probe, the system will not be able to perform touchdowns or valid field-nulling operations.

The adapter assembly is secured in place on the probe by a horizontal screw (see Figure 4-2). Use the Allen wrench in the VSM ULF Option User's Kit to loosen and tighten the screw if you reposition the adapter assembly.

4.2.3 Electronics Control Box

Figure 4-3 shows the electronics control box, which mounts on top of the fluxgate probe and contains the electronics that operate the fluxgate sensor. The digital display on the front panel of the electronics control box shows the field, in gauss, as measured by the fluxgate sensor. The power to the fluxgate is turned on-and-off by pressing the “Power” button. The zero-adjustment screw adjusts the zero offset of the fluxgate.

When the magnetometer is installed in the PPMS, the electronics box is connected to the Model 6000 by the fluxgate cable, which plugs into the port on the rear panel of the electronics control box (Figure 4-4).

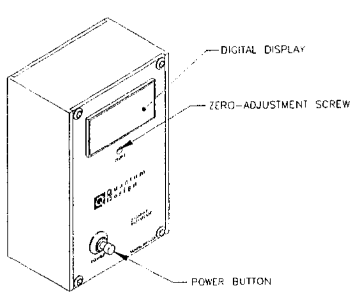

Figure 4-3. Front of electronics control box

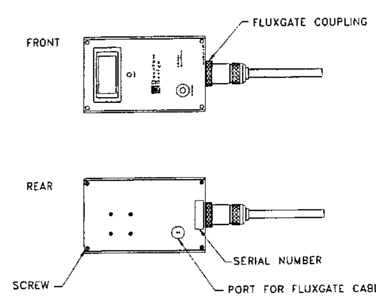

Figure 4-4. Front and back views of electronics control box

The electronics control box can be detached from the fluxgate probe by loosening the fluxgate coupling, which is at the top of the fluxgate probe, and then pulling the box off the probe. Figure 4-4 shows the fluxgate coupling in relation to the fluxgate magnetometer.

Important: Verify that the same serial number is used on the electronics control box and the fluxgate probe. Quantum Design assigns the same serial number to sets of these components to help ensure that the correct ones are used together. If the serial number is not the same, contact Customer Service at Quantum Design.

4.2.4 Wall Storage Bracket

The wall storage bracket (Figure 4-5) holds and protects the fluxgate magnetometer when it is not in the sample chamber. You can vertically mount the storage bracket on any wall, but you should locate it relatively near the PPMS to facilitate installing and removing the fluxgate magnetometer. For instructions on attaching the storage bracket to the wall, see Section 2.3.4.

Near the base of the storage bracket is a two-layer permalloy fluxgate shield that protects the fiberglass tube and fluxgate sensor, which are at the bottom of the fluxgate probe. The fluxgate shield is also a magnetic shield that attenuates the magnetic field of the Earth by more than 60 dB. Thus, within the shield, the remnant field is less than 0.5 mG.

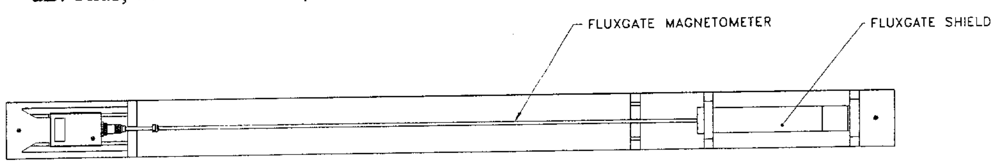

Figure 4-5. Fluxgate magnetometer in wall storage bracket

To further protect the magnetometer, we have designed the wall bracket so that you cannot remove the magnetometer until the probe section has cleared the fluxgate shield.

Important: Place the magnetometer in the bracket as soon as you remove it from the sample chamber. This reduces the risk that it will be damaged as you move around the laboratory.

4.2.5 Interface Cable Assembly

The interface cable assembly for the VSM ULF option (Figure 4-6) reroutes the signal from the ACMS board to the low-field magnet coil in the magnet. (In systems with standard dewars, the ACMS board is in the Model 6000 controller; in PPMS–EverCool systems, the ACMS board is in the Model 6500 controller.)

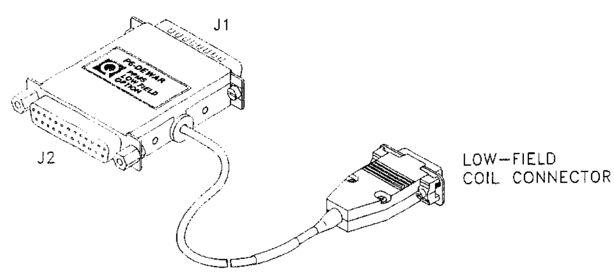

Figure 4-6. Interface cable assembly for the VSM ULF option

The ULF option interface cable assembly has three connectors. The J1 and J2 connectors are on opposite ends of the large, silver-colored box that is labeled "P6–Dewar PPMS Low Field Option." The low-field coil connector is at the end of the cable that is attached to the silver-colored box.

4.2.6 Fluxgate Cable Assembly

Figure 4-7 shows the fluxgate cable, which is the electrical connection between the fluxgate magnetometer and P8–Auxiliary port on the Model 6000 PPMS controller. The Lemo connector on the cable plugs into the port on the rear panel of the fluxgate electronics control box (Figure 4-4), and the DB-25 connector plugs into the Model 6000. This cable feeds a voltage proportional to the field to an analog input on the Model 6000 that is ultimately read by the ULF software.

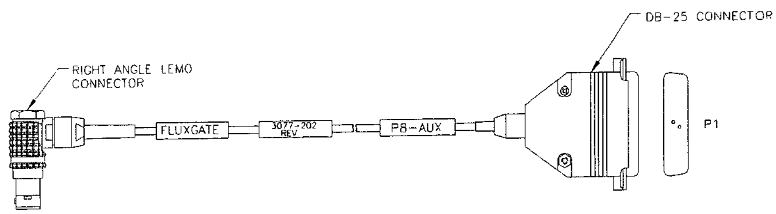

Figure 4-7. Fluxgate cable assembly

4.3 Maintenance and Use of the Fluxgate Magnetometer

Periodically, the VSM ULF fluxgate magnetometer will require a new battery (see Section 4.3.4). Aside from that, it does not need regular maintenance. Instructions for verifying fluxgate magnetometer operations and adjusting the zero offset are given below.

4.3.1 Power Requirements

One standard 9 V transistor battery will continuously operate the fluxgate magnetometer for 8 to 10 hours.

The control unit of the fluxgate magnetometer has an automatic shut-off feature that turns off the power to the magnetometer after it has been on for approximately 15 minutes, which prevents the battery from being discharged if the unit is left on. Those 15 minutes should be enough time to run a field-nulling operation and plot the residual field. However, if the fluxgate magnetometer turns off while you are using it, just press the "Power" button to turn it on again (see Figure 4-3).

When it is time to replace the battery, a small icon of a battery will appear in the upper left corner of the display on the electronics control box. This icon is the low-battery indicator. Section 4.3.4 has instructions for replacing the battery.

4.3.2 Verifying Proper Operation

1. Remove the fluxgate magnetometer from the wall bracket as follows: Lift the fluxgate magnetometer upward until it clears the fluxgate shield, and then pull the fluxgate magnetometer out of the wall bracket.
2. Activate the fluxgate magnetometer by pressing the "Power" button on the electronics control box. The digital display should immediately begin showing the ambient field.
3. Test the fluxgate magnetometer by altering its orientation with respect to the ambient field of the earth, and watch the fluxgate to see if the output changes.
4. If the output does not change, contact Customer Service at Quantum Design.

4.3.3 Adjusting the Zero Offset

1. If necessary, place the fluxgate magnetometer in the wall bracket. The two-layer permalloy fluxgate shield in the wall bracket is a magnetic shield that establishes a true zero field around the sensor.
2. Activate the fluxgate magnetometer by pressing the "Power" button on the electronics control box. The digital display should indicate that the field is zero (0).
3. If the field is not zero, adjust the zero offset of the magnetometer. Use the flathead screwdriver included with the VSM ULF Option User's Kit to turn the zero-adjustment screw until the digital display indicates the field is zero (0).

4.3.4 Replacing the Battery

You must replace the battery in the electronics control box whenever the display shows a small icon of a battery. The icon is the low-battery indicator.

Complete the following steps to replace the battery:

1. If the fluxgate magnetometer is in the sample chamber, remove it (refer to Section 2.5.1).
2. Lay the fluxgate magnetometer on a flat surface and detach the electronics control box from the fluxgate probe.
   - Loosen the fluxgate coupling (see Figures 4-1 and 4-4).
   - Pull the box off the probe.
3. Use the screwdriver included with the VSM ULF Option User's Kit to remove the screws at the corners of the rear panel of the electronics control box (see Figure 4-4).
4. Remove the rear panel from the electronics control box.
5. Remove the battery from its holder. Work carefully to avoid pulling out the wires that connect the battery and rear panel receptacle to the electronics inside the control box.
6. Place a new 9 V transistor battery into the battery holder.
7. Reattach the rear panel to the electronics control box.
8. Please follow the local regulations when you dispose of the used battery.

References

Quantum Design. *Model 1000 Modular Control System User's Manual,* 2003.

————————. *Physical Property Measurement System: Hardware Manual, B-0,* 2004.

————————. *Physical Property Measurement System: Vibrating Sample Magnetometer (VSM) Option User's Manual, A-2,* 2004.

Quantum Design

Physical Property Measurement System

VSM Oven Option User's Manual

Part Number 1097-100

Quantum Design

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	(800) 289-6996
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First edition of manual completed June 2004.

Trademarks

U.S. Patents

4,791,788	Method for Obtaining Improved Temperature Regulation When Using Liquid Helium Cooling
4,848,093	Apparatus and Method for Regulating Temperature in a Cryogenic Test Chamber
5,053,834	High Symmetry DC Squid System
5,110, 034	Superconducting Bonds for Thin Film Devices
5,139,192	Superconducting Bonds for Thin Film Devices
5,311,125	Magnetic Property Characterization System Employing a Single Sensing Coil Arrangement to Measure AC Susceptibility and DC Moment of a Sample (patent licensed from Lakeshore)
5,319,307	Geometrically and Electrically Balanced DC Squid System Having a Pair of Intersecting Slits
5,647,228	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber

Foreign Patents

U.K.	9713380.5	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber
Canada	2,089,181	High Symmetry DC Squid System
Japan	2,533,428	High Symmetry DC Squid System

C O N T E N T S

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P R E F A C E

Contents and Conventions

P.1 Introduction

This preface contains the following information:

- Section P.2 provides an overview of the scope of the manual.
- Section P.3 outlines the contents of the manual.
- Section P.4 shows the conventions that appear in the manual.

P.2 Scope of the Manual

This manual contains background about the PPMS Vibrating Sample Magnetometer (VSM) Oven option; instructions for installing and using the VSM Oven software and hardware; and instructions for performing sensitive measurements when the VSM Oven option is installed in the PPMS unit.

P.3 Contents of the Manual

- Chapter 1 provides an overview of the VSM Oven option and the theory of operation.
- Chapter 2 provides instructions for installation and removal of the VSM Oven option, safety recommendations, and contact information for Quantum Design.
- Chapter 3 covers sample composition and how to mount samples for measurement with the VSM Oven.
- Chapter 4 summarizes the measurement process with the VSM Oven option and guides you through an immediate-mode measurement.
- Chapter 5 describes the hardware and electrical components of the VSM Oven option and the contents of the VSM Oven Option User's Kit.

- Chapter 6 describes the differences you will encounter when using MultiVu with the VSM Oven option compared to the standard VSM equipment.
- Appendix A provides a functional description of the Model CM-C VSM Oven module, including diagrams and electrical specifications.
- Index is a guide to information organized by key terms and phrases.

P.4 Conventions in the Manual

File menu	Bold text identifies the names of menus, dialogs, options, buttons, and panels used in the PPMS MultiVu and VSM software.
File >> **Open**	The >> symbol indicates that you select multiple, nested software options.
`.dat`	The Courier font indicates file and directory names and computer code.
Important	Text is set off in this manner to signal essential information that is directly related to the completion of a task.
Note	Text is set off in this manner to signal supplementary information about the current task; the information may primarily apply in special circumstances.

CAUTION!

Text is set off in this manner to signal conditions that could result in loss of information or damage to equipment.

WARNING!

Text is set off in this manner to signal conditions that could result in bodily harm or loss of life.

WARNING!

Text is set off in this manner to signal electrical hazards that could result in bodily harm or loss of life.

CHAPTER 1

Introduction to the VSM Oven Option

1.1 Introduction

This chapter contains the following information:

- Section 1.2 is an overview of the VSM Oven option.
- Section 1.3 describes notable features of the VSM Oven option.
- Section 1.4 describes the VSM Oven option theory of operation.
- Section 1.5 outlines safety considerations for working with the VSM Oven option.
- Section 1.6 lists contact information at Quantum Design and its service centers.

1.2 Overview

The oven for the PPMS VSM provides a way to make sensitive D.C. magnetometry measurements at controlled temperatures from 300 K up to 1000 K. Using a specially designed heated sample holder and VSM sample rod with electrical feedthrough, the VSM Oven vibrates the sample inside the VSM detection coilset. Both the standard VSM option and a PPMS high-vacuum option are required in order to operate the VSM Oven.

Heating of the sample is achieved by applying current to a platinum resistive heating element lithographically patterned onto the custom-designed sample holder. A thermocouple embedded on the back side of the sample holder measures the temperature in the sample region, and a thermistor at the top connector of the sample holder corrects for heating of the cold junction. In this manual, we will refer to the VSM Oven sample holder as the *heater stick* (see Figure 5-1). To maximize thermal contact, the sample is attached to the heater stick using alumina-based cement (included in VSM Oven Option User's Kit, Figure 5-5). Then, the platinum heater region is wrapped securely with a thin copper-foil radiation shield that retains heat and reduces thermal gradients between the sample and heater stick.

The VSM Oven heater stick is a 1 gram heated substrate on which the sample is glued. This design is in contrast to that of other high-temperature oven inserts for magnetometers, which often are bulky and have long thermalization times. By embedding the thermometry in the substrate along with the heater, we have made vast improvements on typical thermal-response times and sample-temperature accuracy. Due to the low thermal mass of the heated substrate, you can maintain heating rates at the sample of over +200 K/min throughout the full temperature range of the oven. Note that the cooling rate will depend on the current temperature of the heater stick, because cooling occurs through thermal radiation from the heater stick to the VSM detection coilset.

Ease of use is another advantage of the Quantum Design VSM Oven option—it uses the same VSM detection coilset as the standard (low temperature) mode of the VSM option for the PPMS. To change from the standard VSM mode to the VSM Oven mode, you simply insert a new sample into the VSM.

1.3 Notable Features of the VSM Oven Option

Figure 1-1 illustrates the hardware and functional connections necessary for operating the VSM Oven. A new CAN module, the Model CM-C VSM Oven module, has been introduced to handle the temperature control of the VSM Oven heater stick. This module plugs into the Model 1000 Modular Control System, which communicates with the PC via the CAN network cable. The oven-control cable plugs into the front panel of the oven-control module. This cable passes heater power and temperature readback information to the heater stick via the electrical feedthrough on the wired access port and the wired oven sample rod.

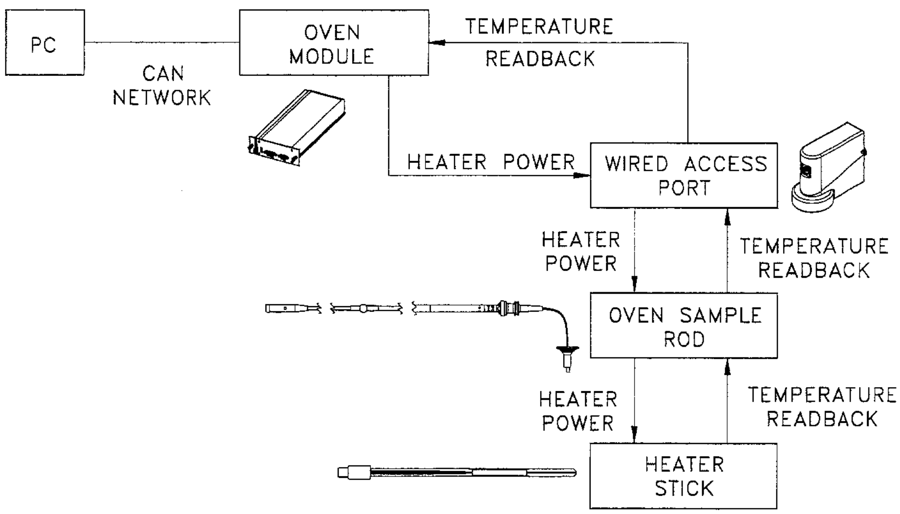

Figure 1-1. Operating principle for the VSM Oven option

1.4 Theory of Operation

The platinum heater is driven synchronously to the power line frequency (50 Hz or 60 Hz, depending on country and region) with a sinusoidal excitation. Magnetic feedthrough from the heater currents into the VSM detection coilset is minimized by patterning the heater noninductively and by operating at line frequency, where the VSM detection circuitry can easily reject the signal. The thermocouple voltage is monitored constantly by a sensitive low-drift DC microvolt preamp in the VSM Oven module. The thermocouple junction is located in the middle of the heater region of the stick, and the thermocouple wires terminate at the connector at the top of the stick. Note that the thermocouple table is referenced to a cold junction at 273 K (0 °C). Also located at the connector is a negative temperature coefficient thermistor that corrects for the thermocouple cold junction temperature. The thermistor is read about 10 times a second using a 2 msec current pulse.

The temperature at the sample T_{sample} is calculated from the thermocouple voltage ΔV_{TC} and thermistor resistance $R_{thermistor}$ as follows:

$$T_{sample} = T_{TC}(\Delta V_{TC} + \Delta V(T(R_{thermistor}))),$$

where

$T(R_{thermistor})$ = standard table for temperature vs. thermistor resistance,

$\Delta V(T)$ = standard table for type S thermocouple voltage vs. temperature standard, and

$T(\Delta V)$ = inversion of the $\Delta V(T)$ thermocouple table.

In order to enable temperature control down to 300 K at the heater stick, the VSM puck is set to 295 K while the system operates in VSM Oven mode. Due to the heat load from the heater stick when it is at high temperatures, the software lets the block temperature of the PPMS go as low as 283 K while it tries to maintain the puck temperature at 295 K.

Figure 1-2 below shows a simplified schematic of the control circuit for the heater stick. "PID" refers to the Proportional-Integrator-Differential temperature control of the A.C. drive for the heater.

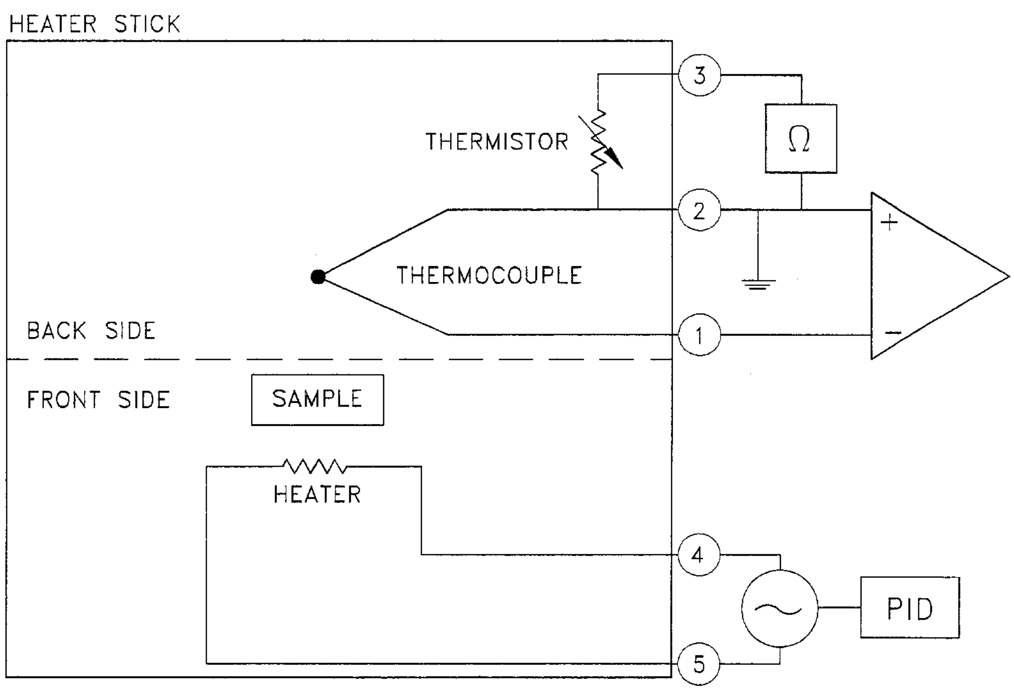

Figure 1-2. Control circuit for the VSM Oven heater stick

1.5 Overheating Prevention Mechanisms

To safeguard the equipment from overheating, the PPMS sets the coilset temperature at 295 K while it is operating in oven mode, and the VSM Oven software uses the VSM coilset temperature as the primary diagnostic. In the event that the VSM coilset temperature rises above 350 K, the system shuts down the power to the oven heater.

1.6 Safety Precautions

WARNING!

The VSM Oven option is used in conjunction with the Physical Property Measurement System (PPMS), so you should be aware of the safety considerations for that equipment. PPMS-related safety precautions include those for the use of superconducting magnets and for the use of cryogenic materials, as is reviewed in the *Physical Property Measurement System: Hardware Manual.*

Above all, Quantum Design and its staff ask that you use standard safe laboratory procedures.

- Use common sense.
- Pay attention to the state of the system and to your surroundings.
- Investigate and take appropriate action if the behavior of the system appears abnormal—something could be wrong with it.
- Supervise inexperienced users and train them in laboratory safety and in general electrical safety procedures.

The VSM and PPMS have safety features to prevent accidents from causing injury or serious equipment damage. *If you use the equipment in a manner that is not specified by Quantum Design, the protection afforded by the equipment may be impaired.*

1.6.1 VSM High-Temperature Heater

Handle the heater stick with caution when you remove it from the PPMS.

The heater stick should be near room temperature by the time you take it from the wired access port—it has very low mass (less than 1 gram of hot material) and cools substantially when the sample chamber is vented with helium gas. Yet, you should remember that the central region of the heater stick can reach temperatures up to 727 °C (1000 K), and this would cause severe burns if you touched it.

1.6.2 Cryogens

> **WARNING!**
>
> Always wear protective clothing and ensure that the room has good ventilation when you work with cryogenic materials such as liquid helium and liquid nitrogen. These precautions will help protect you against cryogenic material hazards: (1) they can expand explosively when exposed to room temperature; (2) they can cause serious burns.

- Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium, liquid nitrogen, or other cryogens. Avoid loose clothing or loose fitting gloves that could collect cryogenic liquids next to the skin. The extreme cold of liquid and gaseous cryogens can cause serious burns and has the potential to cause loss of limbs.
- Work with cryogenic materials only in well-ventilated areas. In the event a helium container ruptures or there is a helium spill, vent the room immediately and evacuate all personnel. In a poorly ventilated area, helium can displace the air, leading to asphyxiation. Because helium rises, it is generally safest to work with it in well-vented rooms with high ceilings.

1.6.3 Magnets

> **WARNING!**
>
> Any person wearing a pacemaker, electrical medical device, or metallic implant must stay at least 5 m (16.5 ft.)[1] from the PPMS dewar. In addition, personnel must keep all ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar. Verify that magnetic fields are at zero (0) before handling the VSM linear motor transport in any way.

The following precautions should be followed to ensure the safety of personnel who work with or around a PPMS with a superconducting magnet. This material is covered in more depth in Chapter 1 of the *Physical Property Measurement System: Hardware Manual.*

- Verify that any person who has a metallic implant or is wearing a pacemaker or electrical or mechanical medical device stays at least 5 m (16.5 ft.) from the PPMS dewar. Large magnetic fields are dangerous to anyone who has a metallic implant or is wearing a pacemaker or other electrical or mechanical medical device.

  Important: The automated control system can turn on the magnet while the system is unattended. Furthermore, the three-dimensional magnetic field of the PPMS will penetrate nearby walls, the ceiling, and the floor. Therefore, your safety considerations should include such adjacent spaces.

---

[1] At the current time, 5 m should be a large enough distance to protect wearers of metallic implants or medical devices from most magnetic fields produced by Quantum Design magnets. However, the safe distance from newer magnets (in development) could be greater. Hence, personnel who work with and around the superconducting magnets should thoroughly review documentation for new equipment.

- Keep all iron, nickel, and other ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar. Large magnets, such as the PPMS superconducting magnets, can attract iron and other ferromagnetic materials with great force. The observable effects of magnetic fields are listed in Chapter 1 of the *Physical Property Measurement System: Hardware Manual.*
- Never attempt to install, remove, or handle the VSM linear motor transport when there is a field set in the PPMS or in any other nearby equipment. In addition, the VSM linear motor transport must be secured when it is stored within 5 m (16.5 ft.) of the PPMS or any other large field source. The VSM linear motor transport presents a considerable hazard in a large magnetic field such as that produced by the PPMS or other laboratory equipment such as an NMR magnet, as the linear motor transport contains nearly 9 kg of iron.Electricity

1.6.4 Electricity

WARNING!

The VSM and the PPMS are powered by nominal voltages between 100 V to 240 V AC. These voltages are potentially lethal, so you should exercise appropriate care before opening any of the electronics units, including turning off the equipment and disconnecting it from its power source.

- Turn off and unplug all electronic equipment before removing any equipment covers.
- Keep electrical cords in good working condition and replace frayed and damaged cords.
- Keep liquids away from the workstations.

1.7 Contacting Quantum Design

If you have questions or problems related to your QD equipment, please contact your local QD service representative. He or she will ask you to describe the problem, the circumstances involved, and the recent history of your system.

United States

Quantum Design World Headquarters
6325 Lusk Boulevard
San Diego, CA 92121

Tel: 1-858-481-4400
1-800-289-6996
Fax: 1-858-481-7410

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Web: http://www.qdusa.com

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Tel: 49-6151-880631
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Email: qd.euroservice@lot-oriel.de
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Service for Austria, Belgium, Crete, Croatia, Czech Republic, Denmark, England, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and Yugoslavia

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Fax: 81-3-5954-6570

Email: qdjapan@tkb.att.ne.jp
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Fax: 82-2-2057-2712

Web: http://www.qdkorea.com

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Beijing 100005
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Fax: 8610-6518-8155

Email: lambert@oxford-instruments.com.cn
Web: http://www.oxford-instruments.com.cn

Service for People's Republic of China

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Taipei, Taiwan R.O.C.

Tel: 886-2-8780-5228
Fax: 886-2-8780-5225

Email: lonson.lin@omega-cana.com.tw

Service for Taiwan, Hong Kong, Singapore

C H A P T E R 2

Installing and Removing the VSM Oven Option

2.1 Introduction

This chapter contains the following information:

- Section 2.2 includes definitions and a list of the VSM Oven components.
- Section 2.3 describes the procedures for the *initial* installation of the VSM Oven option.
- Section 2.4 describes how to reconfigure the PPMS for the VSM Oven.
- Section 2.5 describes how to remove the VSM Oven from the PPMS.

2.2 Overview of the VSM Oven Installation

This chapter describes the procedures you will use to install the hardware and software for the VSM Oven option. If you purchased the VSM Oven option as part of a complete Quantum Design (QD) system, many of these procedures will have been performed before you receive the equipment.

2.2.1 Terminology

To distinguish among the various activities that are involved in installing and operating the VSM Oven option, we offer the following usages and definitions:

- ***Activate option*** refers to the **Utilities >> Activate Option...** command in MultiVu, which incorporates option-specific commands into MultiVu. For example, when you activate the VSM option, the **VSM Control Center** will open so that you can set VSM-related parameters.
- ***Install hardware*** refers to activities involved in setting up equipment, such as plugging in the VSM Oven module, connecting cables, attaching the wired access port to the VSM head, and so on.
- ***Install sample*** refers to inserting a sample and sample rod into the PPMS using the **VSM Install/Remove Sample Wizard**. This wizard is available only while the VSM option is activated within MultiVu.

- ***"Mode"*** refers to the types of VSM measurements that can be made. When you have activated the VSM option in MultiVu, you can operate in either the *standard* (low temperature) mode or the *oven* mode. During installation, the VSM Oven software is automatically incorporated into the standard VSM software, so it does not have to be activated and deactivated separately from the standard VSM option.
- ***VSM Oven-enabled*** refers to the VSM MultiVu application when the VSM Oven hardware and software have been integrated.
- ***PPMS VSM User's Manual*** refers to the *Physical Property Measurement System: Vibrating Sample Magnetometer (VSM) Option User's Manual.*

2.2.2 VSM Oven Components

Table 2-1 lists the components of the QD VSM Oven option. Please verify that you have received them all before you start the installation.

Table 2-1. System components of the PPMS VSM Oven option

COMPONENT	PART NUMBER	ILLUSTRATION
Model CM-C VSM Oven Module*	4101-200	Figures 1-1, 2-6, 5-10–5-11, A-1, A-6
Wired Access-Port Assembly	4097-020	Figures 1-1, 2-6, 5-3–5-4
VSM Oven Sample-Rod Assembly	4097-010	Figure 1-1, 5-2
VSM Oven-Control Cable Assembly	3097-010	Figures 2-6, 5-9
Heater Stick Assembly** (2)	4097-050	Figures 1-1, 3-1, 5-1, 5-5
VSM Oven Option User's Kit	4097-040	Figure 5-5
VSM Oven Option User's Manual	1097-100	
Copper-Foil Shields** (10)	4097-042	Figures 3-1, 5-5
VSM Oven Sample-Mounting Platform Assembly**	4097-041	Figures 3-1, 4-1, 5-5–5-6
Mounted Nickel Standard**	4097-055	Figure 5-5
Model 6000 Firmware ROM (v. 1.9.1.2 or later)*		
VSM/MultiVu Application Software (v. 1.3.2.2 or later)*		

*These items might be pre-installed. **These items are shipped in the VSM Oven Option User's Kit.

2.3 Initial Installation of the VSM Oven Option

Important: The instructions in this section only apply to the *initial* installation of the VSM Oven option. If you subsequently reconfigure the PPMS to use a different (non-VSM) option, use the instructions in Section 2.4, "Reconfiguring the PPMS for the VSM Oven Option," when you are again ready to use the VSM Oven.

The procedures for the initial installation of the VSM Oven option will depend on whether the oven was purchased as part of a complete QD system (e.g., PPMS with VSM options) or as an upgrade to an operating PPMS.

If you purchased the VSM Oven option along with your PPMS, you can go to Step 3 of Section 2.3.7, "Install New Software." If you purchased the oven as an upgrade, please review the support materials and the procedures below as a guide to installation.

VSM Oven Requirements

Operation of the VSM Oven option requires a PPMS with a Quantum Design high-vacuum option, the standard VSM option, and the Model 1000 Modular Control Tower. Hence, the procedures for installing the VSM Oven option in an operational PPMS depend on the pre-existing equipment. Below are the procedures that will be required if you do not have a high-vacuum option or a standard VSM installed at the time that you purchase the VSM Oven option:

- install a high-vacuum option (if one is not already installed)
- install and verify the modular control system and CAN network adapter (if they are not already installed on the PPMS)
- insert the necessary control modules (Model CM-A, Model CM-B, and Model CM-C) into the Model 1000 Modular Control Tower (if one or more are not already installed)
- update the firmware ROMs in the Model 6000
- install the standard VSM hardware
- connect the VSM components (Oven and standard options) to the PPMS
- update the software

Some or most of these procedures might have been performed at the factory. Please review the instructions before you begin, and call Customer Service at Quantum Design if you have any questions.

2.3.1 High-Vacuum Option

The PPMS must be equipped with one of the Quantum Design high-vacuum options in order to operate in the VSM Oven mode. If your VSM Oven purchase included a high-vacuum option, use the option instructions to install it as the first step in the overall installation.

Important: If you have (or have received) a Quantum Design Cryopump High-Vacuum option, please note the following modifications to typical operations.

Changes to Cryopump High-Vacuum Operations

The presence of the VSM linear motor transport on the PPMS significantly increases the volume of the PPMS sample chamber as compared to other options for the PPMS. Hence, when the system is in oven mode, cryopump operations have been modified as follows:

- When a sample is installed, a purge/seal operation will be performed before the system begins any pre-pumping. This helps remove adsorbed gases and water from surfaces on the linear motor.
- After the cryopump flapper valve has been opened, the timeout to reach high vacuum has been set at 60 minutes instead of the standard 30 minutes.
- In the event that the sample chamber does not reach the base pressure in 60 minutes, the VSM Oven software issues a "High Vacuum" error warning to the user and records the error in the `Vsmlog.txt` file. The system does not stop operation of the VSM Oven when there is a High Vacuum error.

2.3.2 Install the Modular Control System and CAN Network Adapter

You will use the instructions in this section only if you have an operational PPMS and computer without the Model 1000 Modular Control System and driver software.

1. Install the Model 1000, CAN Network Adapter, and CAN Manager driver software, using the instructions in the *Model 1000 Modular Control System User's Manual.*
2. When you have completed the installation process, verify the connections:
   a. Verify that the power cable has been connected to the Model 1000 and it has been turned on.
   b. Verify that the power LED on the front of the Model 1000 is lit green.
   c. Verify that the Model 1000 is connected to the CAN adapter on the PC via the CAN network cable.

2.3.3 Insert the Control Modules into the Tower

You will use the instructions in this section only if one or more of the control modules have not been installed in the Model 1000. If the modules have all been installed, go to Section 2.3.4.

Before you start the module installation, review the instructions and cautions in the *Model 1000 Modular Control System User's Manual.*

1. Turn off the power to the Model 1000 and disconnect the power cord.
2. Open the lid on the Model 1000, which is shown in Figure 2-1.
3. Remove the cover plate for the appropriate number of low- and high-power module bays. The low-power bays are in the front row and have a single guide pin, and high-power bays are in the back row and have a double guide pin. If you need a low-power bay but none is available, you can use a high-power bay. (But remember that you cannot use high-power modules in the low-power bays.)
4. Carefully lower each module into its bay and slide it into the bay until it is fully and firmly seated.
5. Gently tighten the securing screws only until they are finger tight. The faceplate of the module should be flush with the surrounding plates.

6. If you are installing the Model CM-A and Model CM-B modules, connect them with the VSM–Motor Sync cable (see Figure 2-6 and the *Model 1000 Modular Control System User's Manual*).
7. After you have finished inserting all the required modules, reconnect the power cord and turn on the power to the Model 1000.
8. Verify that the power LED on the Model 1000 and the PWR and COP indicator LEDs on the modules are green (they might be red when the power is first turned on, but they will turn green shortly). See Appendix A and the various manuals for further information about the LEDs.

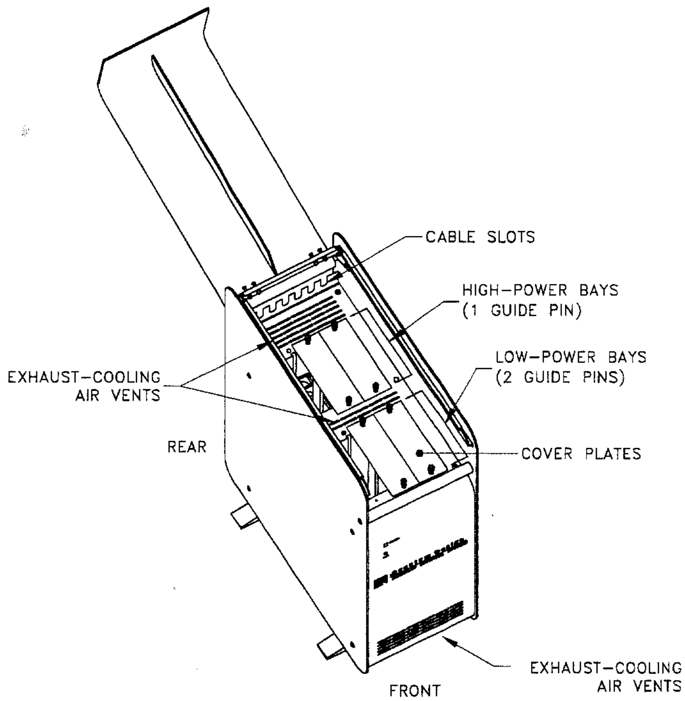


Figure 2-1. High- and low-power bays of Model 1000 module tower

2.3.4 Update the Firmware ROMs in the Model 6000

The VSM Oven option requires ROMs version 1.9.1.2 or later. If new ROMs were shipped with your VSM Oven option, install them in the Model 6000 PPMS controller by using the procedures below. Detailed instructions for these procedures should have been shipped with the VSM Oven, but you also can refer to *PPMS Service Note 1070-803*, "Configuration Download Instructions." for supplemental information.

The ROM update process includes (but is not limited to) putting the PPMS in standby (or shutdown) mode, uploading a copy of the current Model 6000 configuration to the computer, installing the new ROMs, and downloading the saved configuration from the computer back to the Model 6000.

2.3.4.1 PREPARE THE SYSTEM

1. If necessary, start MultiVu.
2. Set the PPMS system temperature to 320 K by using the front panel of the Model 6000 or the **Temperature–System** dialog box:

- Open the **Temperature-System dialog** box (select **Instrument >> Temperature**) and specify a set point of 320 K, as shown in Figure 2-2.
- Click on the **Set** button. Leave the dialog box open so that you can monitor the temperature until it reaches at least 290 K (do not continue with installation until the temperature reaches at least 290 K).

3. In the **Temperature-System dialog** box, click on the **Close** button.

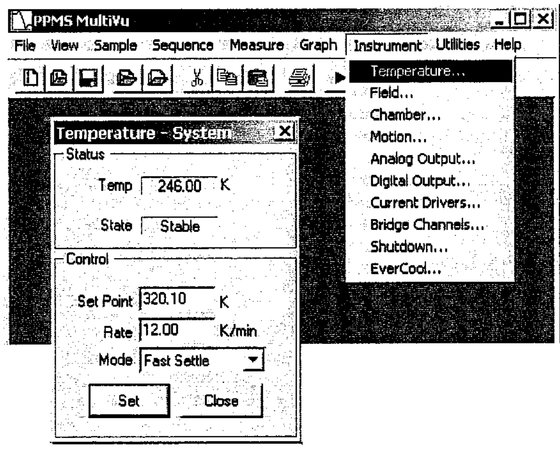


Figure 2-2. Temperature-System dialog box

4. Set the field to zero (0) Oe by using the front panel of the Model 6000 or the **Field** dialog box (Figure 2-3):
   - Select **Instrument >> Field**.
   - In the **Field** dialog box, specify a **Set Point** of zero (0) Oe.
   - Click on the **Set** button.
   - Leave the dialog box open so that you can monitor the field until it is within 1000 Oe of zero (do not continue until the field is within 1000 Oe of zero [0]).
5. In the **Field** dialog box, click on the **Close** button.

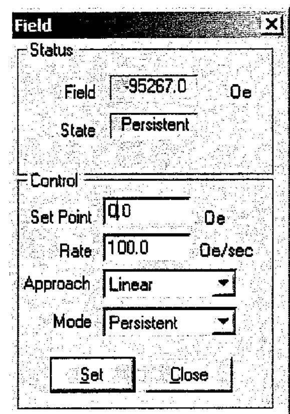


Figure 2-3. Field dialog box

WARNING!

Verify that there are no nearby sources of magnetic field (e.g., NMR or other laboratory magnets) before attempting to install or remove the linear motor transport, as is explained in Section 2.6.1.

6. Set the sample chamber to vent continuously by using the front panel of the Model 6000 or the **Chamber** dialog box (Figure 2-4):
   - Select **Instrument >> Chamber**.
   - Click on the **Vent Cont.** button.
   - Click on the **Close** button.
7. Put the PPMS in shutdown[1] mode (select **Utilities >> Shutdown**).

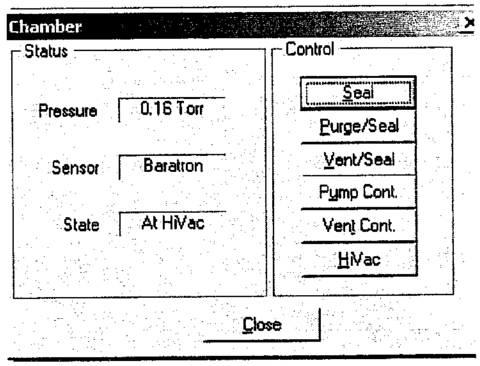


Figure 2-4. Chamber dialog box

2.3.4.2 BACKUP THE SYSTEM CONFIGURATION

Using the ROM configuration utility (`Romcfg32`) and the steps outlined below, upload[2] the current ROM configuration from the Model 6000 to the host computer.

1. Double-click on the **PPMS 32-bit Tools** icon on the PC desktop.
2. When the `Tools` directory opens, double-click on `Romcfg32.exe` to start the `Romcfg32` utility and open the **PPMS Rom Config 32** dialog box (Figure 2-5).

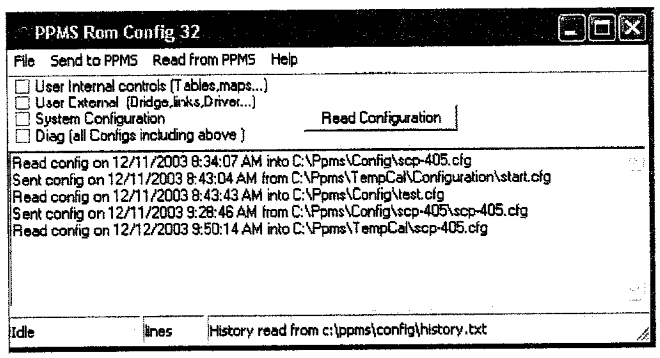


Figure 2-5. **PPMS Rom Config 32** dialog for uploading the Model 6000 configuration files

3. Click in the **Diag (all configs including above)** check box.
4. Click on the **Read Configuration** button (or select **Read from PPMS >> Configuration**). This option will open the **Save configuration as file** dialog box.
5. Name this version of the configuration file and select the directory or folder on the host computer where you want the file saved.
6. Click on the **Save** button. The **PPMS Rom Config 32** dialog box will report on the upload process.
7. When the program status (bottom left corner of the dialog box) changes from "Reading" to "Idle", close the **PPMS Rom Config 32** dialog box.

---

[1] Shutdown (or standby) mode does not turn off the system. This mode helps conserve helium resources by turning off the temperature-control heaters.

[2] When you upload a file, you essentially make a backup copy of it. Note that this is *not* the same procedure as copying the file.

2.3.4.3 POWER DOWN AND CHANGE THE ROMS

1. Turn off the power to the Model 6000.
2. Remove the power cord from the Model 6000.
3. Remove the lid from the PPMS electronics cabinet.
4. Remove the lid from the Model 6000.
5. Locate the CPU board: from the front of the electronics cabinet, the CPU board is the first board on the left and it has the GPIB connected at its back.
6. For each ROM being replaced, note its orientation on the CPU board (shown by the notched end) and the ROM number (1 or 2) for each slot.
7. Remove the two ROMs from the CPU board.
8. Install the two new ROMs into the CPU board, using the ROM numbers and orientation of the previous set of ROMs to ensure that you place the new ROMs in the correct location and orientation.

2.3.4.4 POWER UP AND RESTORE THE CONFIGURATION

1. Replace the lid on the Model 6000 and on the PPMS electronics cabinet.
2. Reattach the power cord to the Model 6000.
3. Turn on the power to the Model 6000.
4. Restore (download) the most recent ROM configuration to the Model 6000:
   a. Start the `Romcfg32` utility (see Section 2.3.4.2).
   b. Click in the **Diag (all configs including above)** check box.
   c. Open the **Send to PPMS** dropdown menu and select **Send Config**. The **Send Configuration to 6000** dialog box will open, showing the contents of the directory where the most recently downloaded configuration files were placed.
   d. Select the ROM configuration file that you uploaded and saved in Section 2.3.4.2 and click on the **Open** button. The **PPMS Rom Config 32** dialog box will report on the download process and if it was successful.
5. When the `Romcfg32` utility indicates that the download has been successfully completed, set the PPMS system temperature to 305 K and set the chamber to vent continuously, using the instructions in Section 2.3.4.1.

2.3.5 Install the Standard VSM Hardware

You will use the instructions in this section only if the standard VSM option has not already been installed. If your system has a standard VSM option installed, go to Section 2.3.6.

Use the instructions in Chapter 2 of the *PPMS VSM User's Manual* for the following steps:

1. Prepare the PPMS for option installation (Section 2.2.3).
2. Install the VSM detection coilset puck (4096-204) (Section 2.2.4).
3. Insert the VSM sample tube (4096-301) (Section 2.2.5).
4. Mount the VSM linear motor transport (4096-400) on the dewar (Section 2.2.6).

2.3.6 Connect the VSM Option Components to the PPMS

Using Figure 2-6 for guidance, finish connecting the components of the VSM Oven option and the standard VSM option (if needed). Before you continue to Section 2.3.7, verify that you have attached all the connectors and the connections are firm.

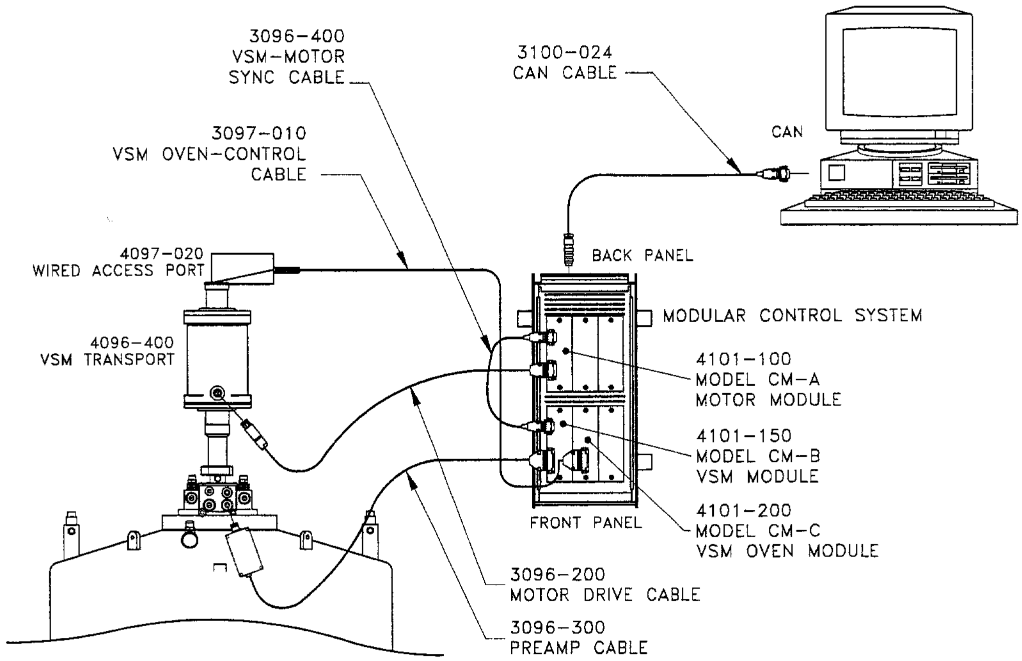


Figure 2-6. PPMS—VSM Oven option components and interconnections

2.3.7 Install New Software

Use the following instructions to install MultiVu and the VSM Oven-enabled software applications on your PC. If you purchased the VSM Oven as part of a complete QD PPMS system, you can go to Step 3 below, "Verify that the VSM software is properly installed …" The instructions below provide a brief overview of the installation wizard. Refer to the *Physical Property Measurement System: MultiVu Application User's Manual* and the *PPMS VSM User's Manual* for more information on MultiVu, the VSM, and installing new software.

Note: If the instructions shipped with the equipment differ from the ones below, follow the shipped instructions.

1. Install the most recent version of the PPMS MultiVu software (Version 1.3.2.2 or later) if it is not already installed. The MultiVu application software should have been shipped with the VSM Oven option, along with detailed instructions for installation. Below is an overview of the process.
   a. Insert the software media (CD or floppy diskette) containing the MultiVu application into the computer.
   b. In the `MultiVu` folder (on the media), double-click on the file named `Setup.exe`. An automated installation program will start and guide you through the software installation.

   c. If you have an earlier version of the MultiVu software, the `Setup` program might ask if it is OK to overwrite one or more files. Indicate that it is OK. When the setup program ends, you should have a subdirectory named "`MultiVu`" in the `QDPPMS` directory.
   d. Continue through the setup program until it indicates that it has been completed.
2. Install the VSM Oven-enabled software. Again, the application software should have been shipped with the VSM Oven option, along with detailed instructions for installation. Below is an overview of the process.
   a. Insert the software media (CD or floppy diskette) containing the VSM application into the computer.
   b. In the VSM folder (on the media), double-click on the file named `Setup.exe`. An automated installation program will start and guide you through the software installation.
   c. If you are asked for the name of a directory in which to install the VSM software, specify `QDPPMS`.
   d. If you are upgrading from the standard version of the VSM software, the `Setup` program might ask if it is OK to overwrite one or more files. Indicate that it is OK. When the `Setup` program ends, you should have a subdirectory named "`VSM`" in the `QDPPMS` directory.
   e. Continue through the `Setup` program until it indicates that it has been completed.
3. Use the steps below to start MultiVu, place the equipment in VSM Oven mode, and verify that the VSM Oven-enabled software has been properly installed (Section 4.3 has more detailed information on the VSM Oven mode).
   a. Start the PPMS MultiVu application program.
   b. Use the **Option Manager** dialog box to activate the VSM option (select **Utilities >> Activate Option** on the main MultiVu menu bar at the top of the application window).
   c. When the **VSM Control Center** opens, start the **VSM Install/Remove Sample Wizard** (in the **Install** tab, click on the **Install/Remove Sample** button).
   d. When the first page of the **VSM Install/Remove Sample Wizard** opens, click on the **Open Chamber** button. The wizard will prepare the system for sample installation.
   e. When the instructions panel of the dialog box says "**Press "Next" to install new sample,**" click on the **Next >>** button at the bottom of the dialog box.[3] In page 2 of the **VSM Install/Remove Sample Wizard,** you will be given a choice between operating in "Standard VSM mode" and "VSM Oven mode."
   f. Select **VSM Oven mode** and click on the **Next >>** button.
   g. If the **VSM Install/Remove Sample Wizard** continues and opens the **Output Data File** dialog box, it indicates that the VSM Oven-enabled software has been properly installed on your computer.[4] You now can exit from the **VSM Install/Remove Sample Wizard** by clicking on the **Cancel** button.
4. The system is now ready to operate in VSM Oven mode.

---

[3] Note that this is not the typical installation procedure (see Chapter 4 for typical procedures).
[4] If the **VSM Install/Remove Sample Wizard** does not progress to the **Output Data File** dialog box or you have any other problems with the installation, please contact Customer Service at Quantum Design.

2.4 Reconfiguring the PPMS for the VSM Oven Option

You will use the procedures in this section whenever you re-install the VSM Oven option. For example, if the VSM Oven option was installed and then the VSM options were removed so that you could use the Heat Capacity option, you would use these procedures to reconfigure the PPMS for the VSM options. Many of the procedures used in *initial* installation are also used in re-installation of the VSM options, but some procedures apply only to initial installation or to re-installation.

WARNING!

Verify that there are no nearby sources of magnetic field (e.g., NMR or other laboratory magnets) before attempting to install or remove the linear motor transport, as is explained in Section 2.6.3.

Because the VSM Oven option requires the presence of the standard VSM, it is included in the reconfiguration procedures below.

1. Use the instructions in Chapter 2 of the *PPMS VSM User's Manual* for the following steps:
   a. Warm up the PPMS to room temperature, set the field to zero, and remove any existing items (e.g., puck, probe, standard-centering ring) from the sample chamber (Section 2.3.1).
   b. Install the VSM coilset puck and the VSM sample tube (Section 2.3.2).
   c. Install the VSM linear motor transport (Section 2.3.3).
2. Reconnect the system components, referring to Figure 2-6 in this manual for guidance:
   a. Install the wired access port (4097-020) on the linear motor transport.
   b. Connect the VSM motor drive cable (3096-200) to the VSM linear motor transport.
   c. Connect the VSM preamp cable (3096-300) to the gray Lemo connector at the probe head.
   d. Connect the VSM oven-control cable (3096-010) to the wired access port.
   e. Verify that the connections are firm.
3. Use the instructions in Sections 2.3.5–2.3.6 of the *PPMS VSM User's Manual* to activate the VSM Oven-enabled application from within MultiVu and configure the VSM System.

2.5 Removing the VSM Oven Option

WARNING!

Verify that there are no nearby sources of magnetic field before you attempt to install or remove the linear motor transport.

You do not need to remove the VSM option components or hardware from the PPMS while the system is idle. However, if you intend to use the PPMS for other types of measurements (e.g., Heat Capacity, Thermal Transport), you first must remove and deactivate the standard VSM option. You do not need to deactivate the VSM Oven because MultiVu treats it as part of the standard VSM. However, you must remove the oven heater stick and sample rod, if they are being used.

As summarized below, you will use MultiVu, the **VSM Control Center**, and the **VSM Install/Remove Sample Wizard** to prepare the system so that you can remove the hardware components. The overall procedures are essentially the reverse of the installation procedure and as explained below, assume that MultiVu and the VSM options have been activated so that you have access to the control center.

1. Prepare the PPMS to remove the VSM components:
   a. Use the **Field** dialog box to set the field to zero (see Figure 2-3).
   b. Start the **VSM Install/Remove Sample Wizard** (double-click on the **Install/Remove Sample** button).
   c. In page 1 of the **VSM Install/Remove Sample Wizard**, click on the **Open Chamber** button. This will warm the sample chamber to 320 K, vent the chamber, and move the transport to the load position.
   d. Remove the sample rod (standard VSM or VSM Oven) when the instructions area of the **VSM Install/Remove Sample Wizard** indicates that it is ready to install or remove a sample (Figure 2-7).
   e. Now click on the **Shutdown** button to shut down the linear motor transport.
   f. Click on the **Cancel** button when the instructions area of the **VSM Install/Remove Sample Wizard** indicates that you can exit or insert a new sample (Figure 2-8).
2. When the **VSM Install/Remove Sample Wizard** has closed and placed you back at the first page of the **VSM Control Center,** deactivate the VSM option by using the **Option Manager** (select **Utilities >> Activate Option**).

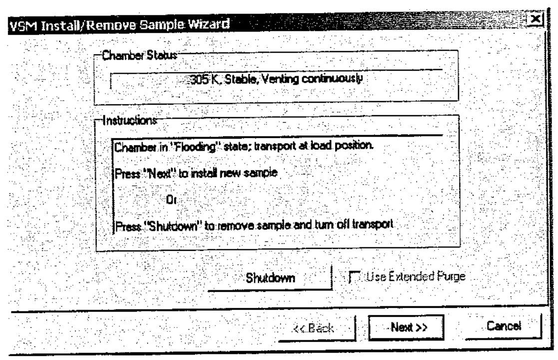


Figure 2-7. VSM Install/Remove Sample Wizard: Install or remove sample

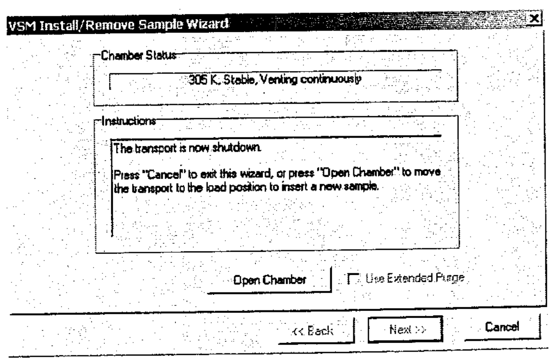


Figure 2-8. VSM Install/Remove Sample Wizard: Transport shutdown

3. Disconnect the cables leading from the Model 1000 at the wired access port, the linear motor transport, and the probe head.
4. Remove the wired access port from the linear motor transport.
5. Remove the linear motor transport from the dewar and place it in the storage case.
6. Remove the VSM sample tube and coilset puck from the sample chamber.

C H A P T E R 3

Preparing Samples for the VSM Oven

3.1 Introduction

This chapter contains the following information:

- Section 3.2 describes how to prepare a sample for high temperature measurements.
- Section 3.3 describes how to mount a sample on the heater stick so that high temperature measurements can be performed.

3.2 Sample Properties

3.2.1 Size and Shape

The sample should be no wider than 3 mm (0.120 in), as the heater stick itself is 3.6 mm (0.140 in) wide. The ideal sample geometry is a thin plate that can be glued flat to the heater stick, thus allowing optimal thermal contact to the heater. When you intend to measure physically large samples (generally larger than about 3 x 3 mm), refer to Table 3-1 in the *PPMS VSM Option User's Manual* for information about the effect on accuracy of the reported moment.

3.2.2 Composition

Solid plates and thin films are ideal for use in the VSM Oven. The sample must tolerate being bonded to the heater stick with a high-temperature adhesive. We provide a vial of alumina-based cement (see below) in the VSM Oven Option User's Kit (Figure 5-5). The sample also must be strong enough to remain intact when it is chipped off the heater stick after it has been measured.

3.3 Sample Mounting

Mount your samples on the heater stick (Figure 5-1) by using the steps below. The procedures are shown graphically in Figure 3-1, A–D.

> **CAUTION!**
>
> Handle the heater stick by the front side, which has the grey metal film patterns. Avoid touching the back side of the heater stick where the small thermocouple wires are embedded.

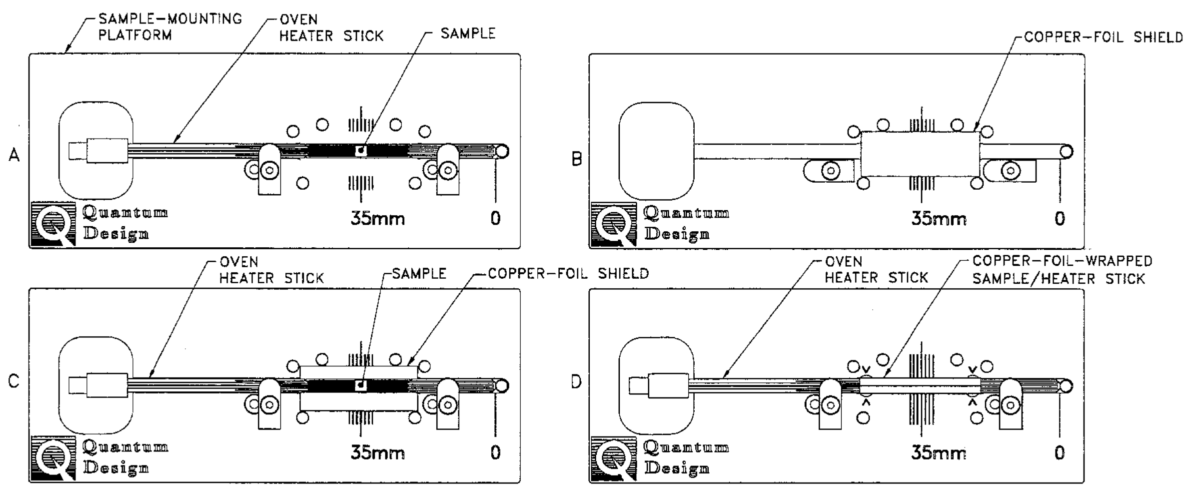


Figure 3-1. Using the sample-mounting platform to mount a sample on the oven heater stick

1. Prepare the sample and heater stick and mount the sample (Figure 3-1A).
   a. Clean the sample and the surface of the heater stick with a soft cotton swab wetted with alcohol. See Section 5.2.1 for a more detailed description of the heater stick.
   b. After the surfaces are cleaned and dried, place the heater stick in the blue sample-mounting platform supplied in the VSM Oven User's Kit (Figure 5-5). Push the bottom end of the heater stick against the plastic post located at the "0" marker, and lock it in place by rotating the white plastic tabs.
   c. Mix the alumina cement thoroughly and apply a generous drop to the heater stick at the center of the heater meander pattern (at "35 mm" on the scale) where the sample will be placed. The cement should be thick but still fluid.
   d. Place the sample on the glue drop before it begins to dry, pressing the sample down so that it is as close as possible to the surface of the heater. Leaving a visible border of glue around the sample, wipe away any excess cement from the heater stick.
   e. Record the sample offset by using the scale on the mounting platform. The offset should be a value between 33 mm and 37 mm for the best temperature accuracy, as shown in Figure 3-1A.
   f. Carefully remove the heater stick from the mounting platform and cure the cement for 10 to 20 seconds by using a heat gun held about 20 cm (8 in) away. Heating the cement drives away the water base and greatly strengthens the bond.

g. Test the bond by gently pushing the sample from the side to verify that the sample does not easily come off the stick.

2. Wrap the sample and heater stick with a copper-foil shield (Figures 3-1B–3-1D).
   a. Select a copper-foil shield that is shiny and free of tarnish and position it in the mounting station as shown in Figure 3-4B.
   b. Place the heater stick with the sample on the shield (Figure 3-4C) and lock it in place with the tabs.

CAUTION!

Use a clean tool such as the tweezers in the VSM Oven Option User's Kit to handle the copper-foil shield. Do not handle the copper shield with your fingers, because it might tarnish.

   c. Using a clean hard tool such as the handle of a pair of tweezers (included in the VSM Oven Option User's Kit), push down gently on the heater region so that the copper shield begins to bend around the stick.
   d. Fold both flaps of the shield over the top of the heater stick so that the heater and sample are completely covered (Figure 3-4D). Flatten the shield so that it is flush with the surface of the stick.
   e. Use the tweezers to pinch the shield at both ends of the heater region so that it grips the notches in the heater stick. The locations of the notches are indicated by four "^" marks on the platform. This compression will prevent the shield from slipping during VSM measurements.
3. Remove the heater stick from the mounting platform.
4. Plug the heater stick into the bottom end of the VSM oven sample rod.
5. Verify that the connector for the heater stick is fully engaged with the sample rod.
6. The sample is now ready to install in the PPMS.

CHAPTER 4

VSM Oven Measurements

4.1 Introduction

This chapter contains the following information:

- Section 4.2 summarizes the measurement process when using the Quantum Design VSM Oven option.
- Section 4.3 describes how to install samples for taking VSM Oven measurements.
- Section 4.4 describes how to take measurements with the VSM Oven option.
- Section 4.5 describes how to remove a sample when using the VSM Oven option.

4.2 Overview of VSM Oven Measurements

The VSM Oven measurement process first involves locating the center position of the sample. Next, the system synchronously oscillates the sample and detects the voltage that has been induced in the coilset by the magnetized sample.

In preparation for the measurement, you will use the automated **VSM Install/Remove Sample Wizard** to install the sample and set the system to take measurements in the VSM Oven mode. The next steps include centering the sample, setting measurement parameters, and setting up measurement command files as well as operations that are more advanced.

The measurement process and use of the software are explained in the following sections. If you are experienced at taking measurements with the standard VSM, you will find that some of the MultiVu utilities and dialogs now have different capabilities and measurement limits.

Important: Before you begin the measurement process, verify that the VSM Oven option and the appropriate application software have been installed (Chapter 2) and the sample has been mounted on the heater stick (Chapter 3).

4.3 Installing a Sample

This section takes you through the process of installing a sample into the VSM sample chamber, starting with a summary of how to attach the sample to the heater stick and measure the sample offset. Section 4.3.2 describes how to activate the VSM option, which is necessary to operate the VSM Oven, and Section 4.3.3 describes the sample-installation process.

4.3.1 Attach Sample and Measure Sample Offset

Main points of the sample-mounting and sample-centering procedures are reviewed below. Chapter 3 has complete instructions—please review those procedures before you mount your sample.

1. Attach the sample to the heater stick using the techniques discussed in Chapter 3. The target line at 35 mm is the recommended mounting location, but the actual sample position can be 1 or 2 mm from this line.
2. Use the sample-mounting platform to measure the distance from the center of the sample to the bottom of the heater stick, reading the position from the scale as demonstrated in Figure 4-1. This distance is called the sample offset. Measure the sample position to an accuracy of 0.5 mm.

   Important: It is important to read the actual position of the sample, not the target position. Accuracy is also important; you should carefully measure the sample position to an accuracy of 0.5 mm.

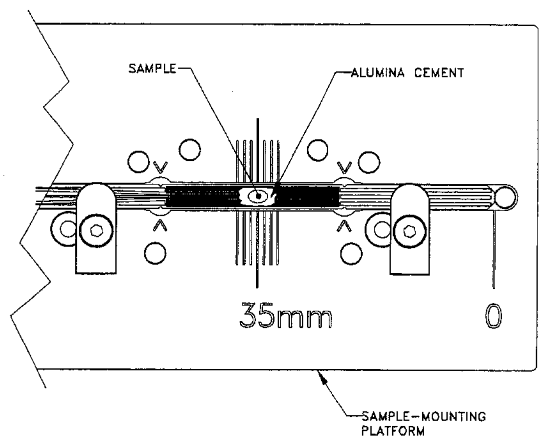


Figure 4-1. Mounting a sample with alumina cement

3. Record the sample offset and then remove the heater stick (with the mounted sample) from the mounting platform.
4. Finish the sample preparation (e.g., curing the sample and wrapping it with copper foil) according to the directions in Chapter 3.
5. Plug the heater stick into the bottom end of the VSM Oven sample rod (Figure 5-2).

4.3.2 Activate the VSM Option and the VSM Control Center

You will take measurements with the VSM Oven option by using the software for the standard VSM, which is activated and operated in MultiVu. Although many of the procedures for the two programs are similar, you will see that some are specific to the option being used.

1. To activate the VSM option, select **Utilities >> Activate Option** in the MultiVu window. The **Option Manager** window will open (Figure 4-2).

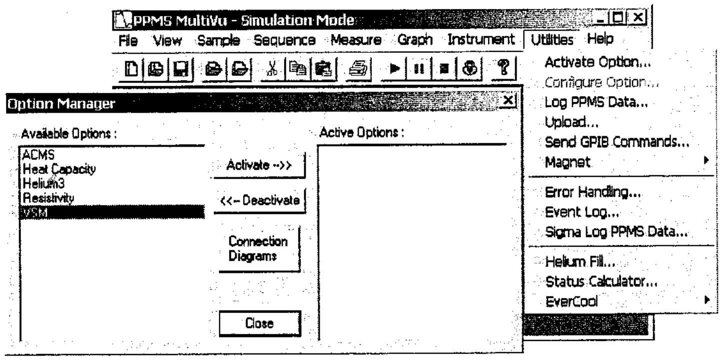


Figure 4-2. Activating the VSM option with the Option Manager dialog box

2. Select VSM and click on the **Activate** button. The **VSM Control Center** (Figure 4-3) will open in the main MultiVu window as soon as you activate the VSM option. (When operating in simulation mode, the title of the **VSM Control Center** is **VSM SIM**.) Components of the **VSM Control Center** will guide you through the sample-installation process.
3. The **Status** area at the bottom of the **VSM Control Center** will indicate if you have activated the VSM option and which measurement mode you have selected. As is shown in Figure 4-3, the **Status** area will report **"VSM Ready"** after the VSM option has been activated. After the installation process has been completed, the **Status** area will report, "VSM Oven Active" and "VSM Oven selected" if you have selected the VSM Oven mode.

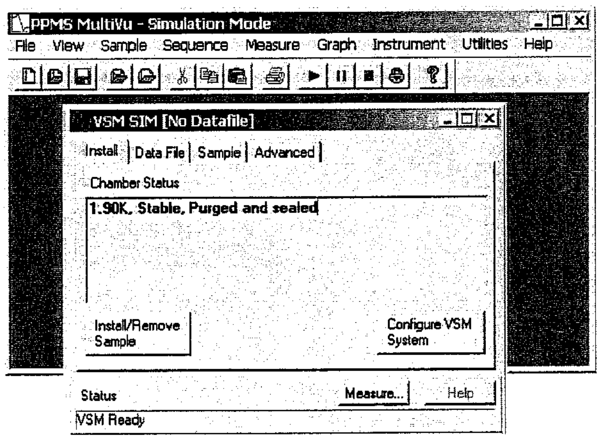


Figure 4-3. Main MultiVu window and main window of the VSM Control Center (in simulation mode)

Also, note the **Install/Remove Sample** button, which is located below the **Chamber Status** area, and the **Measure** button, which is located above the **Status** area. You will use these command buttons for sample installation, centering, and measurement.

The VSM Control Center

The **VSM Control Center** organizes VSM-specific operations via automated programs (wizards) and four main panels or "tabs": the **Install** tab, the **Data File** tab, the **Sample** tab, and the **Advanced** tab. These introductory instructions focus on an installation method that uses the **Install** tab and the **VSM Install/Remove Sample Wizard** (**VSM Install** wizard for short).

See Chapter 6 for information about oven-specific commands and changes to the standard VSM software. Chapter 6 also includes a basic review of MultiVu and the VSM software. Refer to Chapter 6 of the *Physical Property Measurement System: Vibrating Sample Magnetometer (VSM) Option User's Manual (PPMS VSM User's Manual* for short*)* for more detailed information on the VSM software and the **VSM Control Center**.

4.3.3 Install the Sample

To install the sample you will use the **VSM Install/Remove Sample Wizard** (**VSM Install** wizard for short), which is a set of automated instructions that guides you through the sample-installation process and allows you to select the VSM Oven mode or standard VSM mode.

The overall installation process involves warming and venting the sample chamber, moving the transport to the load position, choosing between operating in the standard VSM mode or the VSM Oven mode, characterizing the sample, designating a data storage file, installing the sample, and designating (or scanning for) the sample offset. Note that this section covers the sample-installation process only. The sample-removal process is covered in Section 4.5.

1. If necessary, activate the VSM application (see Section 4.3.2) and click on the **Install** tab to bring it to the front of the **VSM Control Center** (Figure 4-3).
2. In the **Install** tab of the **VSM Control Center**, click on the **Install/Remove Sample** button. This button opens page 1 of the **VSM Install** wizard, which is shown in Figure 4-4. The **VSM Control Center** might be hidden behind the other panels, but it will still be open.

   Note the **Chamber Status** and **Instruction** areas in Figure 4-4. These areas inform you about the installation process and the next steps.

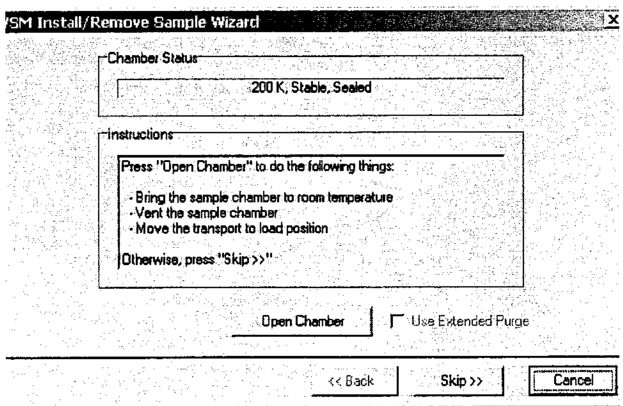


Figure 4-4. VSM Install/Remove Sample Wizard dialog box (VSM Install wizard for short), page 1: Initial Instructions

3. Click on the **Open Chamber** button (below the **Instructions** area). The wizard will bring the sample chamber to room temperature, vent the chamber, and move the transport to the load position, and the **Instructions** area will show the status of these processes. In Figure 4-5, the **Instructions** area indicates that the chamber has been flooded and the transport is in the load position.

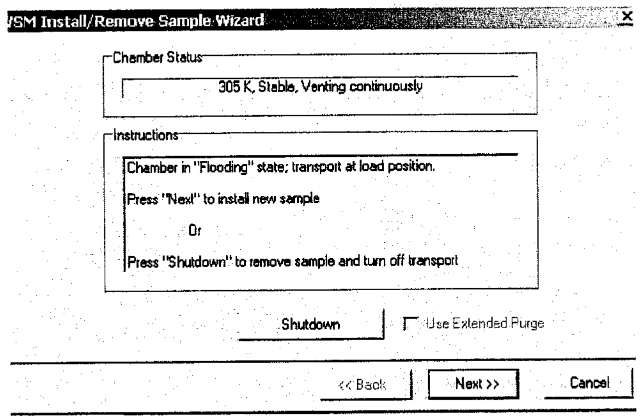


Figure 4-5. VSM Install wizard, page 1: Install or remove sample

4. Now use the sequence outlined below to install the sample rod and sample. Note that you can insert or remove your sample from the PPMS at any stage of the **VSM Install** wizard, as long as the sample chamber is flooding and the transport is at the load position.
   a. Attach the heater stick to the sample rod.
   b. Open the lid on the wired access port on the VSM linear motor transport
   c. Insert the sample rod into the wired access port until the magnetic lock at the top of the sample rod engages the magnetic lock ring in the linear motor transport. Verify that the magnetic lock has engaged the magnetic lock ring.
   d. Plug the connector on the top of the sample rod into the plug inside the access port (see Figure 5-3).

   Important: The sample will be subjected to vertical magnetic fields of up to approximately 200 gauss when it passes through the linear motor transport. If this is unacceptable for your samples, please contact Customer Service at Quantum Design.

5. Click on the **Next** >> button at the bottom of the window. This will open page 2 of the **VSM Install** wizard (Figure 4-6), in which you designate the type of measurement you will be taking.

   Important: You can come back to this page and change your selection at any point during the **VSM Install** wizard. However, if you want to change the operating mode after the **VSM Install** wizard has ended, you must restart the wizard from the beginning.

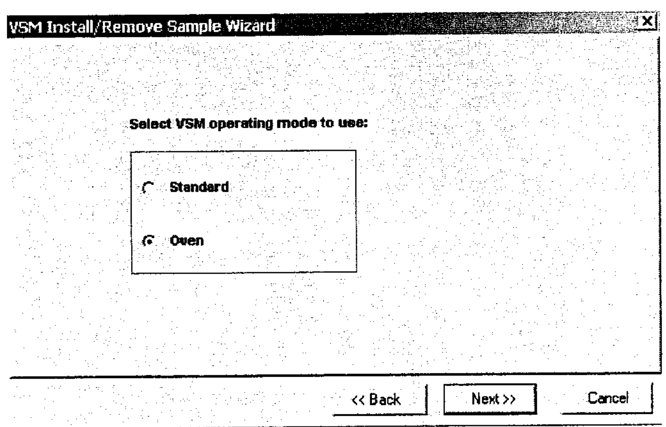


Figure 4-6. VSM Install wizard, page 2: Selecting the VSM operating mode

From this point on in the sample-installation process, you will see some differences between the instructions and dialogs for measurements in the VSM Oven mode and those for the standard

VSM mode. Here we show the instructions and dialogs for the VSM Oven. For instructions on installing a sample with the standard VSM equipment, refer to the *PPMS VSM User's Manual.*

6. Click in the option button next to **VSM Oven** and then click on the **Next** >> button at the bottom of the window. Page 3 of the **VSM Install** wizard, the **Output Data File/Sample Information** dialog box (Figure 4-7A), will open so you can designate an output data file.

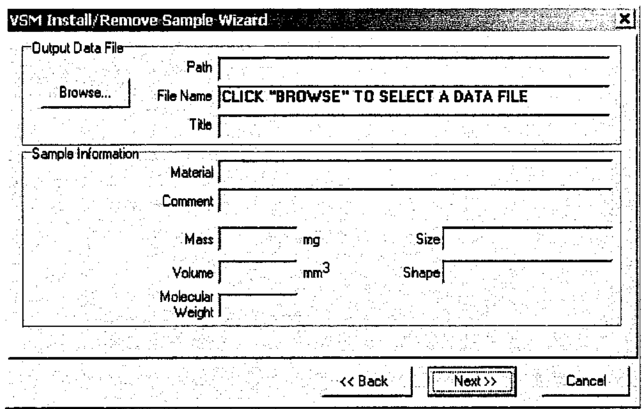


Figure 4-7A. VSM Install wizard, page 3: Output data file dialog

7. To create or open an output data file, click on the **Browse** button in the top left-hand side of the **VSM Install** wizard. The **Browse** button will open the **VSM Select Data File** dialog box (Figure 4-7B).

   Important: You *must* designate an output data file (by selecting an old file or by making a new one) if you want the measurement data saved in an easily accessed format.

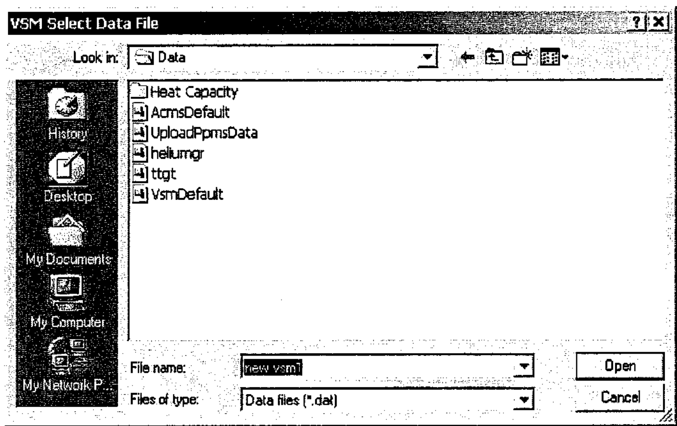


Figure 4-7B. Using the VSM Select Data File dialog box to designate an output data file

8. Use the instructions below to select an existing file (see "a") or create a file (see "b"). Note that when you select an existing data file, new measurements will be appended to the file.

   Important: If you select an existing file that has the wrong type of format (for example, a data file for a different PPMS measurement option), you will receive an error message.

   a. To append data to an existing file, use the **VSM Select Data File** dialog to select the file name, and then click on the **Open** button. The file will open and you will be returned to page 3 of the **VSM Install** wizard, which is shown in Figure 4-7F. Now go to Step 9 below.

   b. To create a new file, enter the file name in the **VSM Select Data File** dialog, and then click on the **Open** button. A popup dialog will open (Figure 4-7C), indicating that you must enter the sample properties. Click on the **OK** button.

      - The **VSM Datafile Title** dialog will open (Figure 4-7D), asking you to provide a title for the graph view of the data. Note that this is optional.

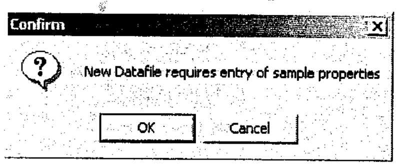


Figure 4-7C. Confirming creation of a new data file

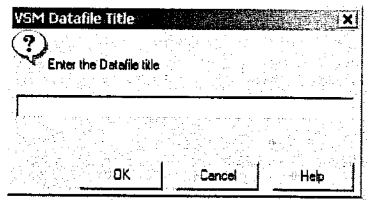


Figure 4-7D. Creating a title for the data file

      - Enter the title you want displayed at the top of the plot and click on the **OK** button. The **VSM Sample Properties** dialog box (Figure 4-7E) will open so that you can describe the sample for your records (also optional).

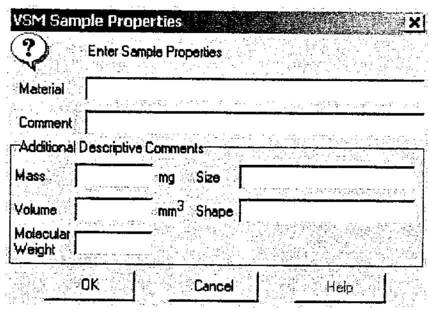


Figure 4-7E. Describing sample properties

      - When you have completed your description, click on the **OK** button to return to page 3 of the **VSM Install** wizard.

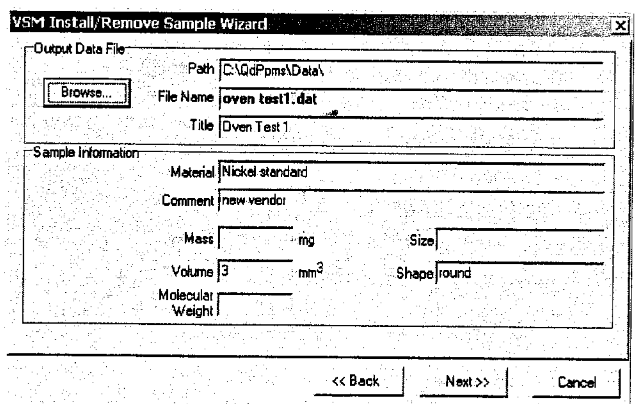


Figure 4-7F. Displaying output data file name and sample properties

9. The **Output Data File** and **Sample Information** areas of the dialog will now display any of the optional information that you entered in the **VSM Sample Properties** dialog box, as shown in Figure 4-7F. If you designated a pre-existing file as the data output file, the dialog will display the sample information from that file.

10. Click on the **Next >>** button at the bottom of the **Output Data File** dialog box. Page 4 of the **VSM Install wizard** will open (Figure 4-8) so that you can provide or obtain the sample-holder coordinates. Here we explain use of the automatic centering scan (**Scan for Sample Offset**). The other two centering options, **Enter Offset manually** and **Advanced Centering**, are explained in Section 6.5.2.2.

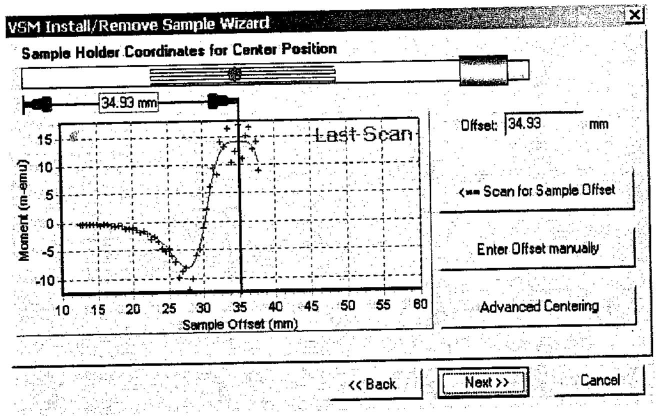


Figure 4-8. VSM Install wizard, page 4: Sample-holder coordinates for center position

Note that there are slight differences between the dialog boxes used for the VSM Oven mode and the standard VSM mode: for standard VSM mode, the illustration shows a sample holder, but for the VSM Oven, it shows a heater stick with a zigzag pattern that represents the heater region.

As in the case of the standard VSM sample holder, we recommend that you place the sample at a sample offset of 35 mm. The software will warn you if the sample is placed outside the heater region. The heater region includes sample offsets from 23 mm to 48 mm.

11. Click on the **Scan for Sample Offset** button (right-hand side of the dialog box in Figure 4-8). As shown in Figure 4-9, the system will scan the sample through the detection coilset and use a curve-fitting algorithm to locate the position of the peak-in-signal.

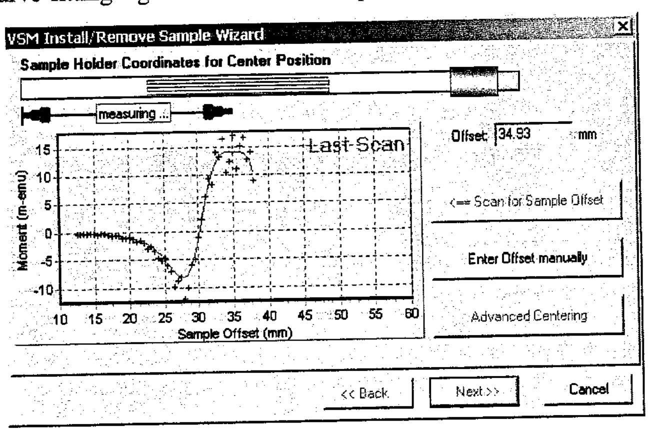


Figure 4-9. VSM Install wizard, page 4: Scanning for sample-holder coordinates

- If a suitable fit to the data is found, a popup dialog box will appear (Figure 4-10) so that you can accept or reject the scanned value.

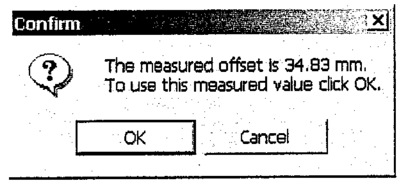


Figure 4-10. Confirming the sample offset

- Click on the **OK** button to accept the value. The popup dialog box will close and the dialog box with the **Sample Offset** graph will reappear (Figure 4-11). You will see the scanned value above the graph and in the **Offset** text box.

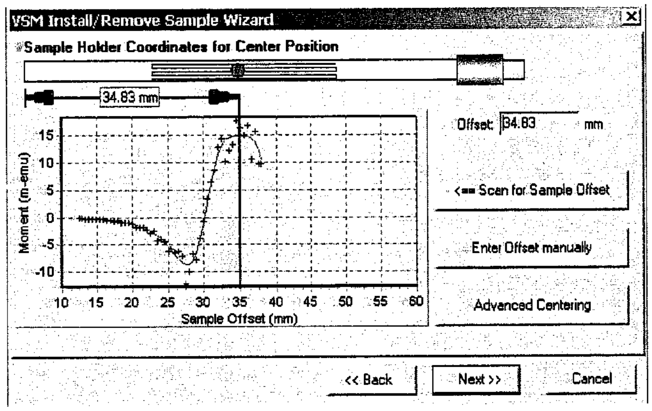


Figure 4-11. VSM Install wizard, page 4: Sample offset confirmed

12. Click on the **Next** >> button at the bottom of the dialog box. This button accepts the default sample-offset value (e.g., in Figure 4-12, the offset is 34.83 mm). When any of the centering operations have been successful, the wizard opens page 5 of the **VSM Install** wizard (Figure 4-12), which reports the sample-offset position and related instructions.

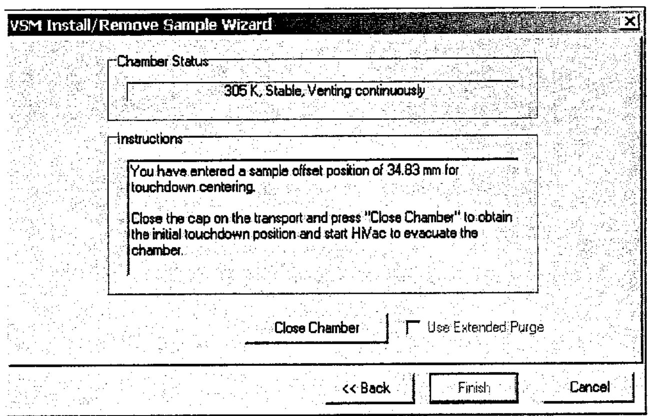


Figure 4-12. VSM Install wizard, page 5: Reporting sample-offset position

13. Click on the **Close Chamber** button, which is just below the **Instructions** area.
14. The **Instructions** area will indicate that a touchdown is being performed (Figure 4-13) and it will report on the process as it takes place.

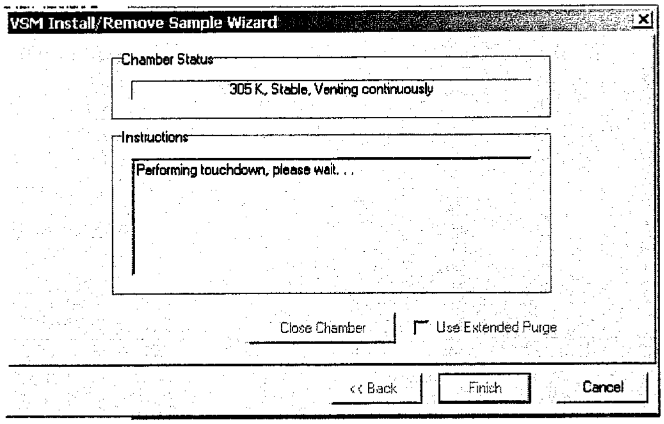


Figure 4-13. VSM Install wizard, page 5: Performing a touchdown

15. When the touchdown has been completed, the **Instructions** area will say "Sample Installation complete" and "Press 'Finish'," as shown in Figure 4-14.

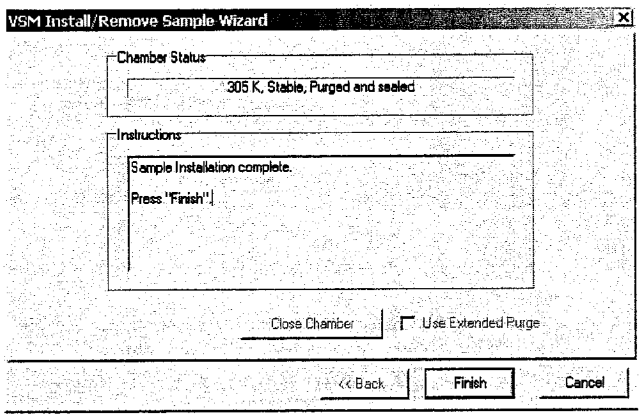


Figure 4-14. VSM Install wizard, page 5: Finishing sample installation

16. Click on the **Finish** button at the bottom of the window. This button will return you to the **Install** tab of the **VSM Control Center**, which now will display the system temperature and other information. The **Status** area will display "VSM Oven Active" and "VSM Oven selected" (Figure 4-15).

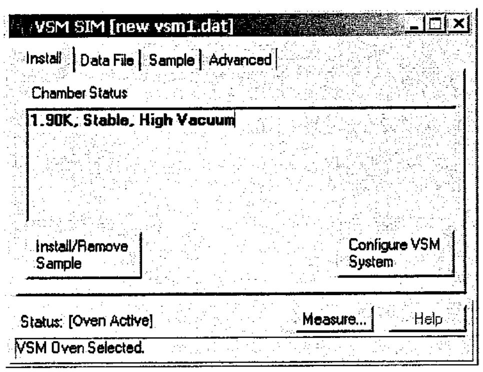


Figure 4-15. Install tab of the VSM Control Center after the VSM Oven mode has been selected.

17. You can now set up the system to take measurements with the VSM Oven option.

4.4 Taking VSM Oven Measurements

You can perform VSM Oven measurements by using immediate-mode commands (e.g., from command buttons or dropdown menus) or by constructing sequence files. This section focuses on the use of immediate-mode commands to specify and perform VSM measurements. The use of sequence commands is discussed in Chapter 6 of the *PPMS VSM User's Manual*, and oven-specific modifications to their use are discussed in Chapter 6 of this manual.

In immediate mode, the primary measurement process uses the **Measure** command and the **VSM Measurement** dialog box to set the measurement parameters.

4.4.1 Measure Command and VSM Measurement Dialog

To specify parameters for VSM Oven measurements, click on the **Measure** button, which is located just above the **Status** area in the **VSM Control Center** (e.g., Figure 4-15). The **Measure** button opens the **VSM Measurement** dialog box, which consists of the **Settings**, **Centering**, and **Advanced** panels or "tabs" (Figures 4-16–4-18).

The left side of each panel has panel-specific settings, but the right side of each panel shows the same **Last Measurement** area, and the bottom of each panel has the same command buttons.

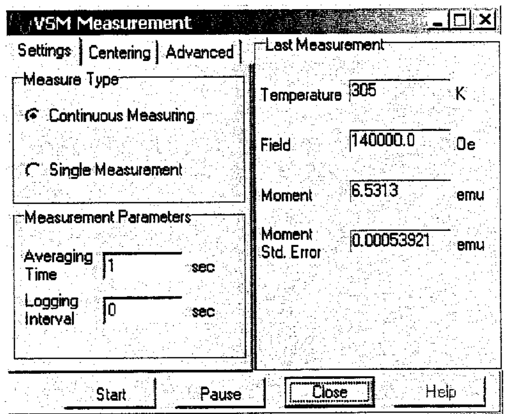


Figure 4-16. VSM Measurement dialog box: Settings tab

"Last Measurement" Area

The right side of each panel contains the **Last Measurement** area, which displays the most recent measurement results (e.g., Figure 4-16). The displayed data are also written to the open data file along with the data items that are defined in Table 7-2 of the *PPMS VSM User's Manual.*

- **Temperature** represents the average temperature during the measurement, in Kelvin.
- **Field** represents the average field, in oersted.
- **Moment** represents the average of the moment over the averaging time, in emu.
- **Moment Std. Error** represents the error on the mean, that is, the error bar on the reported moment.

Command Buttons

The **Start (Stop)**, **Pause (Resume)**, **Close**, and **Help** command buttons are arranged across the bottom of all VSM Measurement panels. The **Start** and **Pause** buttons toggle (change) from **Start** to **Stop** and from **Pause** to **Resume** according to the process you initiated most recently. The **Close** button closes the **VSM Measurement** dialog, but it does not stop the measurements. The **Start** and **Pause** buttons are explained in Section 4.4.3.

4.4.2 Setting Up the Measurement

You will set the main parameters for the VSM Oven measurement by using the **Measure Type** and **Measurement Parameters** subsections of the **Settings** tab (Figure 4-16).

4.4.2.1 SETTINGS TAB

1. In the top left side of the **Settings** tab, the **Measure Type** subsection has check boxes for you to select **Continuous Measuring** or a **Single Measurement**. Both measures are defined by the parameters that you set by using the **Measurement Parameters** subsection.
   - **Continuous Measuring** takes measurements lasting "**Averaging Time.**" If "**Logging Interval**" is less than **Averaging Time**, a new measurement will occur every **Averaging Time** number of seconds. Otherwise, a new measurement will occur every **Logging Interval** number of seconds. If you select **Continuous Measuring**, the system will take measurements until you click on the **Stop** or **Pause** button.
   - **Single Measurement** takes one measurement lasting **Averaging Time**.
2. The **Measurement Parameters** subsection (below the **Measure Type** subsection) contains text boxes in which you enter the **Duration** and **Interval** of the measurements.
   - **Averaging Time** is defined as the averaging time (in seconds) that you want the system to use for each measurement it writes to the data file. The averaging time can be as small as 4 cycles (0.1 sec for 40 Hz), but we recommend an averaging time in the 1–10 second range. The system will round the entered value to the nearest cycle period. For example, if the VSM frequency is 40.2 Hz and you request an averaging time of 1 second, the system will use an internal averaging time of 0.995 second (40 whole cycles divided by 40.2 Hz).
   - **Logging Interval** is defined as the amount of time that elapses between recorded measurements (in seconds). If **Logging Interval** is set to less than **Averaging Time**, then one data point will be displayed and written to the data file every **Averaging Time** number of seconds. That is, all the data will be saved.

The next sections describe the settings in the **Centering** and **Advanced** tabs. The default values are likely to fit many of your measurement needs, but you can adjust them whenever you need additional control.

4.4.2.2 CENTERING TAB

Use the settings on this tab to enable or disable automatic centering operations and to set the parameters for touchdown centering.

To enable or disable automatic centering, click in the appropriate option button in the **Centering** panel (Figure 4-17). We strongly recommend that you disable automatic centering by selecting **No Automatic Centering**. You do not need to set the centering parameters if you disable automatic centering. Refer to the *PPMS VSM User's Manual* for more information on sample centering.

Important: Touchdowns are not required in the VSM Oven mode because the thermal expansion of the heater stick causes negligible movement of the sample relative to the detection coilset. Note, though, that if you have just changed to VSM Oven mode after operating at low temperatures in standard VSM mode, there will be a slight thermal expansion of the sample chamber. Hence, you will improve accuracy by using touchdowns for approximately 30 minutes after the sample reaches room temperature. Otherwise, we recommend using the default setting (**No Automatic Centering**).

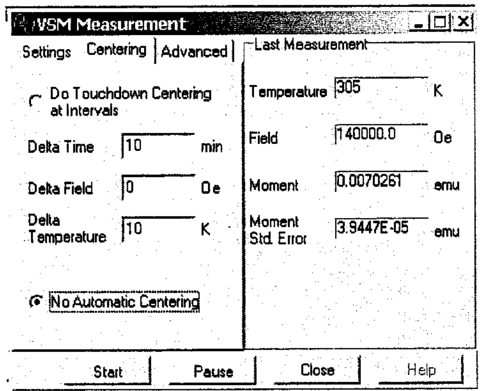


Figure 4-17. VSM Measurement dialog box: Centering tab

4.4.2.3 ADVANCED TAB

The **Advanced** tab of the **VSM Measurement** dialog box (Figure 4-18) contains settings that you can typically ignore, as there are default values. However, the **Excitation Parameters**, **Ranging**, and **PPMS Data Logging** options offer additional control over your measurements, as explained below. Chapter 6 of the *PPMS VSM User's Manual* explains these settings in more detail.

1. You can use the **Excitation Parameters** section to set the **Peak Amplitude. Oscillation Frequency** is set to 40 Hz. Note that the **Max. Accel**. and **Max. Moment** readings will change in accordance with the settings used for **Peak Amplitude**.

   Important: Please read about the **Peak Amplitude** setting (Chapter 6, *PPMS VSM User's Manual)* before you attempt to change it.

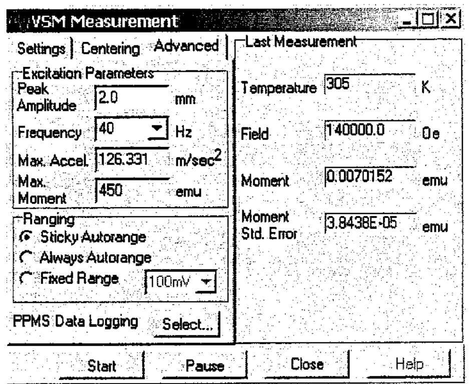


Figure 4-18. VSM Measurement dialog box: Advanced tab

- **Peak Amplitude** specifies the peak vibration amplitude (i.e., one-half the peak-to-peak amplitude) of the sample during a measurement (in mm). For the VSM Oven the maximum **Peak Amplitude** is set to 2 mm.

  Important: The maximum **Peak Amplitude** is different for the standard VSM and the VSM Oven. As shown in Figure 4-18, the maximum oscillation amplitude of the VSM linear motor is 2 mm peak when the VSM Oven is operating, by comparison with 5 mm peak for the standard VSM.

- **Frequency** specifies the frequency at which the VSM oscillates the sample. The system uses an oscillation **Frequency** of 40 Hz.
- **Max. Accel.** is computed from **Frequency** (40 Hz) and the value that you entered for **Peak Amplitude**. It is the maximum calculated acceleration during a cycle.
- **Max. Moment** is computed from **Frequency** (40 Hz) and the value that you entered for **Peak Amplitude**. It is the maximum measurable moment.

2. The **Ranging** setting refers to the way the system chooses the gain of the amplifiers in the VSM module during a measurement. The preamplifiers in the VSM module can change the gain ranges by factors of ten, depending on the size of the signal that is induced in the pickup coils. You can change this setting from **Sticky Autorange** in the rare case when you need more control.

   - **Sticky Autorange** (recommended): The system automatically increases the gain by a factor of 10 if the current peak signal drops below 2% of the current range. The system automatically decreases the gain by a factor of 10 if the current peak signal exceeds 50% of the current range.
   - **Always Autorange**: The system automatically increases the gain by a factor of 10 if the current peak signal drops below 9%. The system automatically decreases the gain by a factor of 10 if the current peak signal exceeds 100%.

     In some cases, the **Always Autorange** setting might improve the signal-to-noise ratio. However, it also could lead to an increased number of range changes and a corresponding drop in data throughput.
   - **Fixed Range**: The system always uses the specified gain range.

3. The **PPMS Data Logging** section has links to a dialog box for designating supplemental measurement data. For a description of the typical data items, refer to the *PPMS VSM User's Manual*, Table 7-2.

   - Click on the **Select Data** button. The **PPMS** dialog box (Figure 4-19) will open, showing additional PPMS system data items that can be saved.
   - For any type of data you would like added to the current file, select the accompanying check box.
   - When you are finished, click on the **OK** button.

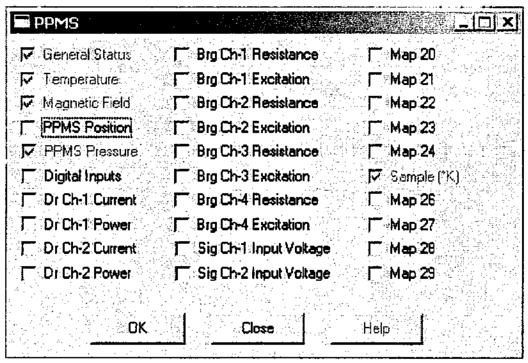


Figure 4-19. Designating additional measurement data to be collected by using the PPMS dialog

4.4.3 Starting/Stopping/Pausing the Measurement

1. To start the VSM Oven measurement process, click on the **Start (Stop)** button at the bottom of the current panel of the **VSM Measurement** dialog box.

   The right panel of the dialog box will display measurement results for the VSM Oven as they are acquired (see Figure 4-18). The displayed data are also written to the open data file along with the data items that are defined in Table 7-2 of the *PPMS VSM User's Manual.*
2. To stop sending new readings to the dialog box and the data file, click on the **Pause (Resume)** toggle button next to the **Start (Stop)** button. Although the system does not save or update readings during a **Pause**, it will continue oscillating the sample and executing any automatic touchdown operations that were scheduled.
3. To restart the data output after a pause, click on the **Resume (Pause)** button.
4. To stop data output and sample oscillation, click on the **Stop (Start)** button.

4.5 Removing a Sample

Use the instructions in this section when there will be a temporary halt in measurements. These instructions do not apply to removing and deactivating the VSM option so that you can install a non-VSM option.

Important: To take measurements with a non-VSM option, refer to Section 2.5, "Removing the VSM Option," which explains the steps for reconfiguring the PPMS for a non-VSM option.

Use the **VSM Install/Remove Sample Wizard** to remove the sample and sample rod. This process is shorter than the one for sample installation—it includes removing the sample rod, closing the wired access port on the linear motor transport, shutting down the transport, and ending the **VSM Install** wizard.

1. Start the **VSM Install/Remove Sample Wizard** by clicking on the **Install/Remove Sample** button in the **Install** tab of the **VSM Control Center** (Figure 4-3).
2. When the **VSM Install/Remove Sample Wizard** has started (Figure 4-20), click on the **Open Chamber** button (below the **Instructions** area). The wizard will warm the sample chamber to 305 K, vent the chamber, and move the transport to the load/unload position. The dialog box will reflect the process, as shown in Figures 4-21 and 4-22.

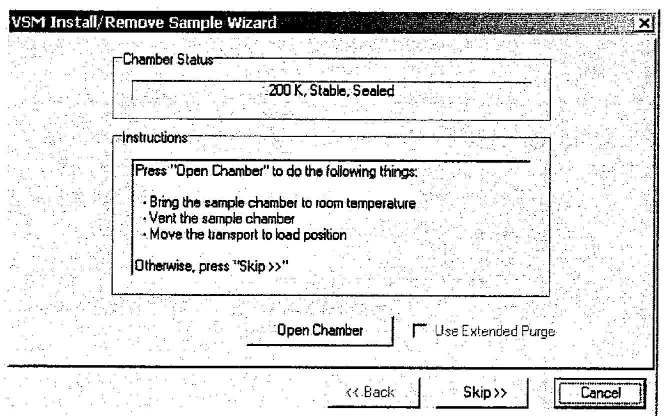


Figure 4-20. VSM Install/Remove Sample Wizard: Initial instructions

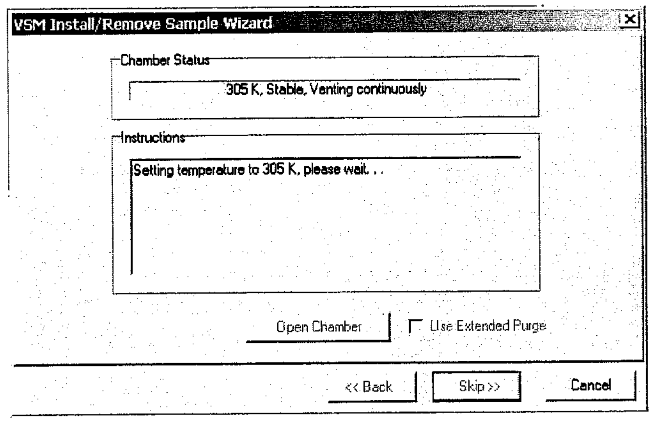


Figure 4-21. VSM Install/Remove Sample Wizard: Chamber preparation

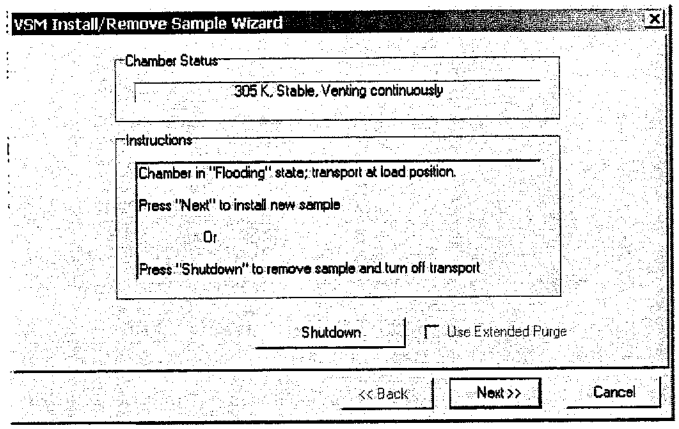


Figure 4-22. VSM Install/Remove Sample Wizard: Install sample or shutdown transport

3. When the instructions are complete and indicate that the system is prepared for the next step (install a sample or shutdown the transport), unplug the sample rod from the wired access port, remove the sample rod, and close the wired access port on the linear motor transport.

CAUTION!

Verify that you have removed the sample rod before you continue with these procedures.

4. Now click on the **Shutdown** button. If the system detects the presence of the sample rod, the **Ppmsmvu** popup dialog box will open (Figure 4-23), instructing you to remove the sample rod before you shut down the transport. Verify that you have removed the sample rod and click on the **OK** button.

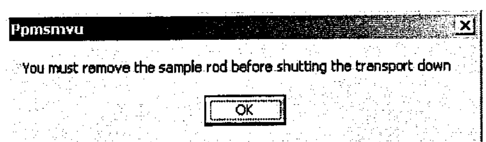


Figure 4-23. Ppmsmvu popup dialog box with shutdown instructions

5. The **OK** button will return you to the **VSM Install** wizard, where the **Instructions** area will indicate that the transport is being moved into the shutdown position. A short time later, the **Instructions** area will indicate that the transport has been shut down (Figure 4-24).

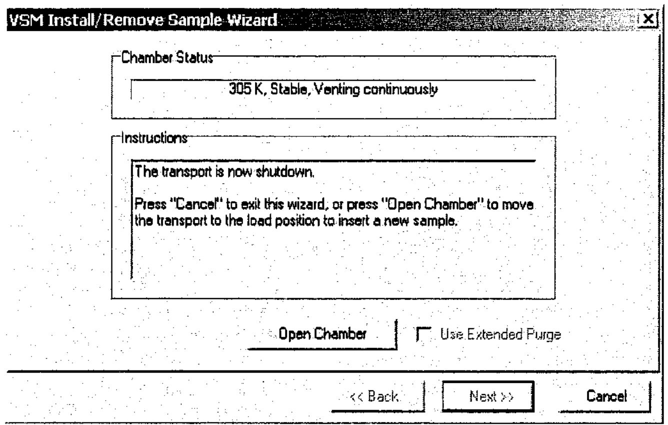


Figure 4-24. VSM Install/Remove Sample Wizard, page 3: Exit wizard or install sample

6. To end the **VSM Install** wizard and temporarily stop taking measurements, click on the **Cancel** button.
7. The **VSM Install/Remove Sample Wizard** dialog box will close and you will be returned to the **VSM Control Center** and the **Install** tab.

After this type of temporary shutdown, you can take VSM measurements again by restarting the **VSM Install** wizard and following the typical sample-installation procedures.

C H A P T E R 5

VSM Oven Hardware

5.1 Introduction

This chapter contains the following information:

- Section 5.2 describes the new VSM components that make up the oven option.
- Section 5.3 describes the contents of the VSM Oven User's Kit.
- Section 5.4 describes the electrical components of the VSM Oven option.

5.2 VSM Oven Hardware Components

This section describes each of the basic hardware components that make up the VSM Oven option: the oven heater stick, the oven sample rod, and the wired access port. Refer to Chapter 2 for instructions on installing the VSM Oven hardware.

5.2.1 VSM Oven Heater Stick

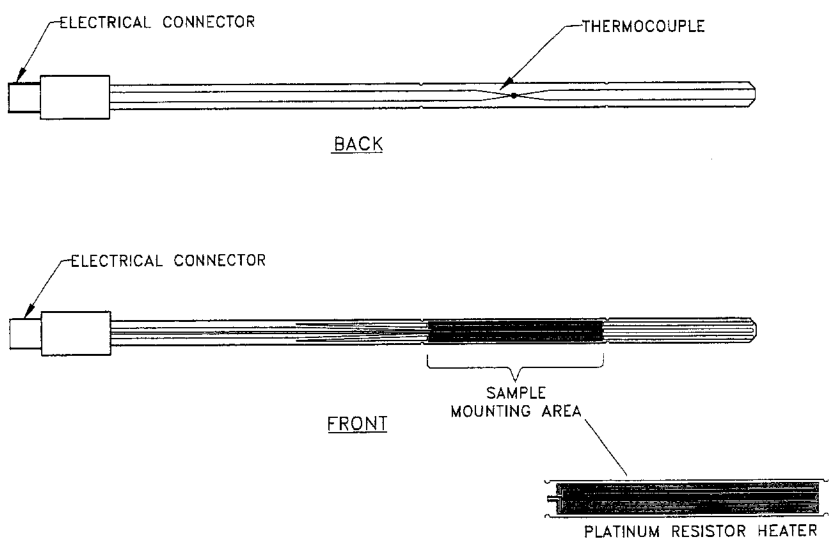


Figure 5-1. Front and back view of the VSM Oven heater stick

The VSM Oven heater stick and its parts are illustrated in Figure 5-1. It can be seen that the heater stick is a combination device that contains the heater, thermometer, and sample holder for the oven option. You will mount samples directly on the heater stick, using the alumina cement included in the VSM Oven Option User's Kit (Figure 5-5).

The heater stick is a long thin sheet of zirconia that has been silk-screened with a platinum meander pattern and then coated with a thin layer of dielectric. The zirconia has extremely low thermal conductivity, which allows the sample-mounting areas to reach extreme temperatures while the electrical connections remain close to room temperature. The platinum conductor acts as the heating element of the VSM Oven option. Samples are mounted directly on top of the platinum resistor in the indicated sample-mounting area.

The back of the heater stick has the temperature-detection system of the VSM Oven option. Inlaid in two grooves in the heater stick is a type S (platinum vs. platinum–10%rhodium) thermocouple. The thermocouple junction is located directly opposite the sample and platinum heater. This thermocouple provides a very precise measure of the sample temperature and it is rated for temperatures over 1000 K.

A thermistor is embedded at the top of the heater stick, inside the protective anodized aluminum shield. The function of this thermistor is to correct the cold junction temperature of the thermocouple, because the thermocouple table is referenced to a cold junction at 0 °C.

At the top of the heater stick is the five-pin male electrical connector (Figure 5-7) that provides power for the platinum heater and has voltage leads for the thermocouple and the thermistor. The heater-stick connector plugs directly into the base of the VSM Oven sample rod shown in Figure 5-2.

5.2.2 Oven Sample Rod

The VSM Oven sample rod is specifically designed for the VSM Oven option—it is not compatible with the standard VSM option. The primary changes were introduced to accommodate and protect the necessary electrical connections to the oven heater stick.

Figure 5-2 shows the oven sample rod in the vertical position (with the magnetic lock and strain relief at the top of the rod). Beginning at the top of the figure, the oven sample rod consists of the following components:

- **Electrical Connections (Top)**

The top electrical connector plugs into the feedthrough on the inside of the wired access port. It has a five-pin male connector identical to the heater connector (Figure 5-7) and an anodized aluminum rim that helps you safely grip the connector when you plug it in and remove it.

Important: Always handle the oven sample rod and its connectors by using the anodized aluminum rim of the electrical connector or the strain relief portion of the oven sample rod. Never pull on the cable while unplugging it, as you might loosen the electrical connections.

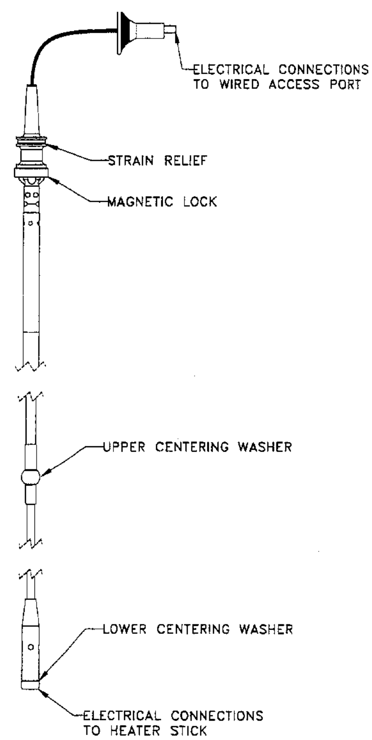


Figure 5-2. Oven sample rod

- **Strain Relief**

  The strain relief portion of the oven sample rod is made of white Delrin plastic. When you install the sample rod, grip it by the strain relief portion.

  This portion of the rod is designed to prevent damage to the wiring as it is fed into the shaft of the oven sample rod. It also protects the wiring while the oven sample rod undergoes vibration.

  Important: Always grip the strain relief portion of the oven sample rod when you insert or remove the rod from the VSM. *Never* grip the cable of the oven sample rod while you remove it, as you might pull the electrical connections loose.

- **Magnetic Lock**

  The magnetic lock is constructed of anodized aluminum. The lock contains six small, very strong magnets that attach the oven sample rod to the armature of the linear motor transport during measurement. Keep the magnets clean and prevent them from contacting any magnetic object.

- **Upper Centering Washer**

  The upper centering washer is made of anodized aluminum that is impregnated with PTFE plastic. This washer is precisely fitted to prevent rattling as it slides through precision guide tubes within the sample tube. The upper centering washer is integrated into the shaft and is designed to be low friction and to have a long lifetime, so long as it is kept clean and smooth.

- **Lower Centering Washer**

  The lower centering washer is made of anodized aluminum that is impregnated with PTFE plastic. This washer slides through precision guide tubes within the sample tube and is precisely fitted to prevent rattling. The lower centering washer is integrated into the shaft and is designed to be low friction and to have a long lifetime, so long as it is kept clean and smooth. This washer is also designed to accommodate the electrical connections on the oven heater stick and to hold the heater stick in place.

- **Electrical Connections (Bottom)**

  This electrical connector is the bottom of the wiring that feeds through the oven sample rod. It connects to the oven heater stick and contains a five-pin female connector.

5.2.3 Wired Access Port

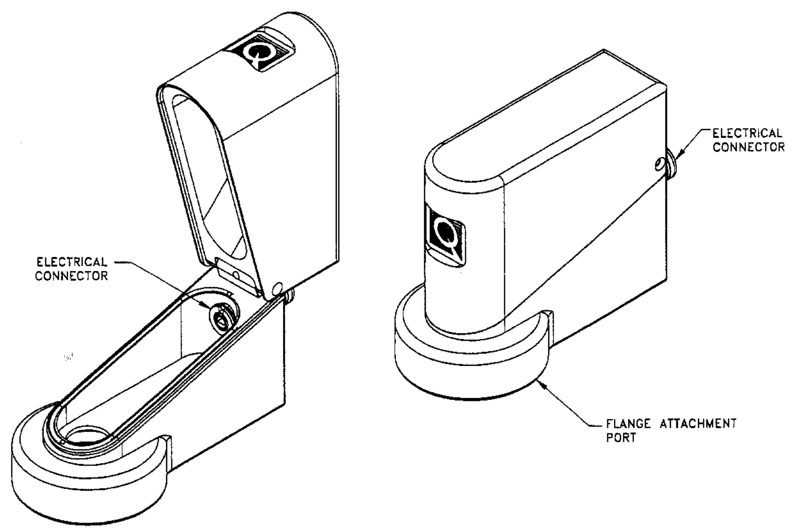


Figure 5-3. Wired access port

Figure 5-3 shows the wired access port that connects to the VSM linear motor transport. The access port is made of anodized aluminum and is designed to be vacuum tight. The oven sample rod is connected to the oven-control cable by an electrical connector that can be seen on the back of the access port (inside and outside). This connector is specially designed: it maintains its vacuum seal and it is free to rotate. Hence, you can connect it to the oven sample rod without twisting the wiring of the rod.

On the bottom of the wired access port is the flange attachment port. This section of the access port has a hole that allows the oven sample rod to slide through and establish a magnetic lock with the VSM linear motor transport. This port screws onto the top of the VSM linear motor transport and locking nut (Figure 5-4) and forms a vacuum-tight seal.

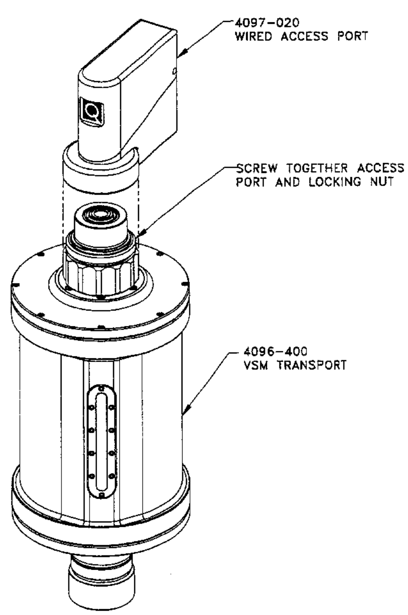


Figure 5-4. Attaching the wired access port to the VSM linear motor transport

5.3 VSM Oven Option User's Kit

The VSM Oven Option User's Kit (Figure 5-5) contains miscellaneous hardware and supplies that you will use to mount samples (see Chapter 3). The portable toolbox is a convenient way to organize these items, which are listed below.

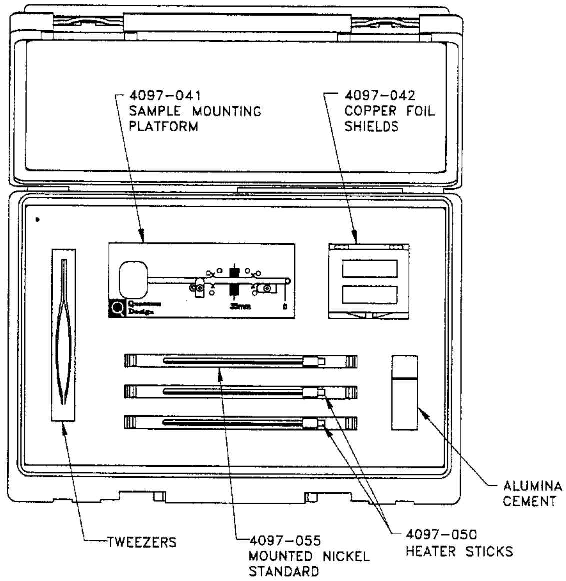


Figure 5-5. VSM Oven Option User's Kit

- **Sample-Mounting Platform**

  The sample-mounting platform is used to mount a sample on an oven heater stick and to properly position the copper shields around the sample-mounting area. Section 3.3 and Figure 5-6 provide more information about mounting samples.

- **Copper-Foil Shields**

  The shields are slips of high-purity copper foil. You will wrap a shield around the sample and sample-mounting area of a heater stick to provide thermal homogeneity over the sample. Refer to Section 5.3.2 for more information about how the shields are used.

- **Tweezers**

  A pair of tweezers is included for your use in the sample-mounting process.

- **Alumina Cement**

  The water-based alumina cement provides good thermal contact between the sample and heater stick. It also holds the sample firmly in place during vibration.

- **Heater Sticks**

  These heater sticks are used as the heater, thermometer system, and sample holder of the VSM Oven option. The heater stick plugs into the bottom of the oven sample rod. Sections 5.2.1 and 5.4.1 and Figures 5-1 and 5-7 provide more information about the heater sticks.

- **Mounted Nickel (Ni) Standard**

  The "mounted nickel standard" is an oven heater stick mounted with a small chip of pure nickel. You can verify the temperature calibration of your VSM Oven option by measuring the Curie temperature (T_c = 627 K) of the nickel chip.

5.3.1 Sample-Mounting Platform

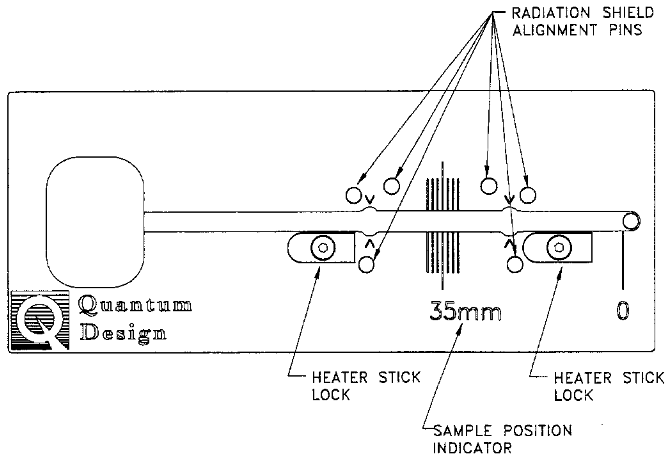


Figure 5-6. VSM Oven sample-mounting platform

Shown in Figure 5-6 is the oven sample-mounting platform. This platform was designed specifically for use with VSM Oven heater sticks. The heater sticks are mounted in the center groove down the long axis of the platform, with the bottom of the stick aligned at the marker labeled "0". Section 3.3 has more information about mounting a sample.

The heater stick locks are used to hold the heater stick firmly in place so that it does not slip out of position while you mount a sample. After you have positioned the heater stick properly, rotate the locks into place. The locks also prevent the heater stick from bowing upward when you place a copper-foil radiation shield beneath it and hold the heater stick stable while you wrap the radiation shield around the stick.

The radiation-shield alignment pins are designed to fit the copper-foil radiation shields. The pins function to properly position and hold the shields in place on the heater stick while you mount a sample.

The sample-position indicator is used to determine the sample offset of the material you have just mounted on the heater stick. This is useful if the moment of your sample is very low and the VSM centering algorithm cannot locate the position of the sample. This sample-position indicator can give you a precise measurement of the sample offset that you can enter into the **VSM Install/Remove Sample Wizard**. Refer to Section 3.3 for more information about sample centering.

5.3.2 Copper-Foil Radiation Shields

The copper-foil radiation shields are thin slips of vacuum-annealed high-purity copper that has been specially selected to be free of magnetic impurities. You will wrap a radiation shield around the sample-mounting area of a heater stick after you have mounted a sample.

The copper-foil radiation shields have a two-fold purpose. First, the high thermal conductivity of copper makes it an ideal medium for maintaining a thermally homogeneous region over the sample-mounting area.

Important: Tightly wrap the copper-foil radiation shield around the sample and heater stick—physical contact between the copper-foil shield and the sample-mounting area is important to maintaining thermal homogeneity.

The second function of the copper-foil radiation shields is to thermally isolate the heater stick and sample from the VSM coilset and the sample chamber. The copper foil has very low emissivity, which prevents excessive heat loss to the environment through radiation and allows the VSM Oven option to achieve a temperature of 1000 K.

Important: The exterior of the copper-foil radiation shields must be shiny, clean, and untarnished. Copper oxide and other materials on the outer surface of the shield can raise its emissivity, preventing the VSM Oven option from achieving temperature stability or reaching 1000 K.

5.4 VSM Oven Electronics

5.4.1 Heater-Stick Connector

Figure 5-7 shows the heater-stick connector, viewed from the outside. It attaches to the bottom of the oven sample rod, which provides a direct electrical feedthrough for each wire. The oven sample rod attaches to the wired access-port connector (Figure 5-8) with a connector identical to that in Figure 5-7. Refer to Figure 1-2 for a schematic of the heater stick.

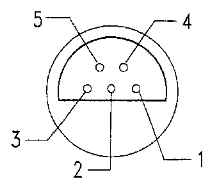


Figure 5-7. Pin assignments on the heater-stick connector

Table 5-1. Pinout connections for the heater-stick connector

PIN	FUNCTION
1	Thermocouple –
2	Thermocouple +/Thermistor B
3	Thermistor A
4	Heater A
5	Heater B

5.4.2 Wired Access-Port Connector

The wired access-port connector provides a feedthrough to the heater stick. Figure 5-8 shows the connector on the wired access port as viewed from the outside. Note that pins 4 and 5 are jumpered together inside the connector.

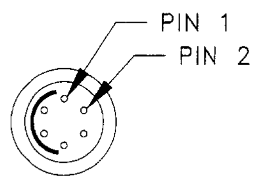


Figure 5-8. Pin assignments on the wired access-port connector (P1)

Table 5-2. Pinout connections for the wired access-port connector (P1)

PIN	FUNCTION
1	Heater A
2	Heater B
3	Thermistor A
4	Thermocouple +
5	Thermistor B
6	Thermocouple –

5.4.3 Oven-Control Cable

Figure 5-9 shows the oven-control cable (3097-010) that connects the wired access port to the "Oven" port (JC-1) on the Model CM-C (the VSM Oven Module). The control cable provides the heater power as well as the temperature readback from both the thermocouple and the thermistor.

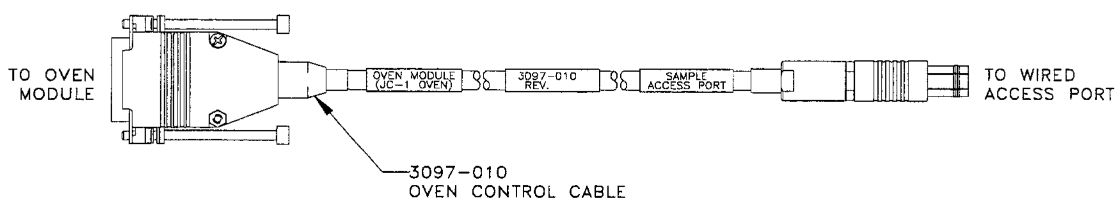


Figure 5-9. VSM Oven-Control cable

5.4.4 Model CM-C (VSM Oven Module)

Figures 5-10 and 5-11 show the front and back of the Model CM-C VSM Oven module (4101-200), which provides the heater with current and reads back temperature information from the heater stick. The oven module also handles all the temperature control for the VSM Oven option. All configuration and control of this module is through the VSM application software on the computer (PC) via the CAN-bus connector on the back panel of the module.

Appendix A contains a pinout diagram and connection table for the CAN connector.

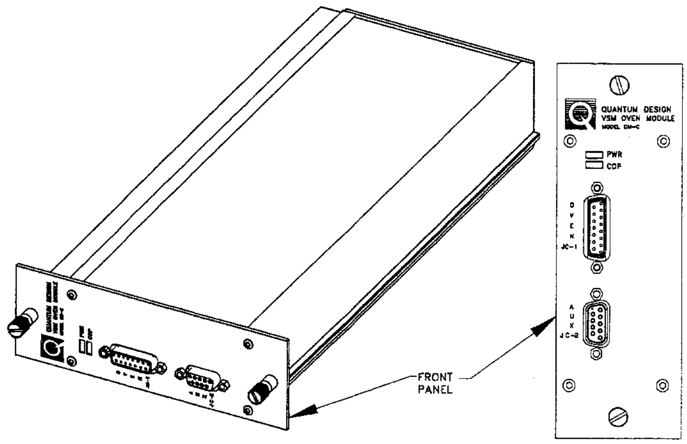


Figure 5-10. Front panel of the Model CM-C VSM Oven module

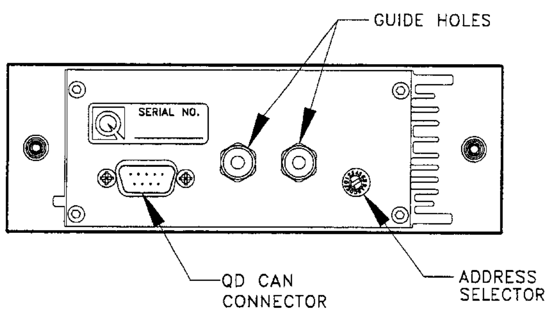


Figure 5-11. Back panel of the Model CM-C VSM Oven module

C H A P T E R 6

VSM Oven Software

6.1 Introduction

This document contains the following information:

- Section 6.2 summarizes the measurement process with the Quantum Design VSM Oven option.
- Section 6.3 describes some notable changes to PPMS operations associated with the VSM oven.
- Section 6.4 provides an overview of the MultiVu software, how to activate and deactivate the VSM Oven, and how to change between VSM modes.
- Section 6.5 describes MultiVu and the VSM Oven-enabled software, focusing on changes associated with the VSM Oven.

6.2 Using the VSM Oven for Measurements

The procedures for using the Quantum Design Physical Property Measurement System (PPMS) VSM in the oven mode are almost identical to those for using it in the standard VSM mode. In fact, when you installed the VSM Oven software, it was incorporated into MultiVu as part of the standard VSM software, so you will use the same software to take measurements with the standard (low temperature) VSM and the VSM Oven. Assuming that the VSM and VSM oven hardware and software have been installed, then each time you use the **VSM Install/Remove Sample Wizard**, you will decide whether you will be measuring with the standard VSM (low temperatures) or with the VSM oven. Other than that, the same process is used for both types of measurements.

You will use the automated **VSM Install/Remove Sample Wizard**, which is accessed through the MultiVu application software, for pre-measurement preparations (e.g., preparing for the installation of the oven, selecting the oven mode). The software also has automated functions to help set VSM Oven measurement parameters and to graph the output of the oven.

6.3 Changes Associated with the VSM Oven

Several notable changes have been made to PPMS operations to accommodate the VSM Oven option, including a mechanism to prevent overheating, changes to cryopump high-vacuum operations, and software and firmware changes. These changes are explained in relevant sections throughout the manual. Aside from these changes, you will use similar procedures to operate the VSM oven and the standard VSM.

6.3.1 Prevention of Overheating

To safeguard the equipment from overheating while it operates in oven mode, the PPMS sets the coilset temperature to 295 K, and the VSM Oven software uses the VSM coilset temperature as the primary diagnostic. In the event the VSM coilset temperature rises above 350 K, the system shuts down the power to the oven heater.

6.3.2 Changes to Cryopump High-Vacuum Operations

The VSM linear motor transport increases the volume of the PPMS sample chamber by comparison with options that do not use the VSM linear motor transport. Hence, when you are in VSM Oven mode, cryopump operations have been modified in the following ways:

- When a sample is installed, a purge/seal operation will be performed before the system begins any pre-pumping. This helps remove adsorbed gases and water from surfaces on the linear motor.
- After the cryopump flapper valve has been opened, the timeout to reach high vacuum has been set to 60 minutes instead of the standard 30 minutes.
- In the event that the sample chamber does not reach the base pressure in 60 minutes, the VSM oven software issues a "High Vacuum" error warning to the user and records the error in the `Vsmlog.txt` file. The system does not stop VSM oven operations when there is a High Vacuum error.

6.4 Using the MultiVu Software Application

The MultiVu software application is the interface to the Quantum Design Physical Property Measurement System (PPMS) and to the different options that can be installed on the PPMS. MultiVu has a standard set of commands that apply to all options that can be used with the PPMS. Other commands are tailored to specific options and are available for use only after you have "activated" the option, as explained in Section 6.4.2.

6.4.1 MultiVu Basics

As shown in Figure 6-1, the top of the MultiVu window has a series of dropdown menus and a tool bar. At the bottom of the MultiVu window, a **Status** bar summarizes the general status of the PPMS and any active option. To show or hide the **Status** bar, select **View** >> **Status Bar** on the dropdown **View** menu at the top of the MultiVu window and select the appropriate option (**Minimum, Maximum, or None**).

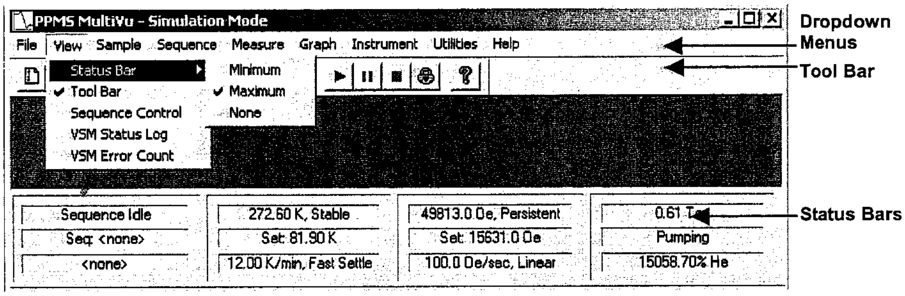


Figure 6-1. The MultiVu software application window and the View >> Status Bar dropdown menu

Starting from the left, the **Status** bar panels (Figure 6-2) display information about a running sequence file, the sample temperature, the strength of the magnetic field, and the status of the sample chamber. The status bar also indicates the level of helium in the dewar.

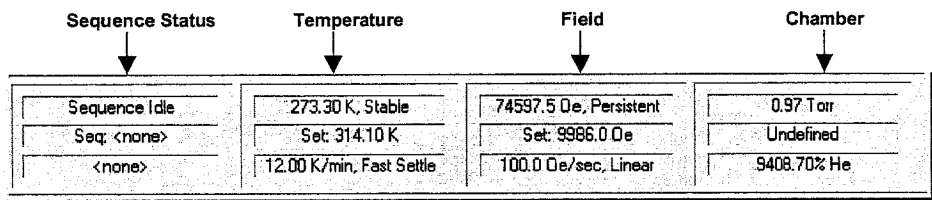


Figure 6-2. The MultiVu Status Bar and the Sequence, Temperature, Field, and Chamber panels

If you place your mouse pointer on a panel and click on it, the related dialog box will open so that you can initiate changes. These dialog boxes are the same ones that open through the dropdown menus at the top of the MultiVu window.

For example, if you click on the **Temperature** panel, the **Temperature-System** dialog box will open so that you can change the temperature set point and the mode and rate of change. This is the same dialog box that opens when you select **Instrument** >> **Temperature** from the MultiVu dropdown menus.

Important: When the VSM oven is operating, MultiVu reports the temperature of the heater stick in the **Temperature-System** dialog (Figure 2-2) and in the **Temperature** panel of the **Status** bar (Figure 6-2). You can set temperatures from 300 to 1000 K both in MultiVu and at the front panel of the Model 6000. The maximum rate is 200 K/min (by comparison with 20 K/min in other options) because of the very low thermal mass of the heater stick and the ease with which temperature can be controlled.

The **Status** bar also displays color-coded warning and error messages to alert you to possible problems with any of those components. See the *PPMS VSM Option User's Manual* and the *Physical Properties Measurement System (PPMS): MultiVu Application User's Manual* for detailed information about error messages and the MultiVu application.

6.4.2 VSM Oven Commands

Commands for the VSM Oven are organized through the **VSM Control Center**. To access the **VSM Control Center** and oven-specific commands in MultiVu, you first must have installed the hardware and software for the standard VSM and the VSM Oven (see Chapter 2) and activated the standard VSM option, as is explained below. The VSM Oven option does not have to be activated and deactivated separately from the standard VSM option, because the VSM Oven software is automatically incorporated into the standard VSM software during installation.

6.4.2.1 ACTIVATING THE VSM OPTION AND CONTROL CENTER

1. To activate the VSM option, select **Utilities >> Activate Option** in the MultiVu window (Figure 6-3).
2. When the **Option Manager** dialog box opens, select **VSM** and click on the **Activate** button. When you click on the **Activate** button, VSM will move from the "Available Options" section to the "Active Options" section of the **Option Manager** dialog box.

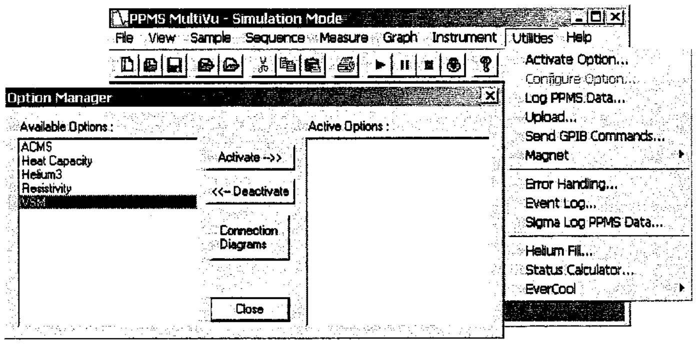


Figure 6-3. Activating the VSM option with the Option Manager dialog box

Concurrently, the **VSM Control Center** will open in the main MultiVu window (Figure 6-4). Components of the **VSM Control Center** will guide the installation process. (In simulation mode, the title of the **VSM Control Center** is **VSM SIM**.)

At this time, the system also will perform a **Home** operation to determine the full range of travel for the sample transport by touching down and then going to the load (top) position.

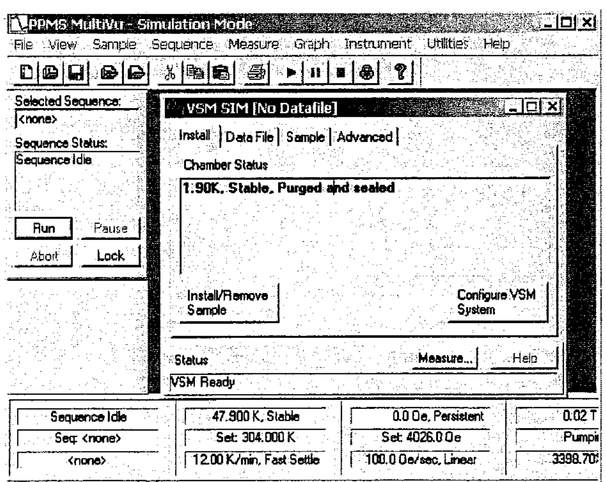


Figure 6-4. Main MultiVu window and main window of the VSM Control Center (In simulation mode, the title of the **VSM Control Center** is **VSM SIM**.)

3. The **Status** area at the bottom of the **VSM Control Center** will indicate if you have activated the VSM option and which measurement mode you have selected. As is shown in Figure 6-4, the **Status** area will report "**VSM Ready**" after the VSM option has been activated.

   If you have experience using the standard VSM option, you will notice that the information in the **Status** area of Figure 6-4 is different from that for the standard VSM. This minor change helps you track the current measurement mode. Other changes to the software could affect your measurements, so it is important that you review the installation and measurement procedures, even if you are an experienced VSM user. For example, some utilities and dialogs in the VSM Oven-enabled software have been given different capabilities and measurement limits than those for the standard VSM software. These differences are discussed in the next sections.

6.4.2.2 DEACTIVATING THE VSM OVEN OPTION

The VSM Oven software is incorporated into the standard VSM software during installation, and oven-specific commands are a subset of the standard VSM commands. Hence, you will not activate or deactivate the VSM Oven separately from the standard VSM option. The only way to deactivate the VSM Oven is to use the **Option Manager** (Section 6.4.2.1) to deactivate the VSM option.

6.4.2.3 CHANGING FROM VSM OVEN MODE TO STANDARD VSM MODE

It is simple to change from operating in the VSM Oven mode to the standard VSM mode.

1. Use Steps 1–3 of Section 4.5 to remove the current sample and sample rod from the sample chamber, except do not close the wired access port.
2. Insert the standard VSM sample rod with sample.
3. Click on the **Next** >> button at the bottom of the **VSM Install** wizard. The **Next** >> button will open the "Select VSM operating mode" page.
4. Set the system to operate in **Standard** mode and click on the **Next** >> button, which will take you to the **Output Data File** dialog.
5. The remaining dialogs will now reflect operations in standard (low temperature) VSM mode.

Note: You also can use the steps in Section 6.4.2.3 above to change from the standard VSM mode to VSM Oven mode. But, when you change to VSM Oven mode after operating at low temperatures in standard VSM mode, you will improve accuracy by using touchdowns for approximately 30 minutes after the sample reaches room temperature (refer to Section 6.5.3.1 for more information).

6.5 MultiVu and VSM Oven-Enabled Software

This section provides an overview of MultiVu and the **VSM Control Center** when the VSM Oven has been enabled. Also discussed are changes to the standard VSM software that permit measurements with the VSM Oven option. Other than these changes, the two versions of the VSM software are the same, so you can refer to the *Physical Properties Measurement System: Vibrating Sample Magnetometer (VSM) Option User's Manual* (*PPMS VSM Option User's Manual* for short) for more complete information on the different menus and commands.

6.5.1 MultiVu Changes

6.5.1.1 WRITING SEQUENCES

If you have the VSM Oven hardware, MultiVu will allow you to write sequences containing temperatures up to 1000 K. In fact, you do not have to be in VSM Oven mode when you write a sequence that contains high temperatures—you can write high temperatures into a sequence even when the VSM option has not been activated. This approach streamlines the construction of high-temperature sequences, as it would be inconvenient if you could only write them while the system is in VSM Oven mode. (But remember that the VSM option must be activated before you can write sequences containing VSM-specific commands and before the system can interpret VSM sequence commands.) Then, when you activate the VSM option and run a VSM sequence, MultiVu will check the temperature limits of the sequence and abort it if the limits are not appropriate to the current VSM mode (for example, if temperatures above 400 K are requested but the system is operating in the standard, low-temperature VSM mode).

6.5.1.2 TEMPERATURE REPORT AND SETTINGS

When the VSM oven is operating, the **Temperature-System** dialog box and the **Temperature** panel of the MultiVu **Status** bar report the temperature of the oven heater stick. You can set the temperature of the VSM Oven to a value from 300 K to 1000 K by using MultiVu or the front panel of the Model 6000. The maximum recommended slew rate is 200 K/min (by comparison with 20 K/min in other options) because of the very low thermal mass of the heater stick and the ease with which temperature can be controlled.

6.5.2 VSM Control Center Components

Figure 6-5 shows the **VSM Control Center** (Oven-enabled). It is designed the same as the standard **VSM Control Center**—it has the same four tabs (**Install**, **Data File**, **Sample**, and **Advanced**), and the **Install/Remove Sample** button, the **Measure** button, and the **Status** area are in the same locations in both versions of the software. However, components of the **Status** area, the **Install/Remove Sample Wizard**, and the **Measure** command have been changed, as have the limits that you will be able to use when you write sequences (Section 6.5.1.1).

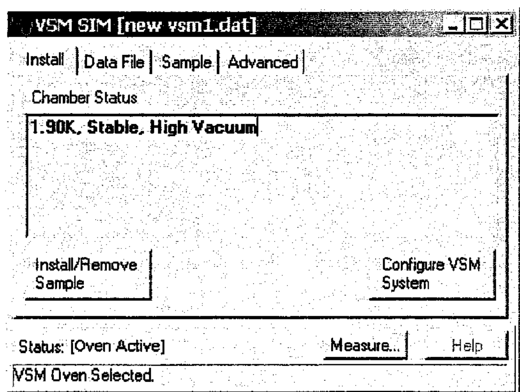


Figure 6-5. The VSM Control Center (oven enabled) after sample installation has been completed

6.5.2.1 STATUS AREA

The **Status** area at the bottom of the **VSM Control Center** includes new information such as the measurement mode you selected during the **VSM Install/Remove Sample Wizard**. For example, after you select VSM Oven mode and complete the **VSM Install/Remove Sample Wizard**, the **Status** area will report "Oven Active" and "VSM Oven Selected" (Figure 6-5). If you had selected standard VSM mode, the **Status** area would display "Standard VSM configuration selected."

6.5.2.2 THE VSM INSTALL/REMOVE SAMPLE WIZARD

The **VSM Install/Remove Sample Wizard** (**VSM Install** wizard for short) organizes the oven and sample-installation process through a set of automated dialog boxes. As is explained in Chapter 4 of this manual and in the *PPMS VSM Option User's Manual*, you start the **VSM Install** wizard by clicking on the **Install/Remove Sample** button located in the lower left of the **Install** tab (Figure 6-5). The initial pages of the **VSM Install** wizard for the VSM Oven-enabled software are somewhat different than those for the standard VSM software, most notably by including a dialog in which you choose to operate in Oven mode or standard VSM mode (Figure 6-6).

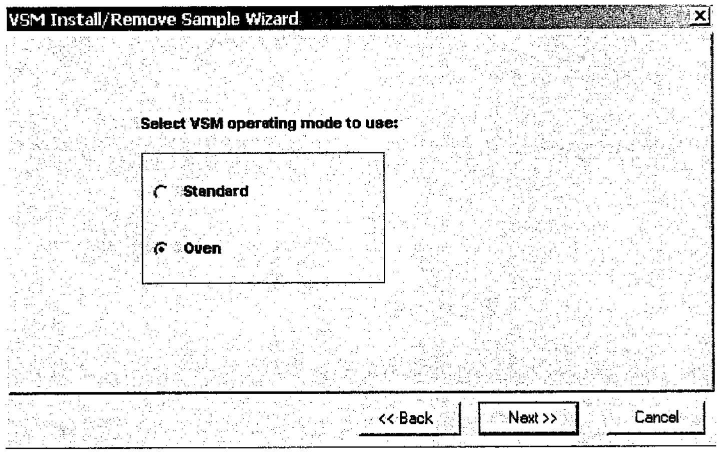


Figure 6-6. VSM Install wizard: Selecting the VSM operating mode

You can return to this page and change your operating mode during any part of the **VSM Install** wizard. However, if you want to change the operating mode after the **VSM Install** wizard has ended, you must restart the wizard from the beginning.

The **Sample Coordinates** pages for the two versions of the VSM software also differ. As shown in Figure 6-7, these pages display an oven heater stick instead of the VSM sample rod, and the sample offset is input via one of three new buttons—**Scan for Sample Offset**, **Enter Offset manually**, and **Advanced Centering**.

Note: A green dot appears in the illustration after a scan has been completed. The dot indicates the location of the sample on the heater stick.

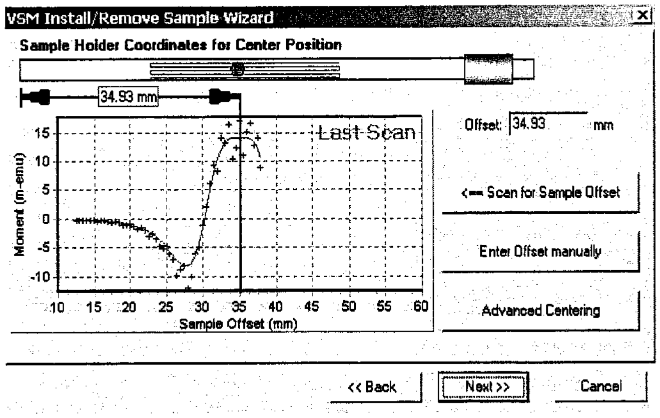


Figure 6-7. The Sample Coordinates page and the three new buttons for determining sample offset

- **Scan for Sample Offset:** This button performs an automatic centering.
- **Enter Offset Manually**: If you have physically measured the sample offset using the sample-mounting platform on the benchtop, you can enter the value manually by clicking on this button. The dialogs will be similar to those that appear when an automatic scan is performed.
- **Advanced Centering**: This button starts a mode that omits touchdown operations. To perform advanced centering, you would instruct the linear motor transport to operate at a fixed motor position instead of stating a sample-offset value.

Other than the above-mentioned changes to the **VSM Install** wizard, the same sample-installation process is used in the standard VSM software and the VSM Oven-enabled software.

6.5.3 VSM Oven Measurements

The **Measure** button in the **VSM Control Center** opens the **VSM Measurement** dialog box (Figure 6-8), which you will use to set parameters for VSM Oven measurements, just as you would if you were measuring with the standard VSM software. The **VSM Measurement** dialog box has the same three tabs (**Settings, Centering**, and **Advanced**) found in the standard VSM software. Aside from exceptions (noted below) for the **Centering** and **Advanced** tabs, you will use these tabs and their settings according to the information in the *PPMS VSM Option User's Manual.*

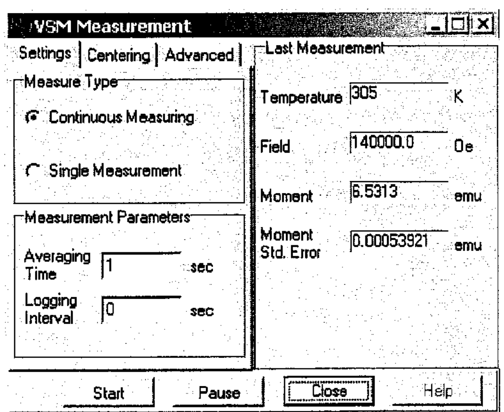


Figure 6-8. The VSM Measurement dialog for the oven-enabled software

6.5.3.1 CENTERING TAB

While operating in VSM Oven mode, the default setting in the **Centering** tab is **No Automatic Centering,**[1] as is shown in Figure 6-9.

Because the thermal expansion of the 2.5 cm long heater region of the oven heater stick produces a negligible movement of the sample, touchdowns are typically unnecessary when you are using the oven mode.

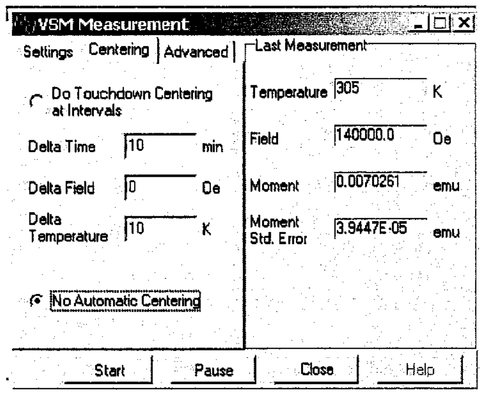


Figure 6-9. Centering tab of VSM Measurement dialog and default setting

Important: When you change to VSM Oven mode after operating at low temperatures in standard VSM mode, there will be a slight thermal expansion of the sample chamber. Hence, you will improve accuracy by using touchdowns for approximately 30 minutes after the sample reaches room temperature.

At all other times, you can use the default VSM Oven setting. Refer to the *PPMS VSM Option User's Manual* for more information about touchdowns.

6.5.3.2 ADVANCED TAB

As is shown in the **Advanced** tab of the **Measure** dialog in Figure 6-10, the maximum VSM linear motor oscillation amplitude is 2 mm peak when the oven is operating, by comparison with 5 mm peak for the standard VSM. This difference is due to the increased heating of the linear motor drive coil when it is running in high vacuum instead of in the exchange gas atmosphere that is used for standard VSM measurements.

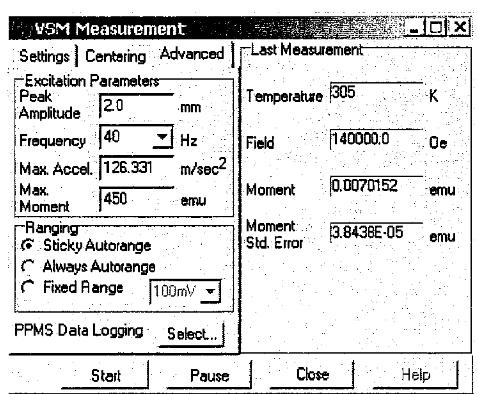


Figure 6-10. Advanced tab of VSM Measurement dialog box, showing peak amplitude during oven use

[1] Recall that **Do Touchdown Centering at Intervals** is the default in the standard VSM mode.

APPENDIX A

Model CM-C VSM Oven Module

A.1 Introduction

This appendix contains the following information:

- Section A.2 provides a functional overview of the Model CM-C VSM Oven module, including a block diagram and electrical specifications.
- Section A.3 describes the front panel and relevant components of the Model CM-C VSM Oven module.
- Section A.4 describes the rear panel and relevant components of the Model CM-C VSM Oven module.

A.2 Functional Overview

The Model CM-C VSM Oven module (4101-200) is a temperature-control module that was designed for the specific needs of the VSM Oven option. Figure A-1 shows the module and its front panel.

The principle function of this module is to provide the appropriate current to a platinum heater based on resistance feedback and temperature readings from a thermocouple and a thermistor. The maximum heater output is 25 V rms at either 50 Hz or 60 Hz with synchronous current readback detection. The temperature-control (PID) loop is closed digitally at about 10 Hz using a 16-bit current source. Other features include in-system programmable on-board flash memory for program storage and a serial ROM for calibration and other configuration data.

The module is designed to plug into the Model 1000 modular control system (module tower), shown in Figure A-2, or an equivalent host chassis that can provide power and the required CAN network signals that communicate with the module.

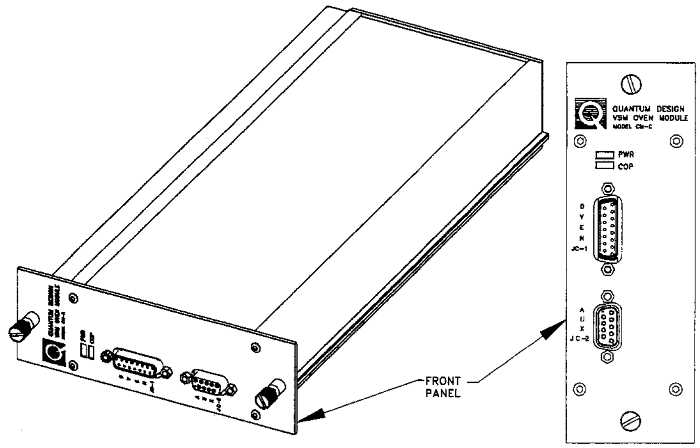


Figure A-1. Front panel of Model CM-C VSM Oven module

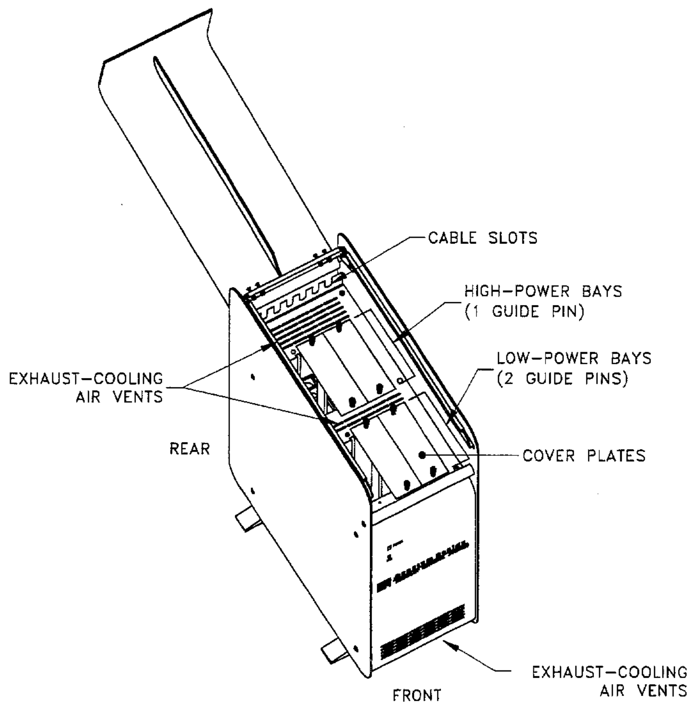


Figure A-2. PPMS Modular Control System or module tower, which contains bays for up to six modules

A.2.1 Functional Block Diagram

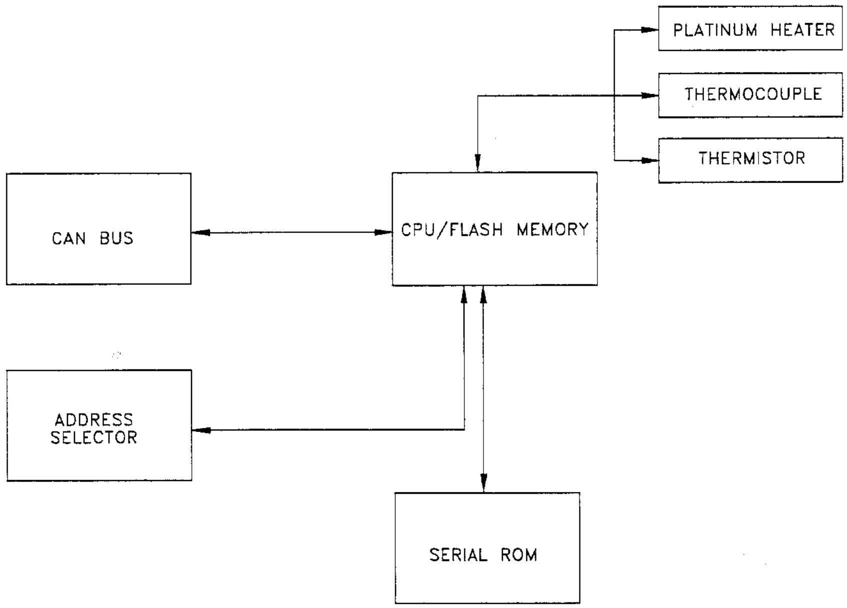


Figure A-3. Functional block diagram of Model CM-C VSM Oven module

A.2.2 Specifications

Table A-1. Electrical specifications for the Model CM-C VSM Oven module

Heater Voltage Compliance Limit	25 V rms
Supply Voltage	±24 V DC
Thermistor Resistance	10 kΩ at 25°C
Thermocouple Voltage (Max)	7.587 mV at 1000 K
Thermometer Sample Plate	14 Hz

A.3 Model CM-C VSM Oven Module: Front Panel

A.3.1 Indicator LEDs

The front panel of the Model CM-C VSM Oven module has two LEDs in the top left, as shown in Figure A-1. The PWR LED indicates the power-on status of the module. The COP (CANopen Protocol) LED indicates the status of the CAN network controller. Table A-2 outlines the LED states and provides solutions in the event of a problem.

Important: The error information in Table A-2 refers to situations that persist for longer than about 15 seconds. Typically, when the module is powered on, the LEDs might briefly flash red before they turn green. This is a normal part of the startup or reset sequence.

Table A-2. LED guide for Model CM-C VSM Oven module

LED	COLOR	STATUS	MEANING AND/OR SOLUTION
PWR	Green	On	The processor is running with no errors (normal).
	Red	Flashing	Errors were encountered during the self-test. The flashing sequence can be used to determine the cause of the failure.
COP	Green	On	CAN status is operational (normal).
		Flashing	CAN status is pre-operational. Verify that the cable is connected to PC.
	Red	On or flashing	Error on the CAN bus. Contact Quantum Design for assistance.

If you are unable to achieve operation with both LEDs green, please contact Quantum Design for assistance.

A.3.2 Front Panel Connectors and Pinout Tables

A.3.2.1 JC-1 OVEN CONNECTOR

This connector is used to supply current to the oven stick heater as well as to read temperature information from the thermocouple and the thermistor. Table A-3 shows the pinout connections from the oven-control cable to the oven module. Note that eight wires pass through to the JC-2 AUX connector (AUX1, AUX2, …, AUX9)

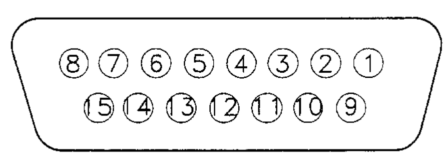


Figure A-4. JC-1 pin assignments on the Model CM-C VSM Oven module

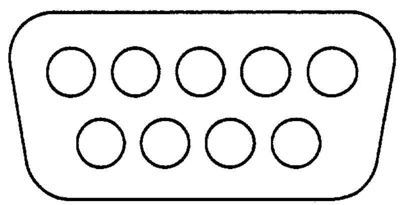
Table A-3. JC-1 pinout connections from the oven-control cable to the Model CM-C VSM Oven module

PIN	FUNCTION
1	Thermocouple +
2	Thermistor A
3	AUX1
4	AUX2
5	AUX3
6	AUX4
7	Heater A
8	N/C
9	Thermocouple –
10	Thermistor B
11	AUX6
12	AUX7
13	AUX8
14	AUX9
15	Heater B

A.3.2.2 JC-2 AUX CONNECTOR

The JC-2 AUX connector is available for future expansion of the VSM Oven option, including transport measurements. Please contact Quantum Design before you attempt to use the connector. Note the pinout connections shown in Table A-3 for this connector.

5 1



9 6

Figure A-5. JC-2 pin assignments on the AUX connector

A.4 Model CM-C VSM Oven Module: Rear Panel

The rear panel of the Model CM-C VSM Oven module contains an address selector, two guide holes, and the CAN connector through which the module sends and receives network data and receives power.

A.4.1.1 ADDRESS SELECTOR

Each module on the CAN bus must have a unique 5-bit binary address. The selector on the back panel is used to set the four least significant bits, while an internal jumper sets the most significant bit. If the selector is set to "0," the module uses its default address. For a Model CM-C VSM Oven module, the default address is 12.

A.4.1.2 GUIDE HOLES

The two guide holes are used to align the connector with a low-power receptacle on the Model 1000 Modular Control System.

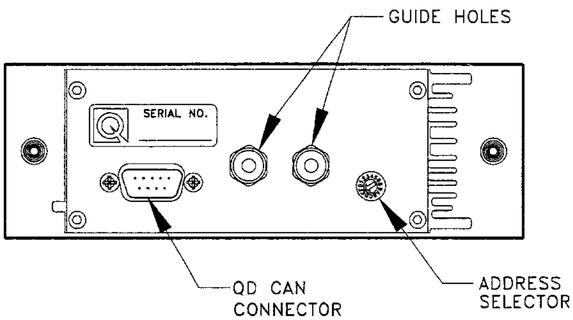


Figure A-6. Rear panel of Model CM-C VSM Oven module

A.4.1.3 QD CAN CONNECTOR AND PINOUT TABLE

The QD CAN connector is the main communication connection for controlling the Model CM-C VSM Oven module. The CAN network signals (CAN High, CAN Low) are connected to all other CAN modules on the bus and to the PC. Power (±24 volts), reset, and sync signals also are sent to the module though this connector.

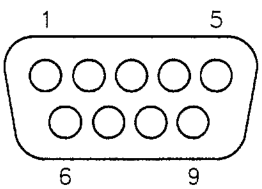


Figure A-7. QD CAN connector on rear of the Model CM-C VSM Oven module

Table A-4. Pinout table for QD CAN connector on rear of the Model CM-C VSM Oven module

PIN	FUNCTION
1	–24 V
2	CAN Low
3	Power Return (24V)
4	Sync Low
5	Line Sync
6	System Ground
7	CAN High
8	Sync High / Reset
9	+24 V DC

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