CTI-CRYOGENICS
HELIX TECHNOLOGY CORPORATION

Cryo-Torr® 100, 7, 8 and 8F High-Vacuum Pump Installation, Operation, and Service Instructions

8040240
Rev. F (5/99)

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Table of Contents

Table of Contents (continued)

Table of Contents (continued)

Figures

Tables

Table of Contents (continued)

Safety

Introduction

On-Board products have been designed to provide extremely safe and dependable operation when properly used. Safety precautions must be observed during normal operation and when servicing the On-Board system.

NOTE: Read this manual and follow these safety guidelines before installing, operating, or servicing On-Board products.

Warnings

A warning describes safety hazards or unsafe practices which could result in personal injury or loss of life. A warning message is accompanied by a symbol as described in the following paragraphs and is also surrounded by a box to attract your attention.

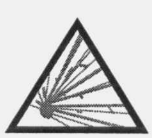
Toxic, Corrosive, Dangerous Gases, or Liquids

Toxic, corrosive, dangerous gases, or liquids which may be present in an On-Board product could cause severe injury upon contact. Make sure the following precautions are taken when handling toxic, corrosive, or dangerous gases.

1. Always vent toxic, corrosive, dangerous gases, or liquids to a safe location using an inert purge gas.
2. Clearly identify toxic, corrosive, dangerous gases, or liquids on containers used to store or ship equipment after such exposure.

Flammable or Explosive Gases

Flammable or explosive gases which may be present in an On-Board product could cause severe injury if ignited. Make sure the following precautions are taken when handling flammable or explosive gases:



1. Always vent flammable or explosive gases to a safe location using an inert purge gas.
2. Do not install a hot filament type vacuum gauge on the high vacuum side of the isolation valve. This could be an ignition source of flammable gases in On-Board products.

High Voltage

High voltage electric shock can cause severe injury or loss of life. Take the following precautions to prevent high voltage risks:

1. Disconnect the high vacuum pump system from all power sources before making electrical connections between system components or before performing troubleshooting and maintenance procedures.

High Gas Pressure

High gas pressure may be present within high vacuum pump systems and can cause severe injury from propelled particles or parts.

1. Do not modify or remove the pressure relief valves, either on the On-Board pump or within the helium compressor.
2. Always depressurize the adsorber to atmospheric pressure before disposing.
3. Always bleed the helium charge down to atmospheric pressure before servicing or disassembling the self sealing couplings.

Cautions

A caution describes safety hazards or unsafe practices which could result in equipment damage.

Cryopump Oxygen Procedures

WARNING

Combustion supported by oxygen in the cryopump could cause severe injury when oxygen is used as a process gas. Special precautions described in the following text should be taken.

When oxygen is used as a process gas, the following precautions should be taken:

1. Insure that there are no sources of ignition (e.g. hot filament vacuum gauges) on the cryopump side of the high vacuum valve operating during the warming or venting of the cryopump.

2. Perform inert gas purge regeneration cycles at flow rates recommended for cryopumps.
3. Regenerate as frequently as practical to minimize the amount of oxidizer present in the cryopump.
4. It is standard practice in the vacuum industry that any system exposed to richer-than-air oxygen levels should be prepared for oxygen service per the manufacturer's recommendations, including use of oxygen service lubricating oils in roughing pumps.

WARNING

Explosion occurring from ozone in the cryopump could cause severe injury. Ozone can be present as a by product of oxygen processes. If ozone is present, special precautions described in the following text must be taken.

Ozone may be unknowingly produced in an ionizing process (e.g. sputtering, etching, glow discharge). Explosive conditions may exist if ozone is present, especially during the warming of the cryopump. Signs of ozone's presence are:

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

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

If ozone is present, the following precautions must be taken:

1. All of the above oxygen precautions must be followed. The required regeneration frequency is dependent upon flow and process conditions. Daily regeneration may be required. Call CTI-CRYOGENICS for assistance.
2. Reduce the oxygen mixture to the lowest level the process will allow.

Section 1 - Cryopump Description

Introduction

This manual provides instructions for installing, operating and servicing the Cryo-Torr 100, 7, 8, and 8F Cryopumps. If you are installing or operating a high-vacuum system you should also have the appropriate Compressor manual that applies to your particular system.

The manuals cover two basic components: the cryopump, compressor, and the controller where applicable. Each manual presents information for installation, operation and servicing of that component. A manual is shipped with each system component (cryopump, compressor, and controller). When you purchase a system, you will receive the three manuals necessary for system installation, plus a loose-leaf binder with index tab separators allowing you to compile a complete indexed system notebook.

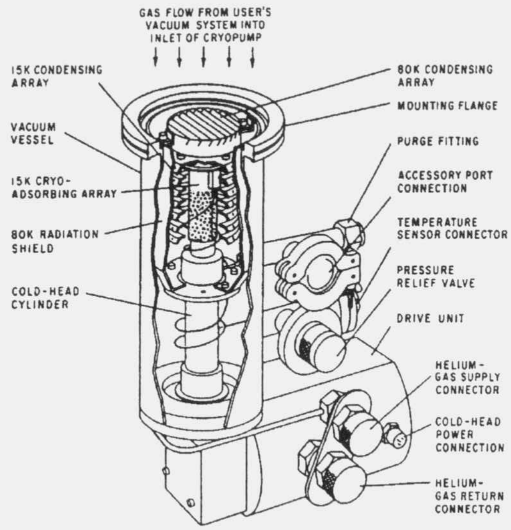
The Cryo-Torr High-Vacuum Pump System provides fast, clean pumping of all gases in the 10^{-3} to 10^{-10} torr range. It operates on the principle that gases can be condensed and held at extremely low vapor pressure, achieving high speeds and throughputs at the cryogenic temperatures of the operating cryopump.

The cryopump is a reliable rugged unit that requires a minimum of servicing. The cryopump exposes no moving parts, operating fluids, or backing pumps to the working vacuum; the possibility of contamination is eliminated.

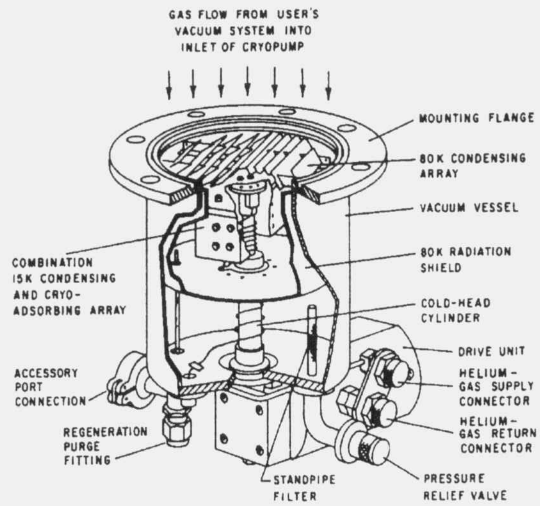
Figure 1-1 shows cutaway views of the cryopumps. The Cryo-Torr 8F cryopump is virtually identical in operation to the Cryo-Torr 8 and is of a flat pump design that offers a dimensional alternative when vertical space is limited. The Cryo-Torr 8F cryopump is available with gas and electrical connectors facing in either a left or right direction to match your piping and electrical interface.

Installation, Operation, and Service Instructions

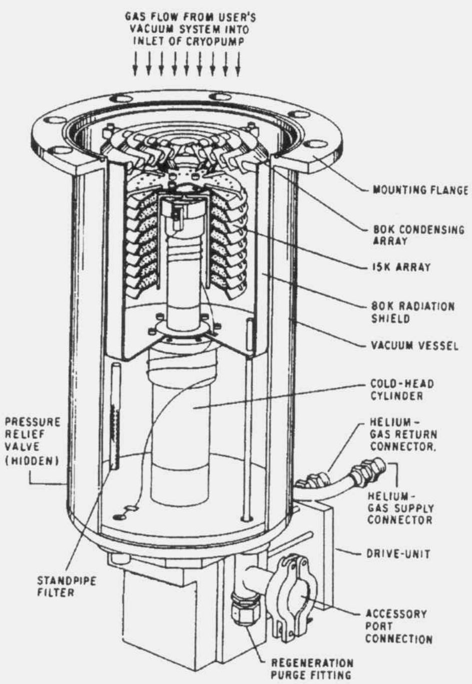
Installation, Operation, and Service Instructions for your Cryo-Torr vacuum pump provide complete and easily accessible information. All personnel with installation, operation, and servicing responsibilities should become familiar with the contents of these instructions to ensure safe, reliable, and efficient cryopump performance.



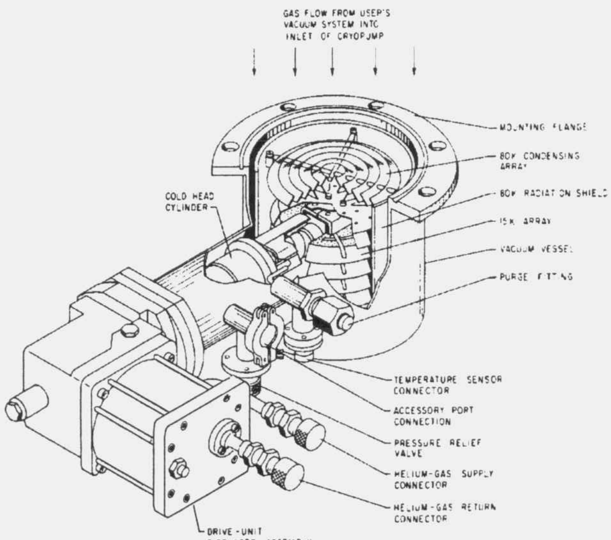
Cryo-Torr 100



Cryo-Torr 7



Cryo-Torr 8



Cryo-Torr 8F

Figure 1-1: Cutaway Views of Cryo-Torr Cryopumps

Table 1-1: Weight (Approximate)

Cryopump	Lbs.	Kg	Shipping Weight	
			Lbs.	Kg
Cryo-Torr 100	22	10	30	11
Cryo-Torr 7	25	11	32	14.5
Cryo-Torr 8	45	20	50	23
Cryo-Torr 8F	42	20	47	21

Table 1-2: Pumping Speeds (Liters/Second)

Cryopump	Water	Air	Hydrogen	Argon
Cryo-Torr 100	1,000	350	480	285
Cryo-Torr 7	3,600	1,000	1,000	850
Cryo-Torr 8	4,000	1,500	2,500	1,200
Cryo-Torr 8F	4,000	1,500	2,200	1,200

Table 1-3: Crossover (Maximum Gas Burst)

Cryopump	Torr-Liters
Cryo-Torr 100	40
Cryo-Torr 7	50
Cryo-Torr 8	150
Cryo-Torr 8F	150

Table 1-4: Condensable Gases Capacity (Argon, Nitrogen, Oxygen, Etc.)

Cryopump	Standard Liters	Torr-Liters
Cryo-Torr 100	90	68,400
Cryo-Torr 7	350	266,000
Cryo-Torr 8	1,000	760,000
Cryo-Torr 8F	1,000	760,000

Table 1-5: Hydrogen Gas Capacity

Cryopump	Hydrogen Partial Pressure (Torr)	Standard Liters	Torr-Liters
Cryo-Torr 100 Cryo-Torr 100	5×10^{-8} 5×10^{-6}	1 2	760 1,520
Cryo-Torr 7 Cryo-Torr 7	5×10^{-8} 5×10^{-6}	2 4	1,520 3,040
Cryo-Torr 8 Cryo-Torr 8	5×10^{-8} 5×10^{-6}	6 12	4,560 9,120
Cryo-Torr 8F Cryo-Torr 8F	5×10^{-8} 5×10^{-6}	4 8	3,040 6,080

Table 1-6: Argon Throughput (Maximum)

Cryopump	SCC/Minute	Torr-Liters/Second
Cryo-Torr 100	75	0.95
Cryo-Torr 7	75	0.95
Cryo-Torr 8	700	8.9
Cryo-Torr F	700	8.9

Interface Connections

Helium Supply and Return Lines

- 10 ft. (3 m) each with 1/2-inch self-sealing couplings (longer lengths, elbows and tees available)

Cold-head Power Cable

- 10 ft. (3 m) (longer lengths available)

Temperature Sensor

- Hydrogen-vapor-pressure gauge
- Diode temperature sensor connector mates with Amphenol P/N 48-16R-10-55/48-23-41

Accessory Port Connection (Roughing)

- Supplied by CTI-CRYOGENICS
- NW-25 ISO-KF flange
- With clamp and blank flange

Regeneration Purge Fitting

- Supplied by CTI-CRYOGENICS
- Parker CPI ULTRASEAL SIZE 6
- With plug and nut

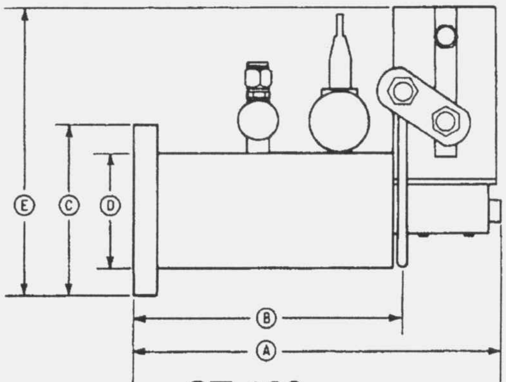
NOTE: *The cryopump may be operated in any position.*

NOTE: *The dimensions in Table 1-7 are basic interfacing dimensions required for cryopump installation. If additional dimensions are required, contact your sales representative or the Order Processing Department to obtain an interface drawing for your particular cryopump.*

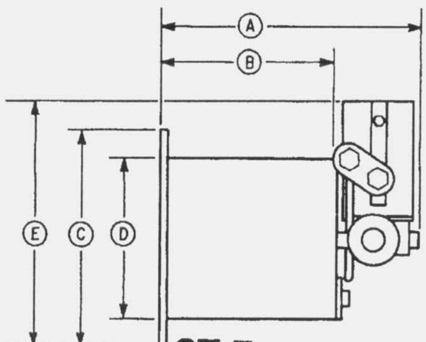
Table 1-7: Interface Dimensions

Cryopump	A (in./mm)	B (in./mm)	C (in./mm)	D (in./mm)	E (in./mm)
Cryo-Torr 100					
(Metal Seal)	12.9 (328)	9.4 (152)	6 (152)	3.9 (99)	10 (256)
(ISO)	12.8 (323)	9.3 (235)	5.12 (130)	3.9 (99)	10 (256)
Cryo-Torr 7					
(ISO)	13.25 (337)	9 (229)	9.5 (130)	7.9 (200)	11.8 (300)
(ANSI)	13.25 (337)	9 (229)	11 (279)	7.9 (200)	12.6 (320)
(UHV)	13.25 (337)	9 (229)	10 (254)	7.9 (200)	12 (307)
Cryo-Torr 8					
(ANSI)	20.7 (526)	13.8 (351)	11 (279)	8 (203)	14.5 (370)
(Metal Seal)	20.7 (526)	13.8 (351)	10 (254)	8 (203)	14.5 (370)
(UHV)	20.7 (526)	13.8 (351)	10 (254)	8 (203)	14.5 (370)
(ISO)	20.7 (526)	13.8 (351)	9.5 (240)	8 (203)	14.5 (370)
Cryo-Torr 8F					
(ANSI)	22.6 (574)	15.8 (402)	11 (279)	8 (203)	14.5 (370)
(ISO)	21.8 (555)	15 (381)	9.5 (240)	8 (203)	14.5 (370)

NOTE: *Cryo-Torr 8F depth dimension is 7.1 in. (179.6 mm) approximate.*



CT-100



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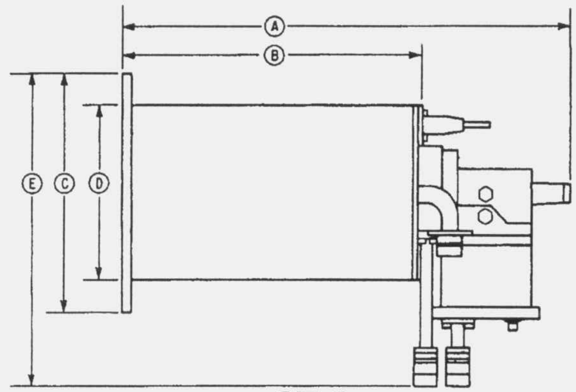

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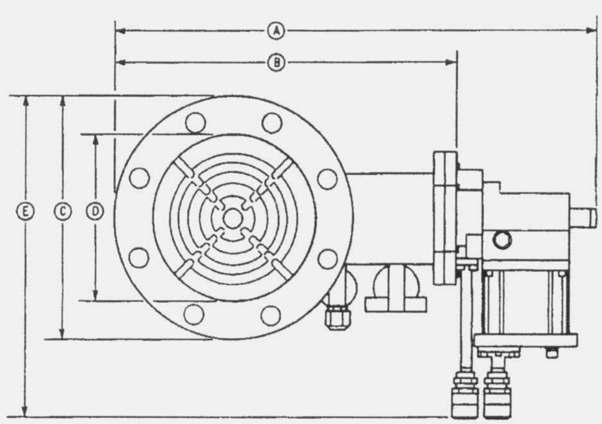


CT-8F

Figure 1-2: Interface Drawings

Section 2 - Inspection

Packaging of the System

A Cryo-Torr High-Vacuum Pump System is packaged in three separate cartons. Table 2-1 lists the contents of each carton, as they relate to these two compressor applications. Note that an Installation, Operation, and Service Manual is included in cartons for the high-vacuum pump, compressor and controller; each manual covers the component packaged in that carton.

When installing a Cryo-Torr High-Vacuum Pump System, CTI-CRYOGENICS recommends that as you unpack a component; then perform an inspection and the necessary tasks for system installation for the component according to the manual (included with the component). Final system installation and operation will be performed following procedures in the cryopump manual (8040240).

The Cryopump

On receipt, remove the cryopump from its shipping carton and inspect the cryopump for evidence of damage. Report any damage to the shipper at once. Also, retain the shipping cartons for use in storage or return shipment.

Inspect the cryopump for damage by examining the following:

1. Overall exterior.
2. Mounting flange and its sealing surfaces after removing the protective cover.
3. Louver assembly of the 80K condensing array. Replace the protective cover.

NOTE: *If you are already familiar with the details of cryopump installation, proceed directly to* ***Section 3 - Quick Installation and Start-up*** *so your cryopump can be made operational quickly. If not, proceed to* ***Section 4 - Installation*** *of this manual for detailed installation procedures.*

Table 2-1: Product Carton Contents

Carton Labels	Compressor Used		Manual Number
	8200	8500	
Cryo-Torr	Cryopump	Cryopump	8040240
Compressor	------ 8200 Compressor ------	------ ------ 8500 Compressor	8040242 8040353 8040251
Accessories	Maintenance Tool Kit and Accessories, P/N 8140000K001	Maintenance Tool Kit and Accessories, P/N 8140000K001	------

Section 3 - Quick Installation and Start-up

Many Users are already familiar with the details of cryopump, controller, and compressor installation, and basic operation. This section presents the installation and start-up steps in summary form so that the cryopump can be made operational quickly. Figures 3-1 and 3-2, present summary procedures for quick installation and start-up. Each step in the table is followed by a reference to the location in the Manual where detailed information is given. Figure 3-3 shows the interconnections between the cryopump and the 8200 Compressor.

This Section is merely designed to get your system *running*. No attempt is made here to present detailed procedures for installing and operating your system. Detailed information is covered in Section 4 and Section 5.

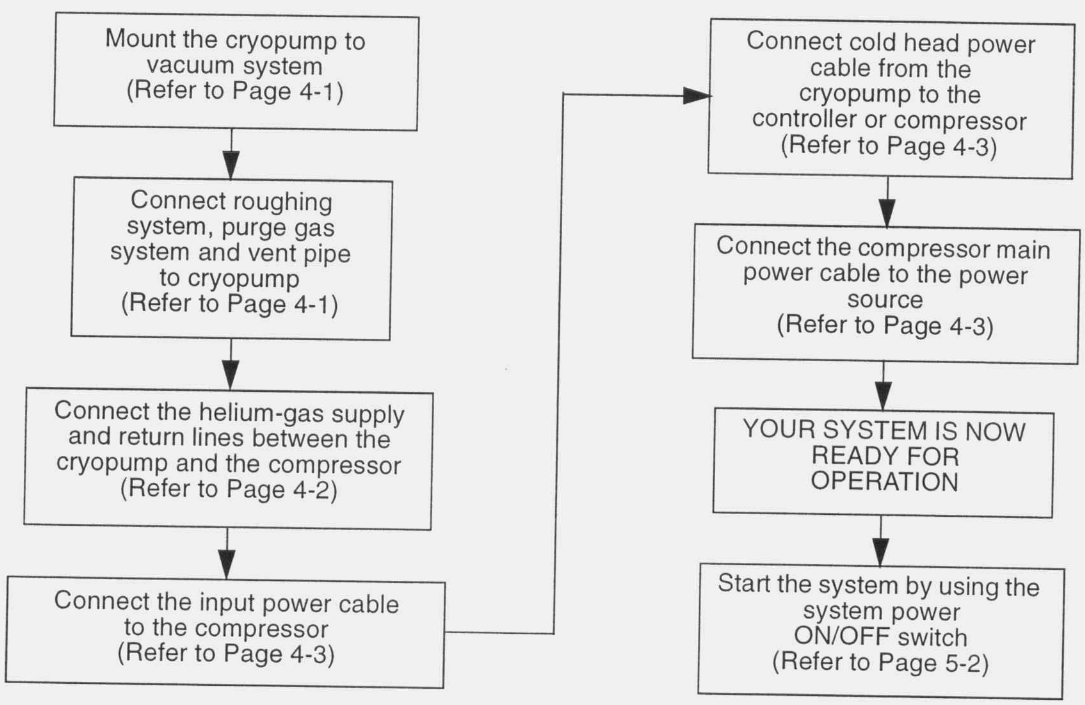


Figure 3-1: Summary of Procedures for Quick Installation and Start-up

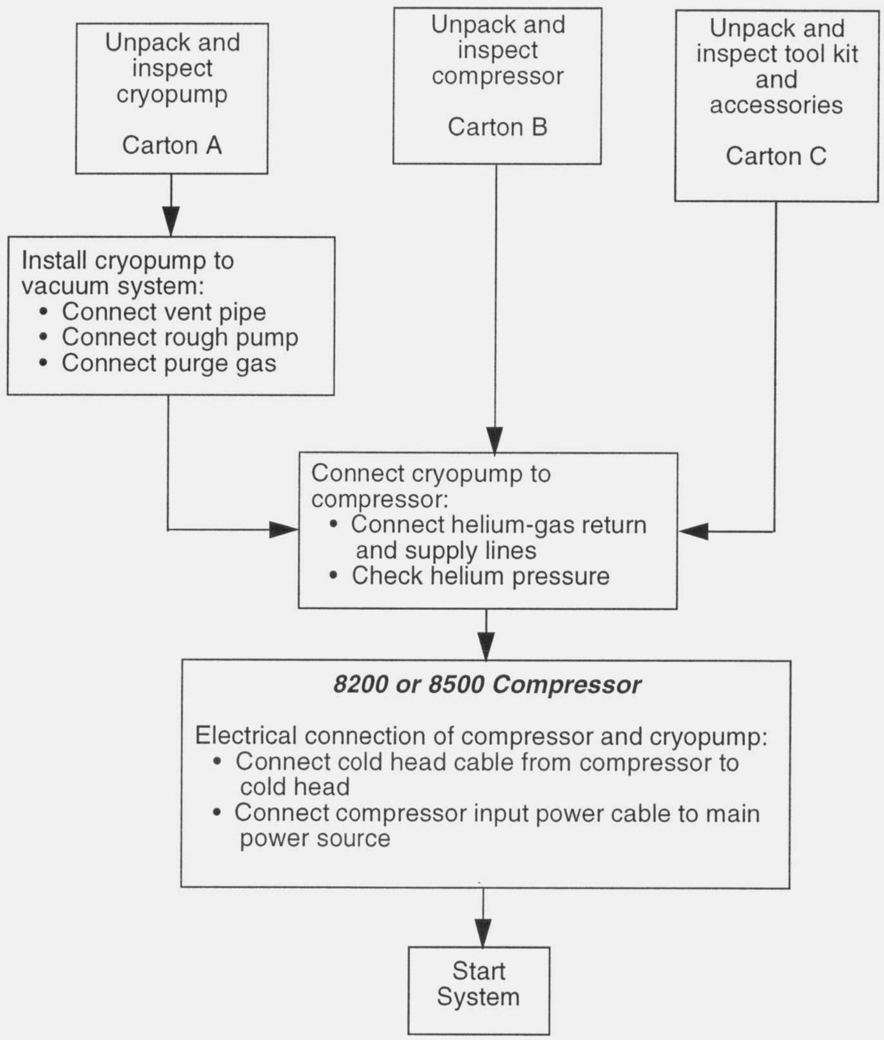


Figure 3-2: Block Diagram for System Installation

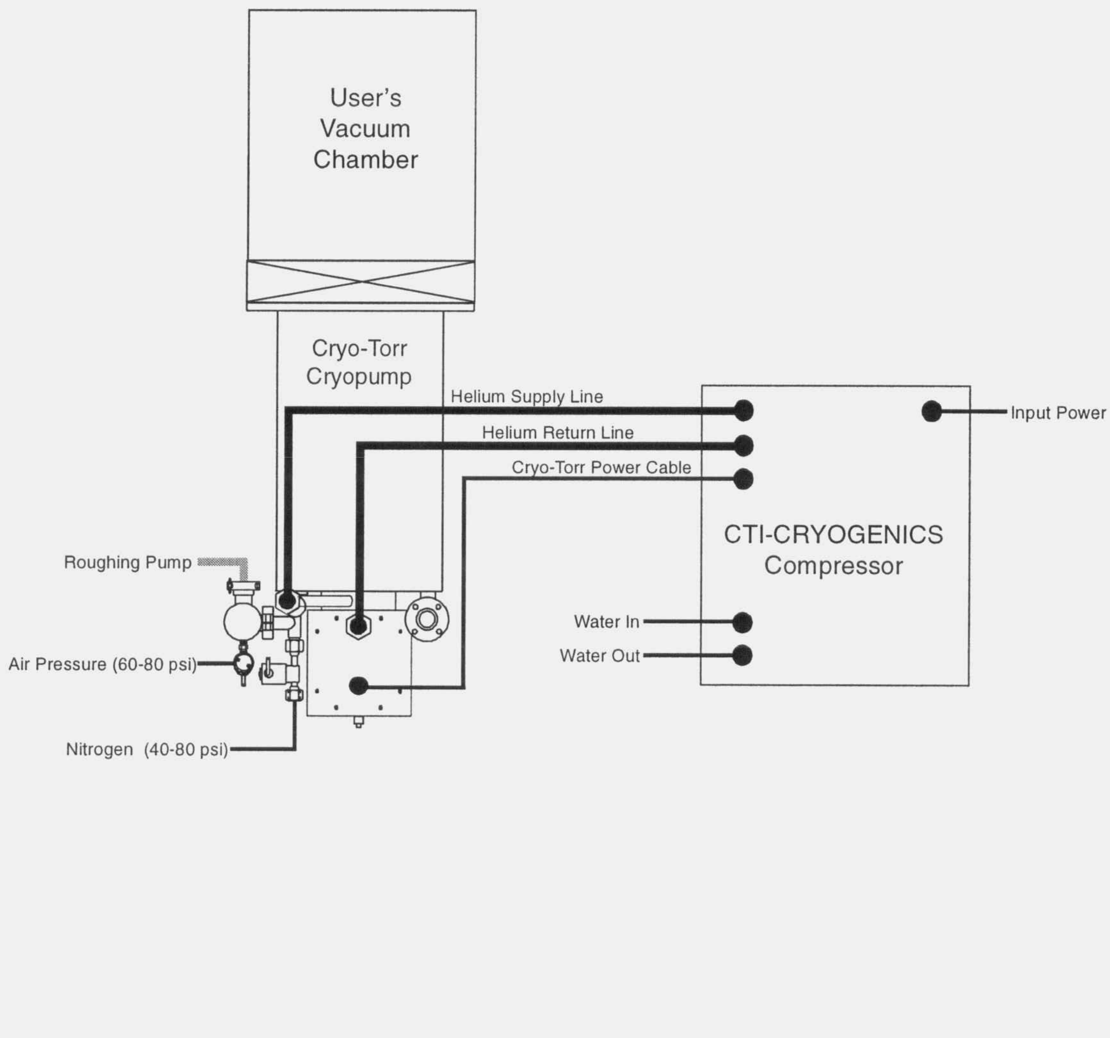


Figure 3-3: Cryopump Interconnection

Section 4 - Installation

Mounting the Cryopump to the Vacuum System

Your cryopump may be installed in any orientation.

Before mounting the cryopump to a vacuum system, an isolation valve (Hi-Vac valve) must be installed between the cryopump and vacuum chamber as a means to isolate the cryopump from the chamber.

To install the cryopump to the vacuum system, refer to Figure 3-3, and proceed as follows:

1. Remove the protective cover from the main flange of the cryopump.
2. Clean all sealing surfaces and install the O-ring or metal seal gasket as appropriate.
3. Mount the cryopump to the Hi-Vac valve or vacuum chamber mounting flange. Be sure all mounting bolts are secure.

Connecting to Roughing Pump

The roughing pump system connects to the cryopump accessory port. The port will accept an ISO NW-25 flange.

Connect the roughing pump system to the accessory port of the cryopump using a roughing line with the largest inside diameter possible to minimize the roughing time required during start-up procedures prior to normal operation.

WARNING

Do not install a hot-filament-type vacuum gauge on the cryopump side of the roughing valve; it could be a source of ignition for flammable gases.

The installation of a DV6M thermocouple (TC) gauge is acceptable providing you install the roughing valve and the TC gauge between the roughing pump system and cryopump. Install the TC gauge and roughing valve as close as possible to the cryopump. A distance of 4 to 6 inches from the cryopump accessory port is desirable.

A molecular sieve roughing trap to minimize oil backstreaming from your roughing pump system may be installed in the roughing pump line near the roughing pump. The trap must be properly maintained.

Connecting Purge Gas

Connect your purge gas supply to the purge gas heater and purge valve. Adjust the supply pressure to operating pressure of 40 psig minimum and a maximum operating pressure of 100 psig maximum; this will allow for the desired purge gas flow rate for the most efficient regeneration.

Connecting a Vent Pipe

The cryopump pressure relief valve (shown in Figure 1-1) may be vented directly into the room or can be connected to a vent pipe.

WARNING

If toxic, corrosive, or flammable gases are pumped, a vent pipe must be connected to the cryopump relief valve and directed to a safe location.

When connecting a vent pipe to your cryopump, a 1.30 inch diameter x 1.38 inch long volume around the relief valve must remain open.

(Vent pipe adapters are available from CTI-CRYOGENICS (P/N 8080250K008).

Connecting the Cryopump to the Compressor

Make the connections between the cryopump and compressor. Refer to Figure 3-3, while making the component interconnections.

1. Remove all dust plugs and caps from the supply and return lines, compressor, and cryopump. Check all fittings.
2. Connect the helium-gas return line from the compressor helium-gas return connector to the helium-gas return connector on the cryopump.
3. Connect the helium-gas supply line from the compressor helium-gas supply connector to the helium-gas supply connector on the cryopump.
4. Attach the supply and return line identification decals (CTI-CRYOGENICS supplied) to their respective connections.

5. Verify proper helium static pressure by confirming that the helium pressure gauge on the compressor reads 245-250 psig (1690-1725 kPa) in an ambient temperature range of 60 to 100°F (16 to 38°C).

If the indicated pressure is higher than 250 psig (1725 kPa), reduce the pressure as follows:

1. Remove the flare cap from the gas charge fitting located on the rear of the compressor.
2. Open the gas charge valve very slowly. Allow a slight amount of helium gas to escape until the helium pressure gauge reads 250 psig (1725 kPa).
3. Close the gas charge valve and reinstall the flare cap.

If the indicated pressure is lower than 245 psig, (1690 kPa), add helium gas as described in **Section 7 - Adding Helium Gas**.

Connecting Power Cables

CAUTION

The power switches on the compressor must be in the OFF position before making any and all electrical connections.

Do not connect the compressor to its power source until all connections have been made between the components of the high-vacuum pump system.

1. Check to ensure the compressor main power cable is properly connected to the compressor.
2. Check to ensure the cold-head power cable is properly connected to the cold head and compressor.
3. Check to ensure the controller or compressor main power cable is properly connected to the main power source.
4. Your system is now ready to operate.

Multi-Cryopump Installation Using 8500 Compressor

NOTE: Contact the CTI-CRYOGENICS, U.S.A. Application Engineering Department (1-800-447-5007) for specific hardware and gas pressure requirements before installing your multiple cryopumps and the 8200 or 8500 Compressor. If you have installed your cryopumps and desire to establish the static pressure for your system, refer to procedures in this section.

Installation with 8200 Compressor

To establish the appropriate gas charge pressure of a multiple (2) cryopump (Cryo-Torr-100) and 8200 Compressor installation using interconnecting lines totaling more than 10 feet (on either the supply or return side), proceed as follows:

1. Connect the multiple cryopump system as shown in Figure 4-1. This figure depicts a typical multi-cryopump installation with an 8200 Compressor. Note that the components are helium connected in parallel (all supply fittings piped together).
2. Check the static charge of the system and add or discharge helium gas as required to bring the static pressure to 245-250 psig (1690-1725 kPa). (Follow the procedures as described in **Section 7 - Adding Helium Gas** to add helium or **Connecting the Cryopump to the Compressor** in this section, to discharge helium).
3. Start the system.
4. Approximately 10 minutes after start-up, note the pressure on the return gauge on the helium compressor. Adjust the pressure by adding or discharging helium to 85-95 psig (585-655 kPa).
5. Allow the system to run until both cryopumps have attained a temperature less than 20K.
6. Again adjust the pressure as in step 4 above, until the return gauge in the compressor is reading 105-115 psig (725-780 kPa).
7. Shut off the system and allow it to reach room temperature (approximately 3 hours without regeneration). Note the static pressure in the system. It should not exceed 255 psig (1755 kPa). This then becomes the static pressure of your multiple cryopump installation.

Installation with 8500 Compressor

Figure 4-2 depicts a typical multi-cryopump installation with an 8500 Compressor. As shown in this figure, an electrical power cable is connected from the compressor to each cold head; also, the components are helium connected in parallel (all supply fittings piped together).

Listed below are multiple combinations of Cryo-Torr 100, 7, 8 and 8F high-vacuum pumps that can be driven by the 8500 Compressor.

Table 4-1: 8500 Compressor/Cryopump Combinations

Cryo-Torr 100	Cryo-Torr 7	Cryo-Torr 8/8F	Total
1	-	1	2
2	-	1	3
3	-	1	4
2	-	-	2
3	-	-	3
4	-	-	4
5	-	-	5
-	1	1	2
-	2	1	3
-	3	1	4
-	2	-	2
-	3	-	3
-	4	-	4
-	5	-	5
-	-	2	2
-	-	3	3
1	-	3	3
-	1	2	3

To establish the helium gas charge pressure of a multiple cryopump installation using interconnecting lines longer than ten feet, proceed as follows:

1. Interconnecting the Cryo-Torr high-vacuum pump components.
2. Attach a helium bottle, regulator, and charging line to the com- pressor.
3. Turn on the system power ON/OFF switch. If the remote energiz- ing feature is installed, place the remote ON/OFF switches to on so the cold heads will run.
4. Note the helium pressure gauge reading immediately after start-up. If should read 50-100 psig (345-690 kPa).
5. If necessary add helium gas, or reduce the helium gas pressure.
6. Allow the cryopumps to operate until a cooldown temperature of 20K or less is reached.

   Adjust the helium pressure if necessary until the helium pressure gauge reads 80-100 psig (550-690 kPa) while the compressor is operating.
7. Shut off the compressor and cryopumps. Allow the system to reach ambient temperature; this usually takes approximately four to five hours.

NOTE: *Record the compressor static pressure in your operating log. This is the static pressure for your particular installation and should be used for checking compressor performance or when troubleshooting the installation.*

8. Ensure that the helium charge valve on the compressor is tightly closed. Then shut off the helium pressure regulator or the helium bottle. Remove the charging line from the male flare fitting and reinstall the flare cap.

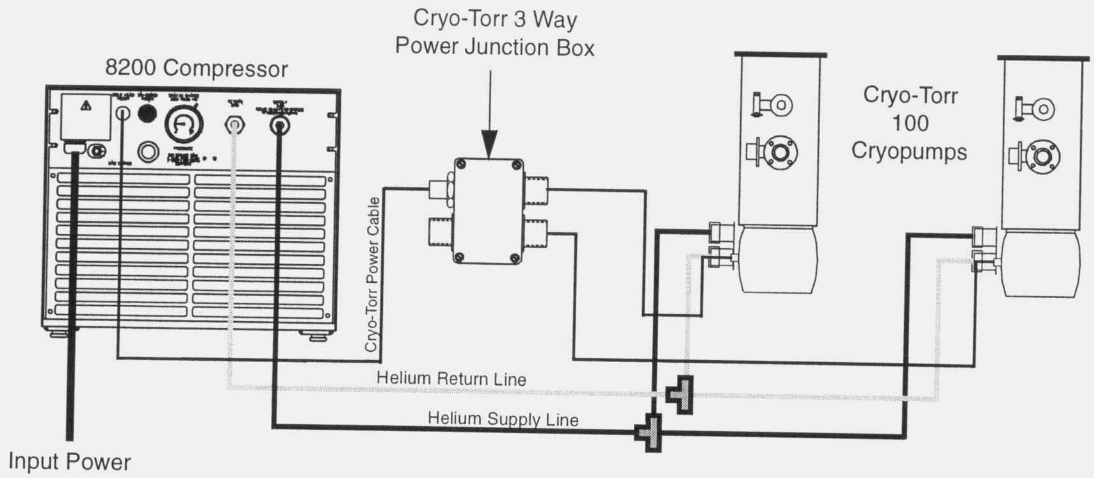


Figure 4-1: Multiple Cryopump Installation with 8200 Compressor

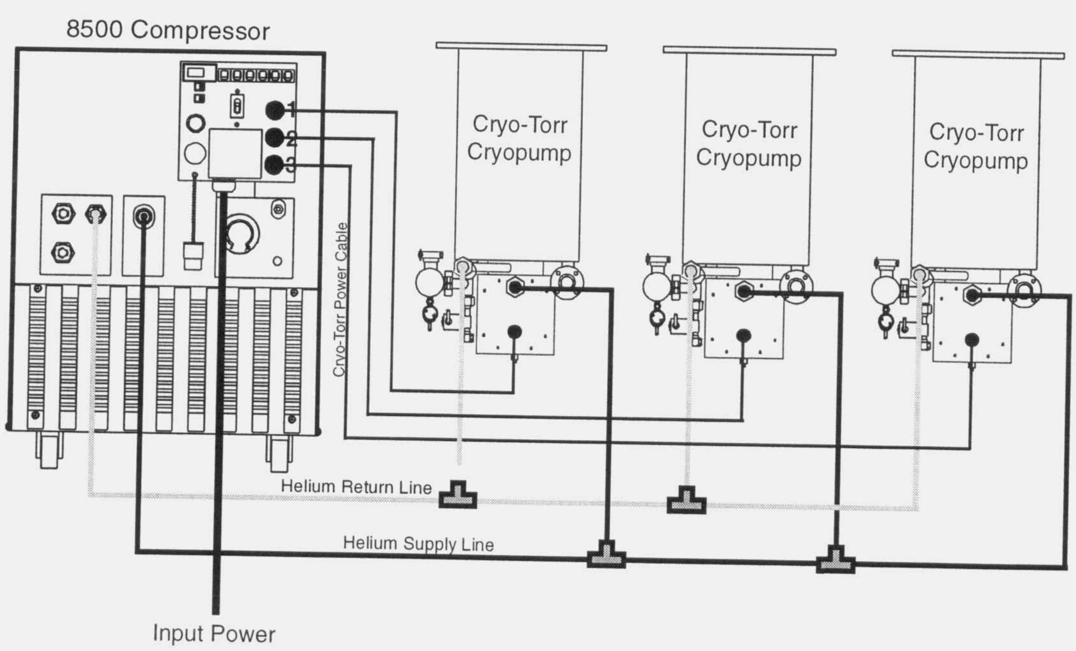


Figure 4-2: Multiple Cryopump Installation with 8500 Compressor

Section 5 - Operation

Before Start-up

Before beginning system operation make certain all the steps in the inspection and installation procedures have been completed and confirmed.

Operating Log

It is advisable to create and maintain an operating log. The record will assist in troubleshooting should problems arise. The log should include as a minimum the following data: the cooldown time to 20K; the roughing time to 50μ; the time to base pressure at crossover; the time between regeneration; and, the compressor pressure reading. These recorded values are useful for future performance reference.

Rough Pumping (Preliminary Vacuum Pumping)

It is not necessary to rough pump the cryopump to very low pressures. Experience has shown that a roughing pressure between 50 and 75 microns is all that is required. This pressure can be measured with a DV-6M thermocouple (TC) gauge mounted as close as possible to the roughing port.

Rate-of-Rise (ROR)

Rate of pressure rise in a newly installed cryopump is an important measure of the tightness of your installation. This is obtained by closing the roughing valve (see Figure 3-3) when the pressure has reached 50-75 microns. Observe the rate of pressure rise over the five-minute period. A rise of less than 10 microns/ minute over a five-minute period (50 microns total) is an indication of the integrity and cleanliness of the cryopump. If the total ROR is greater than 50 microns, repurge the cryopump, check for evidence of leaks, and repeat the roughing cycle and ROR.

NOTE: *Such a procedure may be adapted to quickly check the integrity/ cleanliness of your process chamber.*

Start-up and Cooldown

1. Before start-up confirm the following:
   a. That the Hi-Vac valve to your vacuum chamber is closed.
   b. That the pressure in your cryopump is approximately 100 microns.
2. Turn on the system power ON/OFF switch on the controller/compressor.
3. Note the helium pressure and temperature reading during the initial cooldown. Typical values during cooldown are given in Table 5-1. If the cryopump has not achieved a second stage temperature of 20K or less in the time specified in Table 5-1 with the Hi-Vac valve closed, refer to the **Appendix B - Troubleshooting the Cryopump**.
4. When the cooldown temperature of 20K or less is reached, the cryopump is ready for normal vacuum operation. An additional 30 minutes will often permit the cryopump to reach "bottom-out" temperature.
5. Record the time that was required to reach 20K in your log; also record the compressor return gas pressure at 20K. This value can be useful for future evaluation of cryopump performance.

Table 5-1: Typical Pressure Variations During Cooldown and Normal Operation (All Values Nominal)

Cryopump Model (Qty. Used)	Compressor Model (Controller) Model	Time	Nominal Helium Pressure Psig (kPa)*	Temperature Indicator Reading (k)	H_2V_P Reading (Psia)
CT-100 (1)	8200	Before start-up ***120 mins. after start-up***	250 (1725) 275 (1895)	300 10-20	--- 20
CT-7 (1)	8200	Before start-up ***90 mins. after start-up***	250 (1725) 275 (1895)	300 10-20	--- 20
CT-8 or CT-8F	8200	Before start-up ***90 mins. after start-up***	250 (1725) 280 (1930)	300 10-20	--- 20
Multiple CT-100	8500	Before start-up ***120 mins.***	200 (1380) 65 (450)	300 20	--- 20
Multiple CT-8/CT-8F	8500	Before start-up ***120 mins.***	200 (1380) 95 (655)	300 10-20	--- 20

*Center point of needle swing.

Normal Operation

The Cryo-Torr High-Vacuum pump system is designed to operate without operator assistance.

As an aid to evaluating performance it may be advantageous to record basic parameters at a regularly scheduled period. An ideal time is to coordinate this practice with other maintenance items or whenever regeneration is required. On new systems record this data at least on a monthly basis.

Cryopump Oxygen Procedures

WARNING

Combustion supported by oxygen in the pump could cause severe injury. When oxygen is used as a process gas, special precautions should be taken.

When using oxygen as a process gas, it is strongly recommended that as a minimum, the following precautions be taken.

1. Follow all cryopump operating instructions including:
   - Insure that there are no sources of ignition (e.g., hot filament vacuum gauges) on the cryopump side of the Hi-Vac valve operating during the warming or venting of the pump.
   - Perform inert gas purge regenerations at flow rates recommended for cryopumps.
2. Regenerate as frequently as practical to minimize the amount of oxidizer present in the cryopump.
3. Provide proper and appropriate venting for the cryopump relief valve to vent exhaust gases.
4. Any system exposed to richer-than-air oxygen levels should be prepared for oxygen service per the manufacturer's recommendations, including use of oxygen service lubricating oils in roughing pumps.

WARNING

Explosion occurring from ozone in the pump could cause severe injury. Ozone can be present as a by-product of oxygen processes. If ozone is present, special precautions described in the text below must be taken.

Ozone may be unknowingly produced in an ionizing process (e.g., sputtering, etching, glow discharge). Explosive conditions may exist if ozone is present, especially during warming of the cryopump. Signs of ozone's presence are:

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

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

If ozone is present, the following precautions must be taken, in addition to those already mentioned.

1. The required regeneration frequency should be increased depending upon flow and process conditions. Daily regeneration may be required. (Call CTI-CRYOGENICS for assistance.)

2. Reduce the oxygen mixture to the absolute lowest level the process will allow.
3. Be sure that the system is properly vented to a scrubber or to a safe area preferably outdoors.

Determining Crossover Pressure

Crossover is that point in time when the pumping of a vacuum chamber is switched from "rough" pumping to "high-vacuum" pumping. Rough pumping brings the vacuum chamber pressure from one atmosphere (760 torr) down to a pressure of about 0.5 torr. At crossover the roughing valve is closed and the high-vacuum valve opened bringing the vacuum chamber down to a pressure typically less than 10^{-6} torr. This momentary "pulse" of gas and water molecules is cryo-condensed on the arrays of the cryopump.

To determine the maximum permissible CROSSOVER PRESSURE (CP) perform the following calculation using the CROSSOVER VALUES (CV) for your Model cryopump shown in the table below and the actual VOLUME OF YOUR CHAMBER (VC).

Table 5-2: Crossover Values (CV)

Cryo-Torr	Torr-Liters
CT-100	40
CT-7	50
CT-8	150
CT-8F	150

Example: (For CT-8/8F)
(Volume of chamber = 100 liters)

$$CP = \frac{CROSSOVER\ VALUE}{VOLUME\ OF\ CHAMBER} = \frac{CV}{VC}$$

$$CP = \frac{150 \text{ torr-liters}}{100 \text{ liters}} = 1.5 \text{ torr}$$

NOTE: *The calculated crossover pressure may not be optimized for your system. To help prevent any backstreaming during the roughing of the vacuum chamber, you should stop roughing at as high a pressure as possible. The optimum crossover pressure for a vacuum chamber should cause a very slight rise in temperature with a rapid recovery. Increase the roughing pressure in small increments (15 to 20%) until this rise in temperature is noted; then drop the value by a small amount (10%), this will be the optimum pressure for that vacuum chamber.*

Determining Cryopump Capacity for Condensable Gases

Cryopump capacity is defined as the total standard liters of a gas that can be accommodated within a cryopump prior to regeneration. The number of hours between regeneration cycles can be easily calculated in the case of a continuous gas flow of a known gas species:

$$A = \frac{16.6 \times C}{B}$$

A = Duration of operation with a continuous gas flow (hours)
B = Gas flow (scc/min.)
C = Cryo-Torr capacity for the particular gas species being flowed (std liters); refer to the following Table.

Table 5-3: Condensable Gases Capacity (Argon, Nitrogen, Oxygen, Etc.)

Cryopump	Standard Liters	Torr-Liters
CT-100	90	68,400
CT-7	350	266,000
CT-8	1,000	760,000
CT-8F	1,000	760,000

Example: (For CT-8/8F)

For a sputtering application of continuously flowing argon gas at 70 scc/min., the duration of continuous operation with this gas flow (between regenerations) would be:

$$A = \frac{16.6 \times 1{,}000 \text{ (std liters)}}{70 \text{ (scc/min.)}} = 237 \text{ hours}$$

Determining the Number of Crossover Cycles

The number of crossover cycles between regenerations can also be easily calculated when the crossover pressure and vacuum chamber volume are known:

$$N = \frac{760{,}000 \text{ torr liters}}{P \times V}$$

N = *Number of crossover cycles*
V = *Volume of vacuum chamber (liters)*
P = *Pressure of vacuum chamber prior to crossover (torr) (roughing pressure)*

Example:

$$N = \frac{760{,}000 \text{ torr liters}}{1.5 \text{ (torr)} \times 100 \text{ (liters)}} = 5{,}060 \text{ cycles}$$

Cryopump Shutdown Procedures

Typically a cryopump can be left in operation continuously if you are not processing or not using the vacuum chamber, by simply closing the Hi-Vac valve to isolate the cryopump from your vacuum chamber. You are now able to load, unload, repair or replace components in the chamber and the cryopump will be available for restart of the process as necessary.

If you are planning to shut down the cryopump it is recommended that the cryopump be shut off and a gas purge be initiated and continued until the cryopump has reached room temperature. At this point it can be held under positive pressure, and rough pumped prior to start-up.

Cryopump Storage

If the cryopump is stored while still attached to your vacuum system, the cryopump vacuum vessel should be kept at slight positive atmospheric pressure with dry nitrogen or argon.

If the cryopump is removed from your vacuum system, install the protective cover on the mounting flange of the cryopump vacuum vessel inlet before storage.

The remaining components of your Cryo-Torr high-vacuum pump systems are fully protected during storage if kept under positive helium pressure and all component connections left connected. Periodically check the helium supply pressure gauge on the compressor. If the gauge reads below 245 psig (1690 kPa) for 8200/8300 or below 195 psig (1345) for 8500, add helium as described in **Section 7 - Adding Helium Gas**.

Hazardous Materials

WARNING


If the cryopump has been used to pump toxic or dangerous materials, you must take adequate precautions to safeguard personnel. If such a cryopump is shipped to a Product Service Department, clearly mark on all storage cartons the identity of the toxic or dangerous materials to which the cryopump has been subjected. All shipped equipment that contains hazardous/toxic materials must conform to DOT regulations.

Section 6 - Regeneration

Introduction

The cryopump periodically requires regeneration to return it to its original operating capabilities.

Gases captured from a vacuum chamber and trapped in the cryopump through condensation and cryo-adsorption are held primarily in an ice-like form. Regeneration removes trapped gases through a process similar to defrosting a refrigerator freezer compartment.

During regeneration the cryopump is warmed to room temperature or higher, allowing trapped gases to change from a solid state to a gaseous state and are thereby released from the cryopump through the pressure relief valve to the atmosphere.

WARNING

Toxic, corrosive, or flammable gases must be safely vented to prevent harm to personnel and to avoid equipment damage. If a large amount of oxygen has been cryopumped, refer to **Section 5 - Cryopump Oxygen Procedures.**

When to Regenerate

The need to regenerate the Cryo-Torr high-vacuum pump as a result of saturation is a function of the cryopump capacity and the process gas throughput.

If the cryopump becomes incapable of maintaining a high-vacuum (typically an increase in your vacuum chamber base pressure by a factor greater than 10, even though the cold head and compressor unit are operating satisfactorily), the cryopump requires regeneration.

It is recommended that your cryopump be regenerated on a regular schedule coinciding with system maintenance, weekend system shutdown, etc. A suitable time interval between regenerations can be determined by experience.

Data aiding calculation of gas saturation levels may be obtained in **Section 5 - Determining Cryopump Capacity for Condensable Gases**. Extended loss of electrical power (10 minutes or longer), system vacuum failure, such as venting with a partially open vacuum isolation valve, and operator error may necessitate cryopump regeneration.

NOTE: *Short term electrical outages of up to 10 minutes should not result in the need to regenerate your cryopump.*

Assisted Regeneration

Regeneration incorporating the use of heated dry inert purge gas (nitrogen/ argon) is the preferred method of regeneration and will overcome the unassisted regeneration technical difficulties by:

1. Minimizing the required time to bring the condensing and cryo-adsorbing arrays to room temperature.
2. Reducing the time required to rough the cryopump because the dry inert purge gas will minimize the amount of residual water vapor in the 15K array.
3. Diluting hazardous gases and ensuring their removal from the cryopump housing.

Table 6-1: Required Accessories for Assisted Regeneration

Description	Part Number
Purge gas heater	8080250K020
Purge gas solenoid valve	8080250K023

To accomplish assisted regeneration with heated dry purge gas:

1. Close the Hi-Vac isolation valve.
2. Shut off the cryopump using the system power ON/OFF switch on the controller or the compressor.
3. ***Immediately*** introduce heated dry purge gas through the vacuum vessel purge fitting at approximately 150°F (66°C) and at a flow rate of 1-2 cfm. Allow the purge gas to vent through the "poppet" relief valve.
4. Halt the gas purge when the condensing arrays reach 80°F (26°C) (300k).

5. When the condensing arrays reach ambient temperature, rough the cryopump to an initial starting pressure, usually between 50 and 100 microns. After roughing, you can perform a simple check 1) to ensure that your cryopump regeneration has been thorough, and 2) that no air-to-vacuum leaks are present. The check is called a "rate-of-rise" (ROR).

   Upon completion of your roughing cycle (to 50 or 100 microns), close the roughing valve and observe the "rate of pressure rise" (ROR) over a five-minute period. The ROR should be less than 10 microns/minute over a five-minute period (50 microns total). If the ROR is greater than 50 microns, repurge the cryopump, check for evidence of leaks, and repeat the roughing cycle and ROR.

6. Close the cryopump roughing valve and start the cryopump.

7. The cryopump is ready for use when the second stage array reaches a temperature of 20K or lower.

Section 7 - Maintenance Procedures

Scheduled Maintenance

The only scheduled maintenance required on the Cryo-Torr High-Vacuum System is periodic replacement of the compressor adsorber per the following schedule:

Table 7-1: Adsorber Replacement Information

Compressor	Adsorber P/N	Replacement Interval (Years)
8200	8080255K001	1
8500	8080275K001	3

Refer to the appropriate compressor manual for the procedures for removing and replacing the adsorber.

Unscheduled Maintenance

There are several maintenance items that may arise on an unplanned basis. These items generally do not occur frequently but when they do, some specialized procedures are necessary. They are as follows and are listed in their general order of frequency of occurrence.

1. Cleaning or replacing the cryopump arrays.
2. Adding helium gas.
3. Decontaminating the helium circuit.

Suggested Maintenance Equipment

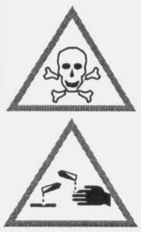
It is advisable to have available the equipment and disposable supplies listed below.

1. Helium, 99.999% pure
2. Indium gasket 0.005-inch thick, 3" x 3" sheet, P/N 3543738P001
3. Maintenance manifold, P/N 8080250K003*
4. Pressure regulator (0-3000/0-400 psig)

5. Helium charging line terminating in a 1/4-inch female flare fitting (P/N 7021002P001)
6. Installation Tool Kit, P/N 8140000K001. Supplied with Cryo-Torr High-Vacuum Pump
7. Lint-free gloves and cloth
8. Oakite or equivalent detergent soap
9. Denatured alcohol
10. Apiezon™ vacuum grease, P/N 579847*
11. Torque wrench, 0 to 30 inch-pounds

*Available from stock; consult the factory or your sales representative.

Cleaning the Cryopump



WARNING

If the cryopump has been used to pump toxic or dangerous materials, you must take adequate precautions to safeguard personnel.

The arrays or other interior surfaces of the cryopump vacuum vessel seldom require cleaning because dust buildup does not affect performance, and the special alloy copper cryo-condensing arrays are nickel plated for corrosion resistance. Cryopump performance in most cases can be recovered by regeneration. In case of a system malfunction, (i.e., backstreaming of a rough pump oil or "dumping" of a process chamber) saturation or contamination of the 15K cryo-adsorbing array (charcoal) may require more than regeneration. The charcoal array, if not severely contaminated, may be recovered by following the vacuum baking procedures in this section.

If you wish to clean the arrays and other interior surfaces, follow the procedures below. Refer to **Appendix C - Illustrated Parts Breakdown**, while performing these disassembly and reassembly procedures.

1. Confirm that an adequate supply of indium gasket material, P/N 3543738P001, is available.
2. Carefully disassemble the components in the vacuum vessel.

3. Clean the components as follows:

> **CAUTION**
>
> Do not clean the 15K cryo-adsorbing array (charcoal) because you will contaminate it in the cleaning process. Use the vacuum baking procedure to recover a 15K cryo-adsorbing array that is not severely contaminated.

   a. Wash each item in strong soap or detergent solution and hot water.

   b. Rinse the items in *clean, hot water.*

   c. Air or oven dry at 150°F (66°C) maximum.

4. To clean a 15K cryo-adsorbing array (charcoal) that is not severely contaminated by oil backstreaming or dust particles covering its surfaces, vacuum bake it at a temperature of 150°F (66°C) for at least 2 hours.

NOTE: *It is good practice to perform this vacuum baking procedure on the 15K array on a regular basis to insure continued efficient cryopump operation.*

5. If the 15K cryo-adsorbing array does not require vacuum baking, the array surfaces may be dusted using a lint-free cloth lightly moistened with denatured alcohol. Allow the array to air dry before assembly.

6. Wearing lint-free gloves, reassemble the cryopump. Replace any indium gasket damaged during disassembly.

7. Hold the torque on all screws that compress indium gaskets for a minimum of 5 seconds to allow proper gasket seating.

Table 7-2: Indium Gasket Mounting Screw Torque Information

Screw Thread	Torque (Inch-Pounds)
No. 4-40	11
No. 6-32	20
No. 10-32	30

Adding Helium Gas

CAUTION

If the compressor helium pressure gauge reads less than 30, decontamination is required. Refer to **Decontamination Procedures** in this section.

There are two conditions that require the addition of helium gas:

1. Compressor not operating; helium pressure gauge reads 245 psig (1690 kPa), or below.
2. Compressor operating; helium pressure reads below that specified in Table 7-3.

Table 7-3: Typical Pressure During Normal Operation (CT-100, 7, 8 and 8F)

Cryopump (No. Used)	Helium Pressure Psig (kPa)*	
	8200 Compressor	8500 Compressor
CT-100 (1) CT-100 (2)	275 (1895) ---	--- 65 (450)
CT-7 (1)	275 (1895)	65 (450)
CT-8 (1) CT-8F (1)	280 (1930)	90 (620)

*Center point of needle swing.

If you need to add helium more than once every 6 months, check for leaks caused by improperly connected self-sealing connections on interconnecting components or any mechanical joint within the compressor.

A User-supplied helium charging line terminating in a 1/4-inch female flare fitting, and a two-stage pressure regulator rated at 0-3000/0-400 psig is required for this operation.

Use only 99.999% pure helium gas.

To add helium gas:

1. Attach a two-stage regulator (0-3000/0-400 psig) and charging line to a helium bottle (99.999% pure). DO NOT OPEN THE BOTTLE AT THIS TIME. Purge the regulator and charging lines as instructed in steps a through d below. Do *not* use helium gas that is *less than 99.999% pure.*

   a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm, then turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.

   b. Slowly open the bottle valve, and purge the regulator and line for 10 to 15 seconds. Turn the regulator knob counter-clockwise until the helium stops flowing.

   c. Loosely connect the charge line to the helium pressure regulator.

   d. Purge the charge line again, as in step a, for 30 seconds, and tighten the charge line flare fitting onto the helium pressure regulator while the helium is flowing.

   This procedure is required to ensure that both the regulator and the charging line will be purged of air and that the air trapped in the regulator will not diffuse back into the helium bottle. For best results, CTI-CRYOGENICS suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.

2. Remove the flare cap of the gas charge fitting on the rear of the compressor.

3. Attach the charging line from the helium pressure regulator to the 1/4-inch male flare fitting installed on the helium charge valve.

4. Set the helium pressure regulator to 300 psig (2070 kPa). Depending on the compressor operating state, add helium gas:

   a. If the compressor is running under normal operating conditions, slowly open the helium charge valve on the rear of the compressor. When the helium pressure gauge rises to that specified in the Table above, tightly close the charge valve.

   b. If the compressor is not running, slowly open the helium charge valve. When the helium pressure gauge rises to 245-250 psig (1690-1725 kPa), tightly close the charge valve.

CTI-CRYOGENICS P/N 8080250K020, will reduce warm-up time about 50 percent, and will maintain the gas temperature below the 150°F (66°C) limit.

7. Once the cryopump has reached room temperature, attach a two-stage regulator (0-3000/0-400 psig) and charging line to a helium bottle (99.999% pure). DO NOT OPEN THE BOTTLE AT THIS TIME. Purge the regulator and charging lines as instructed in steps a through d below. Do *not* use helium gas that is *less than 99.999% pure.*

   a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm; then turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.

   b. Slowly open the bottle valve, and purge the regulator and line for 10 to 15 seconds. Turn the regulator knob counter-clockwise until the helium stops flowing.

   c. Loosely connect the charge line to the 1/8-inch valve on the maintenance manifold.

   d. Purge the charge line again, as in step a, for 30 seconds, and tighten the charge line flare fitting onto the valve while the helium is flowing.

This procedure is required to ensure that both the regulator and the charging line will be purged of air. For best results, CTI-CRYOGENICS suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.

8. Perform in sequence:

   a. Backfill the cold head with helium to a static charge pressure of 245-250 psig (1690-1725 kPa), by adjusting the regulator to the required pressure, and opening the valve on the manifold. Close the valve when the pressure is correct.

   b. Depressurize the cold head by *slowly* opening the ball valve and allowing the helium to bleed out slowly. Do *not* reduce the pressure to *less than* 30 psig or the cold head may be further contaminated.

   c. Perform flushing steps a and b three more times.

   d. Pressurize the cold head to the static charge pressure of 245-250 psig (1690-1725 kPa) and run the cold head drive motor for 10 to 30 seconds by actuating the controller ON/OFF switch.

e. Perform steps b through d three more times for a total of 20 flushes and a total of 4 drive-motor runs.

9. Verify that the cold head is pressurized to the static charge pressure of 245-250 psig (1690-1725 kPa).

10. Disconnect the maintenance manifold from the helium-gas return and helium-gas supply lines.

11. Reconnect the helium-gas return and helium-gas supply lines to the return and supply connectors at the rear of the compressor. The cryopump is now ready for operation.

Compressor Decontamination Procedures

The procedure to decontaminate a compressor is similar to the above procedure with certain exceptions.

- There is no need to operate the cryopump before decontaminating the compressor.
- The maintenance manifold and flex lines will be connected to the supply and return fittings on the compressor.

1. Depressurize the compressor (if pressurized) SLOWLY to 30 psig by opening the ball valve on the maintenance manifold and allowing the helium to bleed out.
2. Charge the compressor slowly to approximately 250 psig (1725 kPa) by opening the 1/8-inch valve on the maintenance manifold.
3. Run the compressor for about 30 seconds.
4. Repeat steps 1 and 2, one more time.
5. Disconnect the maintenance manifold from the helium-gas return and helium-gas supply lines.
6. Reconnect the helium-gas return and helium-gas supply lines to the return and supply connectors on the cold head. The compressor is now ready for operation.

NOTE: *After connecting the compressor to the cryopump, and operating the system for a period of time, it may be necessary to decontaminate the cryopump as some residual contamination from the compressor may become trapped in the cold head. If the entire system were reduced to zero psig (a broken flex line for example), then the cryopump and compressor would have to be decontaminated according* ***Decontamination Procedures*** *in this section.*

Appendix A - Customer Support Centers

Introduction

Refer to Table A-1 for the nearest Customer Support Center for technical assistance or service. North American customers may call 1-800-FOR-GUTS (1-800-367-4887) 24 hours a day, seven days a week. All other customers must call their local Customer Support Center.

Please have the following information available when calling so that we may assist you:

- Product Part Number
- Product Serial Number
- Product Application
- Specific Problem Area
- Hours of Operation
- Equipment Type
- Vacuum System Brand/Model/Date of Manufacture

Table A-1: Customer Support Center Locations

United States and Canada Helix Technology Mansfield Corporate Center Nine Hampshire Street Mansfield, Massachusetts 02048, U.S.A. Tel: 508-337-5000 Tel: 800-379-7224 (within USA) Fax: 508-337-5169 Dial 1-800-FOR-GUTS (1-800-367-4887) 24 hours a day, seven days a week.	**United States and Canada** Helix Technology 3350 Montgomery Drive Santa Clara, CA 95054, U.S.A. Tel: 562-592-5940 Tel: 800-379-7224 (within USA) Fax: 408-988-6630 Dial 1-800-FOR-GUTS (1-800-367-4887) 24 hours a day, seven days a week.
United States and Canada Helix Technology 4120 Freidrich Lane, Suite 600 Austin, TX 78744, U.S.A. Tel: 512-912-2800 Tel: 800-324-6445 (within USA) Fax: 512-912-2888 Dial 1-800-FOR-GUTS (1-800-367-4887) 24 hours a day, seven days a week.	**Germany** Helix Technology Haasstrasse 15 D-64293 Darmstadt Germany Tel: 49-6151-959-55 Fax: 49-6151-959-57
France Helix Technology Domaine Technologique de Saclay 4, rue Rene Razel, Bat Apollo F-91892 Orsay Cedex France Tel: 331-6935-2600 Fax: 331-6985-3725	**United Kingdom** Helix Technology Fleming Road Kirkton Campus Livingston, West Lothian Scotland EH54 7BN Tel: 441-506-460017 Fax: 441-506-411122

Table A-1: Customer Support Center Locations (Continued)

Japan Helix Technology K.K. Queens Tower A 14F 3-1, Minatomirai 2-chome Nishi-ku, Yokohama 220-6014 Japan Tel: 81-45-682-5470 Fax: 81-45-682-5475	**Korea** Helix Technology Zeus Company, Ltd. Zeus Building 3-16, Yangjae-Dong, Sochu-Ku Seoul, 137-130 South Korea Tel: 82-2-577-3181 Tel: 82-2-577-3186 Fax: 82-2-576-3199
Taiwan, Hong Kong, and China Helix Technology Challentech International Corporation No. 1, Lane 9, Pateh Road Hsin-Chu 300, Taiwan, R.O.C. Tel: 886-35-614211 Fax: 886-35-614210	**Australia, New Zealand, and Tasmania** Helix Technology AVT Services Pte. Ltd Unit 1, 12 Pioneer Avenue Thornleigh NSW 2120 Sydney, Australia Tel: 612-9-4810748 Fax: 612-9-4810910
Singapore, Malaysia, Philippines, and Indonesia Helix Technology APP Systems Services Pte Ltd.. 2 Corporation Road #06-14 Corporation Place Singapore 2261 Tel: 65-268-2024 Fax: 65-268-6621	

Appendix B - Troubleshooting

Troubleshooting Techniques

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

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

The problems presented in the Troubleshooting Table are followed by possible causes and corrective actions. The causes and corresponding actions are listed in their order of probability of occurrence. 1) is most likely, 2) is next most likely, etc.

Maintaining a log of certain parameters during normal operation can be a valuable tool in troubleshooting the cryopump. The parameters included in the log should include as a minimum the following: the cooldown time to 20K; the roughing time to 50μ; the time to base pressure at crossover; the time between regeneration; and the compressor pressure reading.

Technical Inquiries

Please refer to **Appendix A** of this manual for a complete list of the CTI-CRYOGENICS' world wide customer support centers.

Table B-1: Troubleshooting the Cryopump

Problem	Possible Cause	Corrective Action
High base pressure of vacuum system; cryopump temperature *below* 20K.	Air-to-vacuum leak in vacuum system.	Check the following: Vacuum chamber and Hi-Vac valve for leaks. Cryopump for leaks. Cryopump relief valve for leaks.
	High partial pressure of non-condensables (helium, hydrogen, or neon) within the cryopump because the 15K array has reached full capacity.	Regenerate the cryopump.
High base pressure of vacuum system, and a cryopump temperature *above* 20K.	A leak through a roughing valve, purge valve, or other accessory.	Check all valves to insure proper seating.
	Decrease in cryopump cold head performance.	Check compressor gauge for low helium charge pressure. Add gas as necessary.
	High partial pressure of non-condensables (helium, hydrogen, or neon) within the cryopump.	Regenerate the cryopump.
	Excessive thermal load on frontal array.	Reduce the thermal radiation load by: Shielding the cryopump. Lowering the temperature of the radiating surface.

Table B-1: Troubleshooting the Cryopump (continued)

Problem	Possible Cause	Corrective Action
Cryopump fails to cool down to the required operating temperature; takes too long to reach temperature (20K).	Low helium pressure in compressor.	Check compressor gauge for low helium charge pressure. Add gas as necessary.
	Helium-gas supply/return line incorrectly attached; self-sealing couplings not fully tightened.	Check the helium-gas supply line is connected to supply connector and all self-sealing couplings are fully seated.
	Vacuum leak in vacuum system or cryopump.	Check the following: Vacuum chamber and Hi-Vac valve for leaks. Cryopump for leaks. Cryopump relief valve for leaks.
	Incomplete regeneration may not have fully cleaned the adsorbing array. High rate-of-rise.	Regenerate the cryopump.
	Compressor problems.	Refer to compressor troubleshooting procedures in Table A.1 of compressor manual.
The cryopump makes a growling noise (8200 Compressor).	Incorrect position of frequency selector switch or of the voltage selector switch.	Measure and confirm incoming voltages, also confirm correct selector switch settings as described in Section 3 (8200 Compressor Manual).

Table B-2: Basic Operating Information

Cryopump (No. Used)	Helium Pressure Psig (kPa)* (Normal Operation-Steady State)	
	8200 Compressor	8500 Compressor
CT-100 (1) CT-100 (2)**	275 (1895) ---	--- 65 (450)
CT-7 (1)	275 (1895)	65 (450)
CT-8 (1) CT-8F (1)	280 (1930)	90 (619)

*Center point of needle swing.
**Powered by 8002 Controller.

Appendix C - Illustrated Parts Breakdown

Table C-1: Legend for Figure C-1

Item No.	Part No.	Description	No. Req'd
—	—	Cryo-Torr 100 Cryopump	1
1	8080006K001	80K Condensing Array	1
2	—	Cap Screw, Hexagon Socket Type, SSTL, #4-40 x 3/8" Lg.	2
3	—	Lockwasher, Split Type, SSTL, #4	6
4	—	Washer, Flat, SSTL, #4	6
5	8080006K003	15K Condensing Array	1
6	—	Cap Screw, Hexagon Socket Type, SSTL, #4-40 x 1/2" Lg.	4
7	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	7
8	—	Lockwasher, Split Type, SSTL, #6	7
9	—	Washer, Flat, SSTL, #6	7
10	8080006K004	80K Radiation Shield	1
11	—	Screw, Flat Head, SSTL, #4-40 x 3/8" Lg.	3
12	8080006K003	15K Cryo-Adsorbing Array	2
12A	—	Temperature Sensor	1
13	—	Vacuum Vessel	1
14	—	O-Ring, #600-V1, Viton, Parker	1
15	—	Plug	1
16	—	Nut	1
17	—	Centering Ring	1
18	—	O-Ring, Alcatel	1
19	—	Flange, Blank	1
20	—	Clamp	1
21	8080250K045	Pressure Relief Valve	1
22	—	O-Ring, #2-037, Viton, Parker V337-9	1
23	8080250K010	Drive-Unit-Displacer Assembly	1
24	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
25	—	Lockwasher, Split, SSTL, #10	2
26	—	Cover	1
—	505013	Indium Sheet, 3" x 6" x 0.005" Thick	1

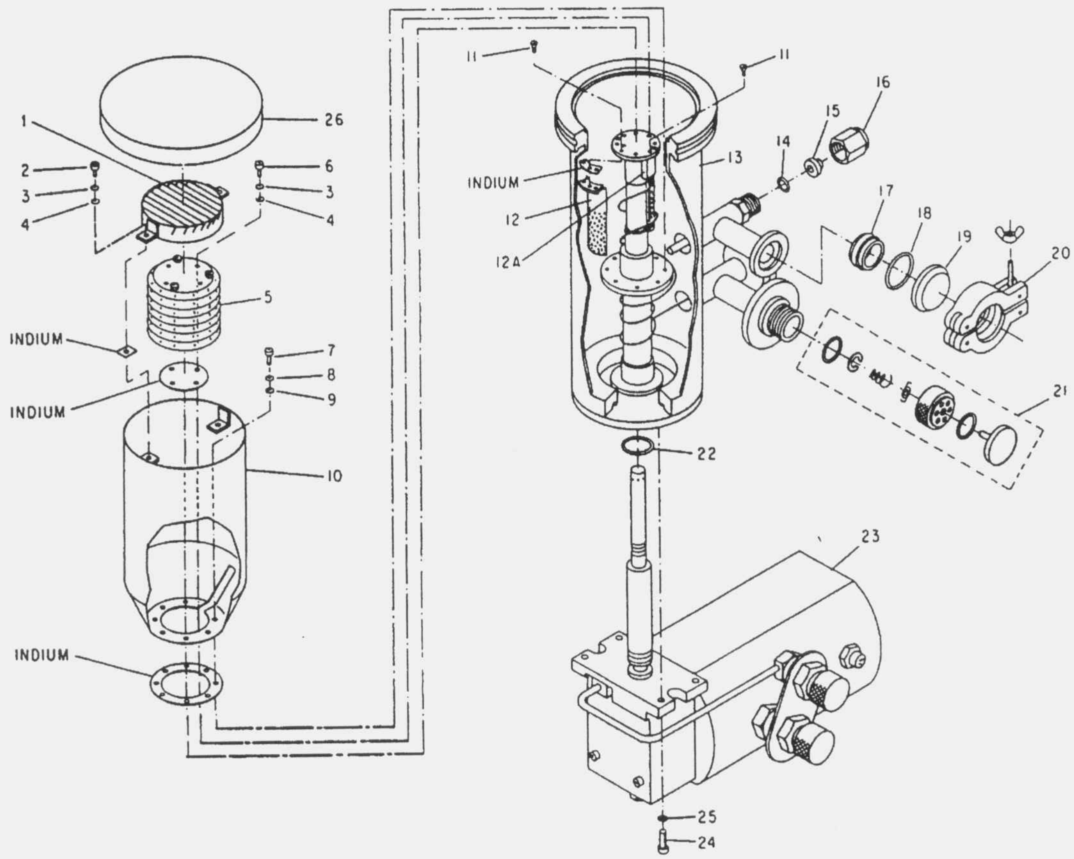


Figure C-1: Exploded View of Cryo-Torr 100 Cryopump

Table C-2: Legend for Figure C-2

Item No.	Part No.	Description	No. Req'd
—	—	Cryo-Torr 7 Cryopump	1
1	8080001K001	80K Condensing Array	1
2	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	14
3	—	Lockwasher, Split Type, SSTL, #6	22
4	—	Washer, Flat, SSTL, #6	22
5	8080001K003	15K Cryo-Adsorbing Array	1
6	—	Screw, Round Head, Brass, #4-40 x 1/2" Lg.	4
7	—	Lockwasher, Split Type, SSTL, #4	4
8	—	Washer, Flat, SSTL, #4	1
9	8080001K004	80K Radiation Shield	1
10*	8080250K006	Hydrogen-Vapor-Pressure Gauge (Optional)	1
11	—	Screw, Flat Head, Brass, #2-56 x 1/8" Lg.	1
12	8080250K045	Pressure Relief Valve	1
13	8080250K004	Accessory Port Cover	1
14	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	8
15	—	O-Ring, #2-20, Viton, Parker, 77-545	2
16	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
17	—	Lockwasher, Split, SSTL, #10	2
18	—	O-Ring, #2-037, Viton, Parker, V337-9	1
19	586441	O-Ring, #2-267, Viton, Parker, V377-9	1
20	—	Vacuum Housing	1
21	—	Cover	1
22	8042033	Diode Temperature Sensor	1
23	8044042G001	Regeneration Purge Fitting	1
24	—	O-Ring, #600-V1, Viton, Parker	1
25	—	Plug	1
26	—	Nut	1
27	—	Centering Ring	1
28	—	O-Ring, Alcatel	1
29	—	Flange, Blank	1
30	—	Clamp	1
31	8080250K010	Drive-Unit-Displacer Assembly	1
—	—	Indium Sheet, 3" x 6" x 0.005"	1

*Not shown in Figure C-2.

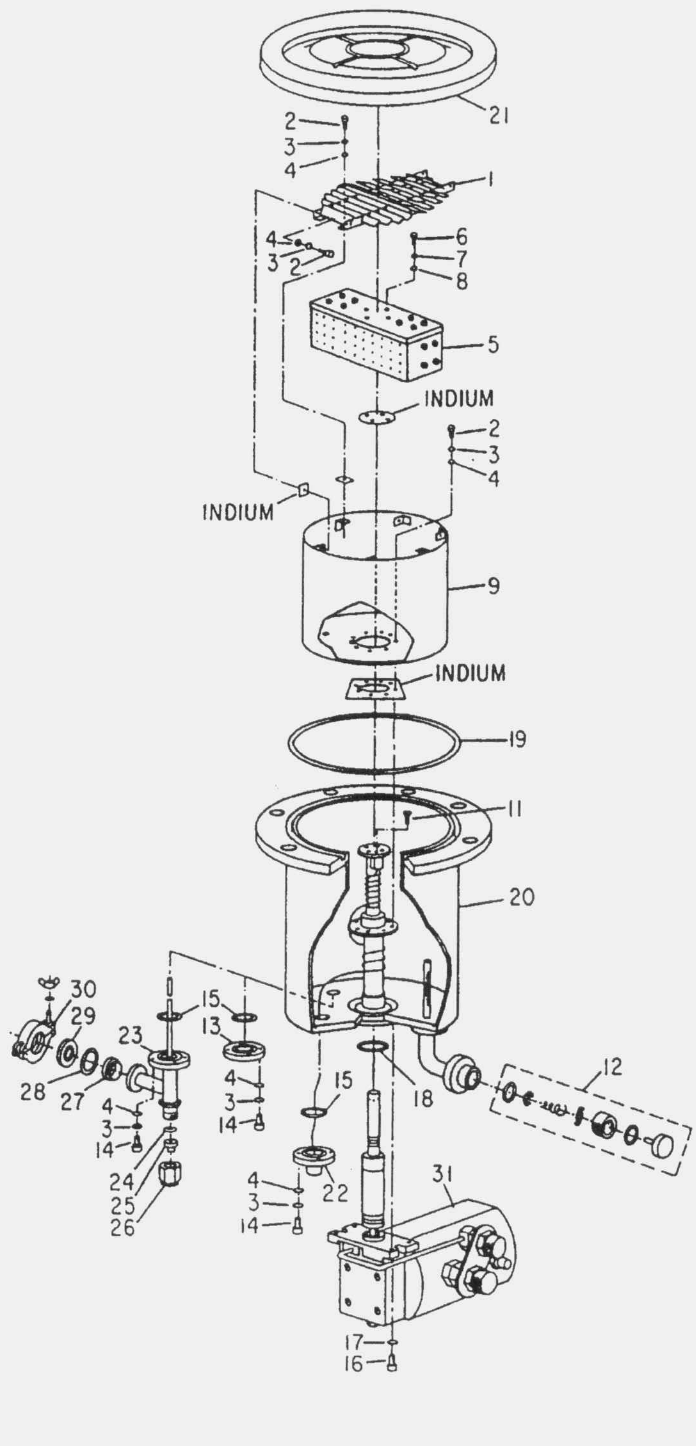


Figure C-2: Exploded View of Cryo-Torr 7 Cryopump

Table C-3: Legend for Figure C-3

Item No.	Part No.	Description	No. Req'd
—	—	Cryo-Torr 8 Cryopump	1
1	8080002K001	80K Condensing Array	1
2	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	12
3	—	Lockwasher, Split Type, SSTL, #6	22
4	8080002K010	15K Array Assembly	1
5	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	10
6	—	Washer, Flat, SSTL, #6	18
7	8080002K004	80K Radiation Shield	1
8	8080250K045	Pressure Relief Valve	1
9	—	O-Ring, #2-20, Viton, Parker V337-9	2
10*	8080250K006	Hydrogen-Vapor-Pressure Gauge	1
11	8080250K009	Diode Temperature Sensor	1
12	8044043G002	Regeneration Purge Fitting	1
13	—	Cap Screw, Hexagon Socket Type, SSTL, #2-56 x 1/2" Lg.	2
14	—	Lockwashers, Split, SSTL, #2	2
15	8080002K005	Drive-Unit-Displacer Assembly	1
16	—	O-Ring, #2-140, Buna-N, Parker N219-7	1
17	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
18	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1-1/4"	4
19	—	Lg.	1
20	586441	Protective Cover	1
21	—	O-Ring, #2-172, Viton, Parker V377-9	1
22	—	Vacuum Housing	1
23	—	O-Ring, #600-V1, Viton, Parker	1
24	—	Plug	1
25	—	Nut	1
26	—	Centering Ring w/O-Ring (Alcatel)	1
27	—	Flange, Blank	1
28	—	Clamp	1
—	—	O-Ring, #2V1-84-8A116, Cryolab	1
		Indium Sheet, 3" x 6" x 0.005" thick	

*Not shown in Figure C-3.

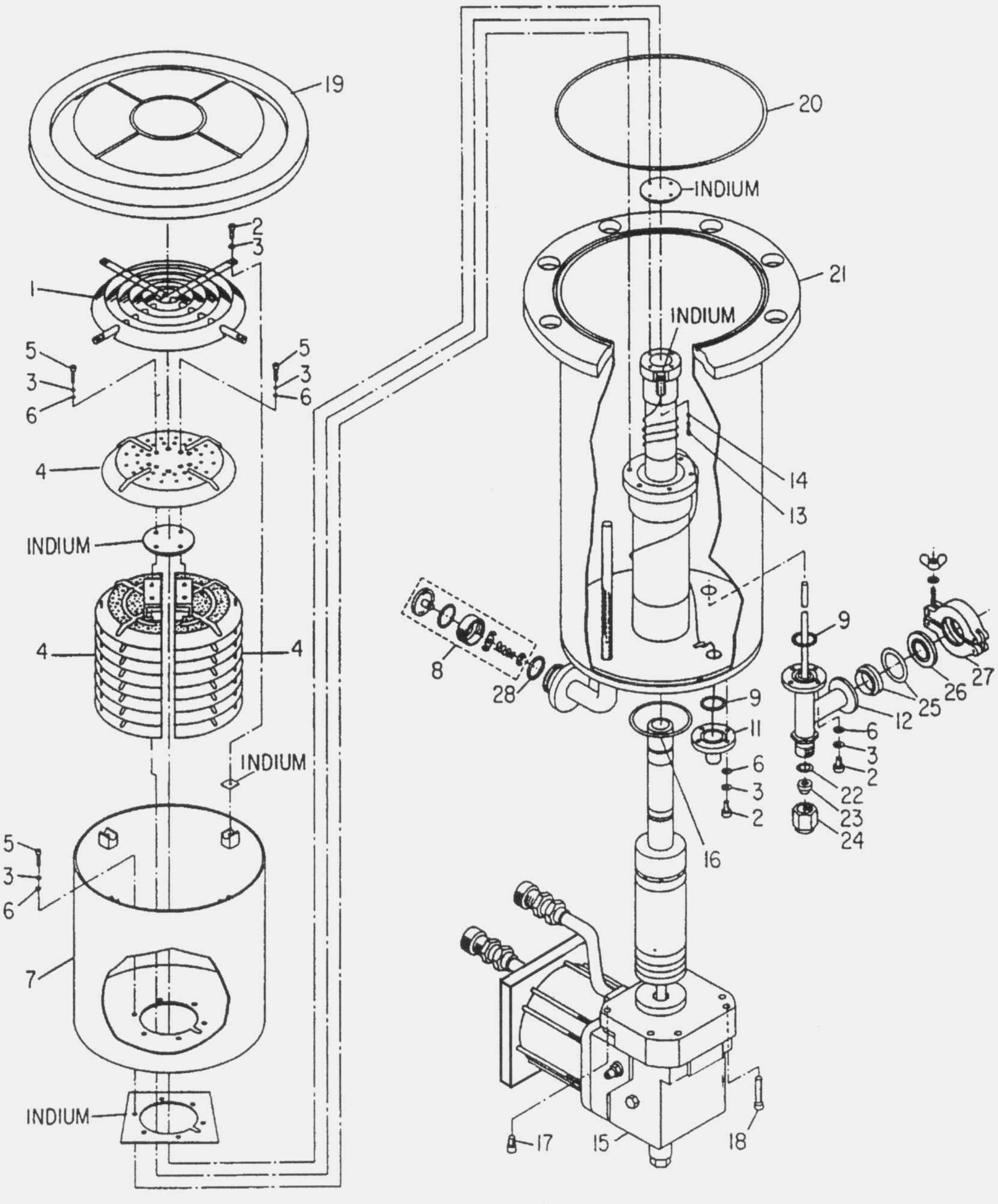


Figure C-3: Exploded View of Cryo-Torr 8 Cryopump

Table C-4: Legend for Figure C-4

Item No.	Part No.	Description	No. Req'd
—	—	Cryo-Torr 8F Cryopump	1
1	8080002K001	80K Condensing Array	1
2	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	8
3	—	Lockwasher, Split Type, SSTL, #6	18
4	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	10
5	—	Washer, Flat, SSTL, #6	10
6	8080007K003	15K Array Assembly	1
7	8080007K004	80K Radiation Shield	1
8	—	Vacuum Housing	1
9	—	O-Ring, V747-75, #2-157 Viton	1
10*	—	Cylinder, Refrigerator	1
11	—	O-Ring, #2-140, Buna-N, Parker N674-70	1
12	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1" Lg.	8
13	—	Lockwasher, Split Type, SSTL, #10	8
14	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1-1/4" Lg.	4
15	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
16	8080002K005	Drive-Unit-Displacer Assembly	1
17	8080250K045	Pressure Relief Valve	1
18	—	O-Ring	1
19	—	Connector Assembly	1
20	—	Wire, Silicon Diode (72 in. length)	1
21	—	Diode Temperature Sensor	1
22	—	Nut, Hex #4-40	1
23	—	O-Ring, V709-90, 2-020	1
24	—	Clamp	1
25	—	Flange, Blank	1
26	—	Centering Ring with O-Ring	1
27	—	Nut	1
28	—	Plug	1
29	—	O-Ring, #6Q0-V1, Viton, Parker	1
30	—	Protective Cover	1
—	—	Indium Sheet, 3" x 6" x 0.005" thick	1
—	8080250K012	Temperature Sensor Replacement Kit, consisting of:	1
—	—	Wire, Silicon Diode (Item No. 20)	1
—	—	Diode Temperature Sensor (Item No. 21)	1

*Not shown in Figure C-2.

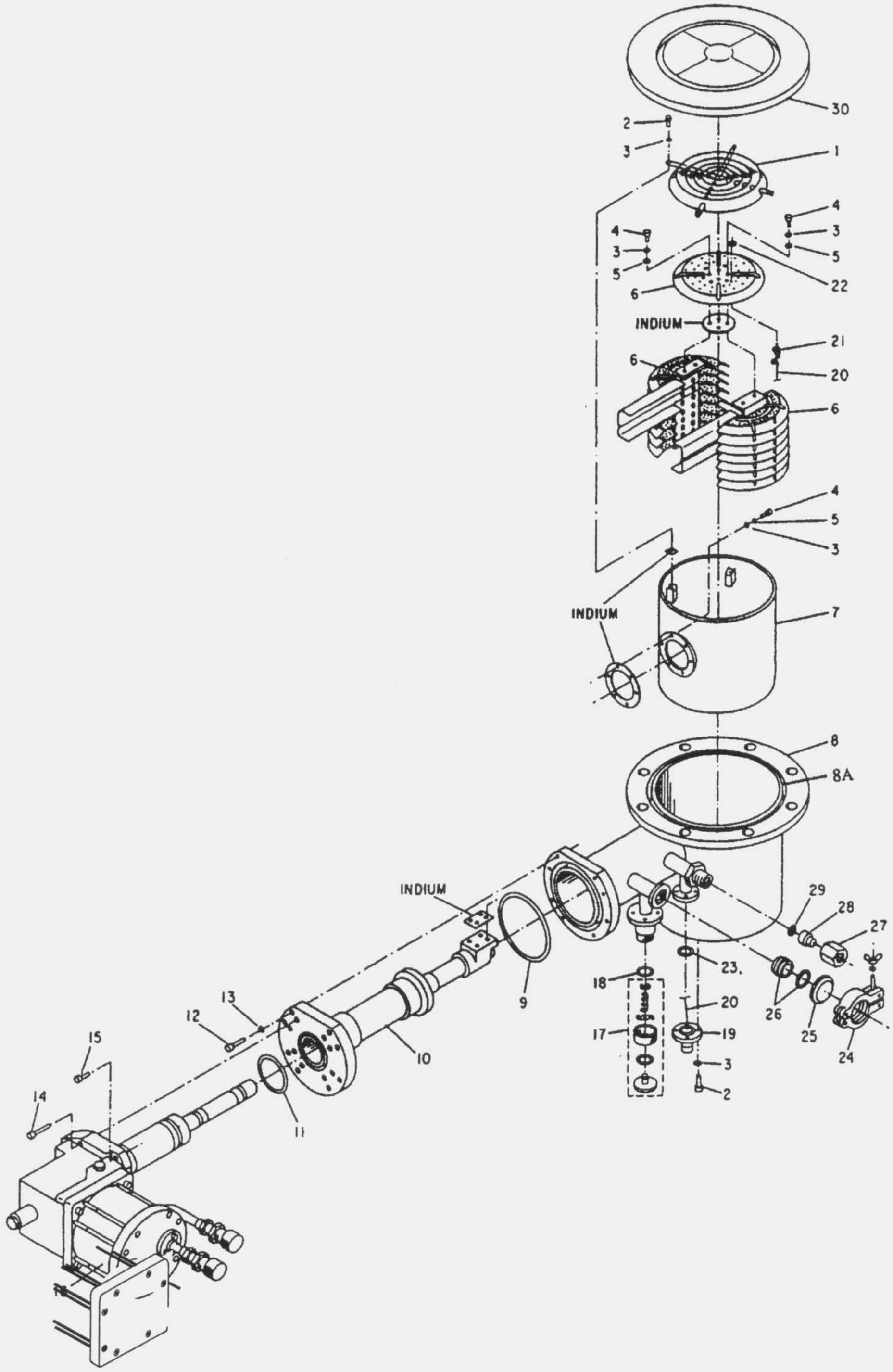


Figure C-4: Exploded View of Cryo-Torr 8F Cryopump

Appendix D - Accessories List for Cryo-Torr High-Vacuum Pumps

Table D-1: Accessory Part Numbers and Description

Part Number	Description
8042001G003	Remote Temperature Indicator (115V, 60 Hz) with Dual Setpoints
8042001G004	Remote Temperature Indicator (208V, 50 Hz) with Dual Setpoints
8044001G001	Automatic Regeneration Controller (115V, 60 Hz)
8044001G002	Automatic Regeneration Controller (208/230V, 60 Hz)
8080250K003	Maintenance Manifold
8080250K020	Purge Gas Heater (110V, 50/60 Hz)
8080250K022	Roughing Valve (110V, 50/60 Hz)
8080250K023	Purge Valve (110V, 50/60 Hz)
8080250K036	Purge Gas Heater (230V, 50/60 Hz)
8080250K037	Rouging Valve (230V, 50/60 Hz)
8080250K017	Purge Valve (230V, 50/60 Hz)

Appendix E - Conversion of Hydrogen-Vapor-Pressure Gauge Readings to Temperature

Use the data given below to convert a reading of the optional hydrogen-vapor-pressure gauge (in psia) to the temperature of the second-stage cold station (in degrees Kelvin). The hydrogen-vapor-pressure gauge should notbe used to measure temperatures higher than 26K.

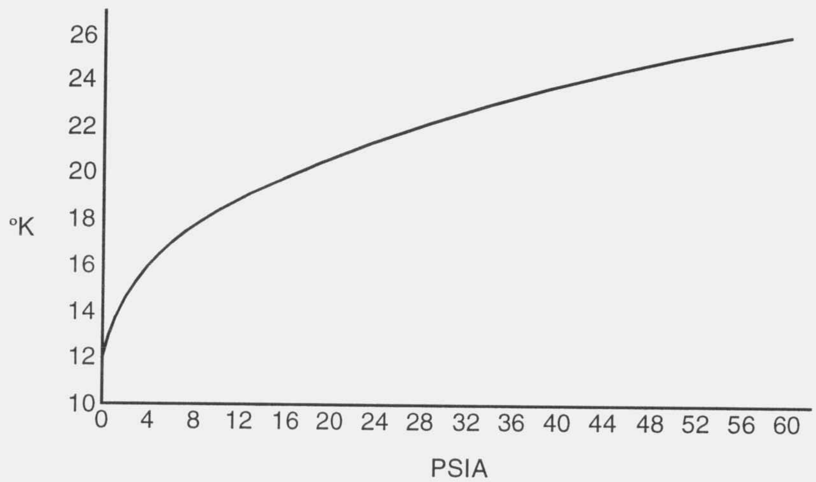


Figure E-1: Temperature versus Hydrogen-Vapor-Pressure

Table E-1: Hydrogen-Vapor-Pressure versus Temperature

PSIA	K
0	Less than12
1	13.9
2	15.2
3	16.0
4	16.7
5	17.2
6	17.7
7	18.1
8	18.5
10	19.2
12	19.7
15	20.5
18	21.1
21	21.7
24	22.2
27	22.6
30	23.1
35	23.7
40	24.3
45	24.8
50	25.3
55	25.8