

Model 1020C and 1050C
Cryodyne[®] Cryocoolers
Installation, Operation and Servicing Instructions

8040273
Rev. 101 (12/02)

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SAFETY CONSIDERATIONS

Your Cryodyne® Cryocooler has been engineered to provide extremely safe and dependable operation when properly used. Certain safety considerations need to be observed during the normal use of your cryocooler equipment. Warning blocks within the Manual text pinpoint these specific safety considerations. Warnings are defined as hazards or unsafe practices which could result in severe injury or loss of life.



HIGH VOLTAGE is present within the system and can cause severe injury from electric shock.

1. Disconnect the system from all power sources before making electrical connections between system components and also before performing Troubleshooting and Maintenance procedures.
2. Ensure that all electrical power switches on the controller/compressor units are in the off position before connecting the compressor unit to its power source.
3. Never connect the cold-head power cable to the cold head while the compressor is running.



HIGH GAS PRESSURE is present within the system and can cause severe injury from propelled particles or parts.

1. Do not modify or remove the pressure relief valves, either on the cold head or within the helium compressor.
2. Always depressurize the adsorber to atmospheric pressure before disposing of it.
3. Always bleed the helium charge down to atmospheric pressure before servicing or disassembling the self-sealing gas half-couplings.

**BEFORE INSTALLING, OPERATING OR SERVICING EQUIPMENT,
READ THIS MANUAL WHICH CONTAINS IMPORTANT SAFETY INFORMATION.**

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Section 1

Introduction

1.1 General

This manual provides instructions for installing, operating and servicing the Model 1020C and 1050C Cryodyne[®] Cryocoolers. If you are installing or operating and servicing a Cryodyne Refrigeration System, you should also have available the 8500 or the Model 1020R Compressor manuals (8040251 or 8040274 respectively).

The manuals cover two basic components: the cryodyne cryocooler and the compressor. Each manual presents information for installation, operation and servicing of that component. A manual is shipped with each system component (cryocooler and compressor).

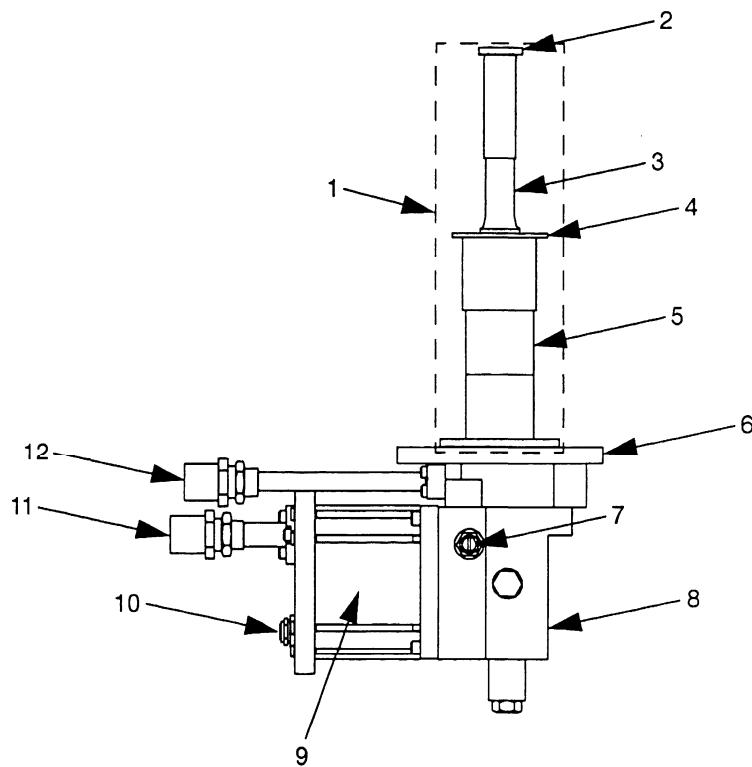
The Model 1020 or 1050 Cold Head, which uses helium as the refrigerant, is designed to interface with many kinds of apparatus that require cryogenic temperatures. The use of a Cryodyne refrigerator as a source of cryogenic temperatures offers a degree of freedom in the design of such interfacing apparatus (in particular, size and operational flexibility) that is generally unobtainable when a liquid refrigerant is employed. Moreover, the cold head can be operated in any orientation without loss of performance. At the end of an operating period of the refrigerator, the cold head cold stations can be raised to ambient temperature in a relatively short time.

Figure 1.1, shows front and rear overall views of the Model 1020 Cold Head and identifies major components. These components are identical on the Model 1050 Cold Head; configuration of the Model 1050 is slightly different from the Model 1020.

Cold head and interconnections specifications for the Model 1020 and 1050 Cold Head are summarized in Table 1.1.

1.2 Installation, Operation and Servicing Instructions

Installation, Operation and Servicing Instructions for your Cryodyne refrigeration system 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 high refrigeration system performance.



Legend

1. Cylinder
2. Second Stage Cold Station
3. Second Stage Cylinder
4. First Stage Cold Station
5. First Stage Cylinder
6. Top Flange
7. Pressure Relief Valve
8. Crankcase (houses drive mechanism)
9. Drive Motor
10. Electrical Power Connector
11. Helium Gas Return Connector (with dust cap)
12. Helium Gas Supply Connector (with dust cap)

Figure 1.1 The Model 1020 Cold Head

Table 1.1 Model 1020 and 1050 Cold Head and Interconnections Specifications

Dimensions (approximate):

- 14.6 inches (369 mm) Length
- 6 inches (152 mm) Width
- 20.5 inches (521 mm) Height

Weight

33 lbs (15 kg) approximate

Power requirement (supplied via the 8500 or 1020 R/RW Compressor)

150 VAC nominal, either 50 or 60 Hz, split phase

Ambient-temperature operating range

40 to 110°F (4.4 to 43°C)

Interface data

- Gas-supply connector: 1/2-inch self-sealing coupling
- Gas-return connector: 1/2-inch self-sealing coupling

Orientation

May be operated in any orientation, but vertical mounting is preferred.

Interconnections

- Helium supply and return piping
- 10 ft. (3 m) each with 1/2-inch self-sealing couplings at each termination.
- Longer lengths, elbows and tees are available.

Cold head power receptacle

Mates with compressor cold head power cable.

Refrigeration capacity

The values listed below represent the minimum refrigeration capacities of the second-stage cold station, assuming the following conditions:

MODEL 1020 COLD HEAD		MODEL 1050 COLD HEAD	
A 10-watt heat load is applied to the first-stage cold station An ambient temperature of 75°F No thermal radiation or gas conduction heat load		A 60-watt heat load is applied to the first-stage cold station An ambient temperature of 75°F No thermal radiation or gas conduction heat load	
Applied Second-Stage Heat Load (Watts)	Second-Stage Cold Station Temperature for 60-Hz Operation (K)	Applied Second-Stage Heat Load (Watts)	Second-Stage Cold Station Temperature for 60-Hz operation (K)
4	14.5	4	17.0
10	19.0	6	18.7
15	26.0		

Figures 1.3 and 1.4 are graphs showing typical refrigeration capacities at 60-Hz and 50-Hz of the Model 1020 and 1050 Cryodyne Refrigerators respectively.

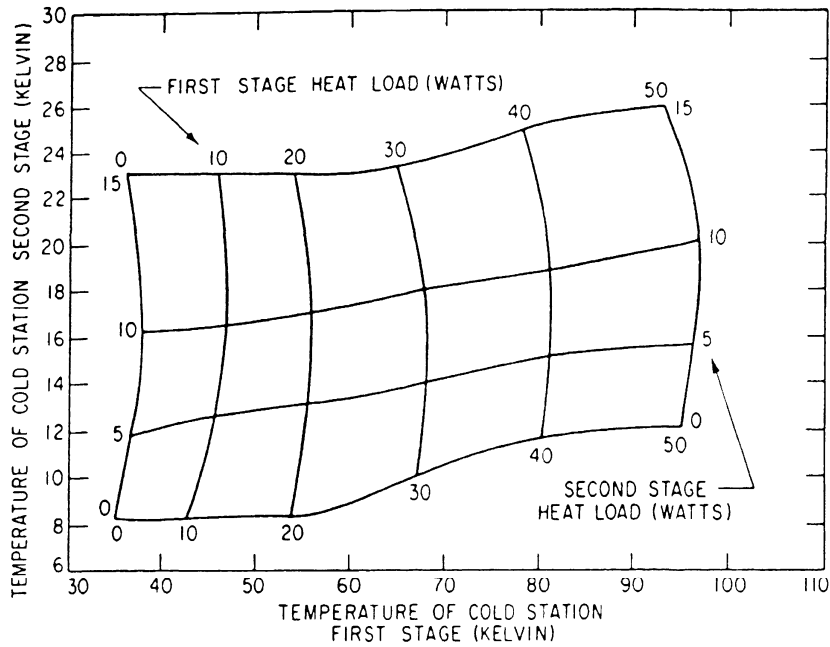
Note: When the refrigeration system is supplied with 50-Hz power, a slight reduction in cold head performance may be observed, compared with the performance obtained with 60-Hz power.

Temperature stability under constant load

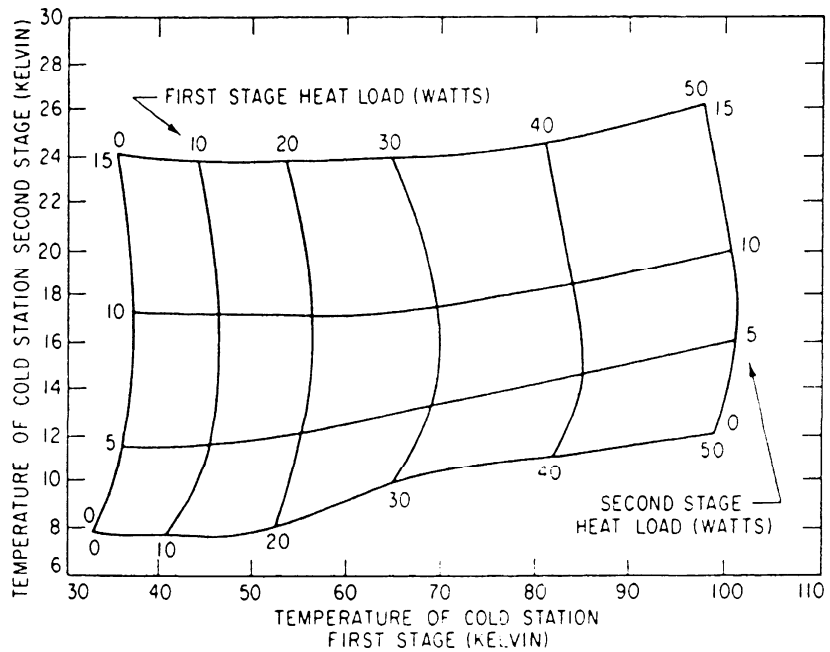
± 2.0K (at the second-stage cold station)

No-load cooldown time to 20K

- 40 minutes; 60-Hz power
- 50 minutes; 50-Hz power



60-Hz Operation



50-Hz Operation

Figure 1.2 Typical refrigeration capacity of the Model 1020 Cryodyne Refrigerator

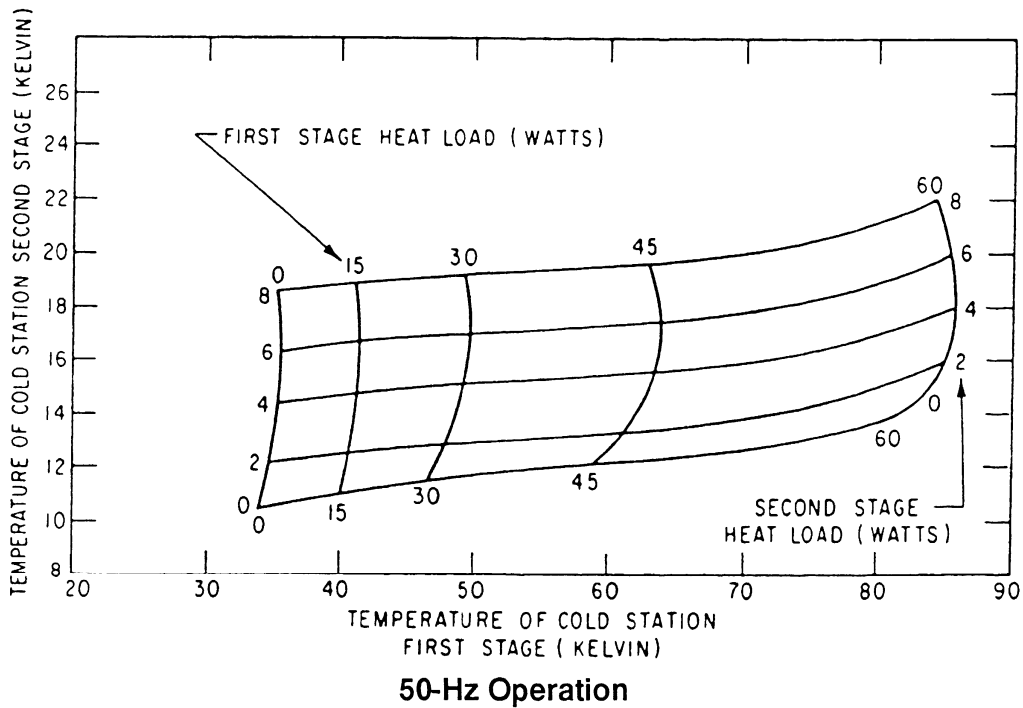
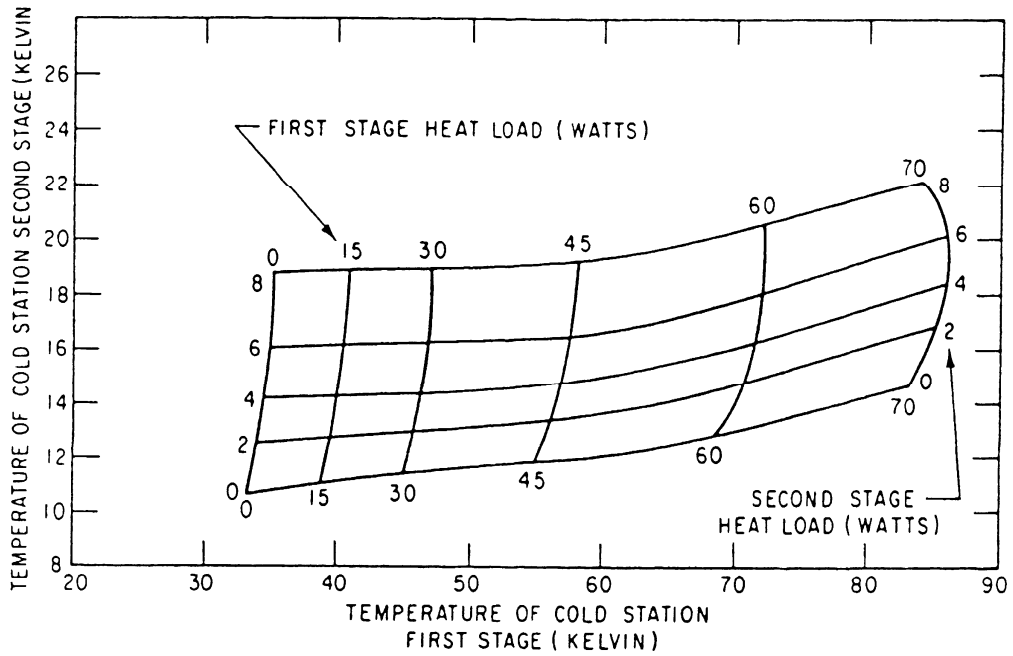


Figure 1.3 Typical refrigeration capacity of the Model 1050 Cryodyne Refrigerator

Section 2 Inspection and Installation

2.1 Inspection

Upon receipt, inspect the Model 1020 or Model 1050 Cryodyne Cryocooler for evidence of damage as described below.

Report damage to the shipper at once.

Retain shipping cartons for storage or return shipment.

Inspect the exterior of the cold head for evidence of damage. Examples of such evidence are a bent cold station and a dented cylinder.

2.2 Cold Head Installation

The cold head and related components must have adequate vacuum integrity for proper operation in your vacuum system. Inadequate vacuum will result in an unwanted gas-conduction heat load from the room-temperature vacuum housing to the cold surface of the cold-head cold stations. A small vacuum leak will cause higher-than-normal cold station operating temperatures, combined with a gradual temperature increase; a large vacuum leak may prevent satisfactory cooldown. Your roughing pump system should be isolated from your vacuum system, once cooldown has started, by closing the roughing valve shown in Figure 2.1. This valve should be of a high-vacuum isolation type (Hi-Vac valve) for isolation of your vacuum system during rough pumping, cooldown, and regeneration.

CTI-CRYOGENICS recommends that a suitable pressure relief valve be installed in your vacuum system to prevent any possible positive pressure rise during warmup.

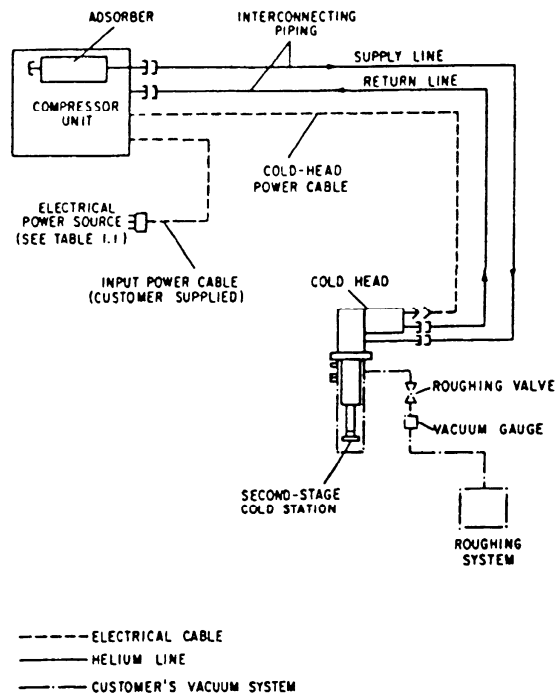


Figure 2.1 Component interconnection diagram


2.3 Installing the Cold Head to the Vacuum System

Proceed as follows to install the cold head in your vacuum system. Refer to Appendix J for the major interface dimensions of the Model 1020 and 1050 Cold Heads.

1. After cleaning all sealing surfaces, install the O-ring in the groove for the O-ring in your vacuum system flange.
2. Mount the cold head to the flange; be sure that all mounting bolts are torqued to specified values.

2.4 Connecting the Cold Head to the Compressor

A typical interconnecting diagram for the Cryodyne refrigeration system is shown in Figure 3.6. Refer also to Figure 1.1, for location of cold head components discussed below.

	WARNING
Do not connect the compressor to its power source until all connections have been made between the components of the Cryodyne refrigeration system.	

Make the connections between the cold head and compressor:

1. Remove all dust plugs and caps from the supply and return lines, compressor and cold head. Check all fittings.
2. Connect the helium return line from the gas-return connector on the rear of the compressor to the gas-return connector on the drive-unit displacer assembly on the cold head.
3. Connect the helium supply line from the gas-supply connector on the rear of the compressor to the gas-supply connector on the cold head.


Verify proper helium supply static pressure by confirming that the helium pressure gauge reads 200 ± 5 psig (1380 ± 35 kPa), in an ambient temperature range of 50 to 100°F (10 to 38°C).

If the indicated pressure is higher than 205 psig (1415 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 200 psig (1380 kPa).
3. Close the gas charge valve and reinstall the flare cap.

If the indicated pressure is lower than 195 psig (1345 kPa), add helium gas as described in the [Maintenance](#) section of the manual for your CTI-CRYOGENICS compressor.

The last step required for installation is making electrical connections:

	WARNING
The system power switch on the rear of the compressor must be in the OFF position before making any and all electrical connections.	

1. Connect the cold head power cable to the rear panel of the compressor and the other end to the electrical power connector on the cold head.
2. Plug the compressor input power cable into the power source.
3. Switch the compressor power switch to the ON position.

Section 3 Operation

CAUTION

Do not begin Cryodyne refrigeration system operation until all steps in the inspection and installation procedures have been completed and confirmed.

3.1 Before Startup

Operating Log

It is highly advisable to create and maintain a detailed operating log. The record will assist in troubleshooting, should problems arise. Figure A.1, page A-2, is a sample operating log included for your use. You may make photocopies of this sample log as necessary.

Temperature Indication

The second-stage cold station temperature is measured by one of two devices: a diode temperature sensor or a hydrogen-vapor-pressure gauge. The diode temperature sensor is designed to be used with the remote temperature indicator or the cryopump monitor (Appendix C).

While the Cryodyne refrigerator can be operated without temperature indication, it is advisable to install the temperature indicator or the cryopump monitor to facilitate accurate operating characteristics. Refer to Appendix C for detailed descriptions of both temperature indicating devices.

Installing the Load

The load can be either attached directly to the cold station concerned, or coupled to it with heat wicks (braided copper straps). Use indium foil (0.002 to 0.005-inch thick) between the mating surfaces to improve thermal conduction.

After installing the load, rough-pump your vacuum chamber down to 5×10^{-2} torr or better. Then close the roughing valve prior to starting cooldown of the refrigerator. Upon cooldown, the refrigerator will cryopump residual gasses in the chamber and an insulating vacuum between 10^{-4} and 10^{-5} torr will be achieved.

3.2 Startup and Cooldown

1. Confirm that the roughing valve is closed.
2. Turn on system power ON/OFF switch.
3. During cooldown, record the operating log data at 15-minute intervals. To ensure minimum cooldown time, do not apply electrical power to any load during the cooldown.

Operating Log

Model 1020C and 1050C Cryodyne Refrigeration Systems

Serial Numbers _____ Date _____
 Sheet _____ of _____
 Cold Head _____ Electrical: Volts _____ Hz _____ Test No. _____ Run No. _____
 Compressor Unit _____ Test Technician _____

Date	Reading			Ambient Temp. (°K)	Cold-Station Temperature (°K)	Pressure (psig)	Vacuum In User's Vacuum Chamber (torr)	NOTES
	No.	Time	Elapsed Time					

Scheduled maintenance service schedule: Replace the compressor adsorber every three years.

Figure A.1 Sample Operating Log

The cooldown time associated with a normal cooldown, with no load attached to a second-stage cold station, is specified in Table 1.1, page 1-3. The cooldown time will increase approximately 15 minutes for each pound-of-mass increase of the attached load. If the cold head cooldown time is not within specified requirements refer to Table 4.1, page 4-2, Cold Head Troubleshooting Procedures.

Pressure regulation during cooldown is automatic. The compressor pressures will vary during cooldown but will usually attain steady values nominally within 45 minutes after cooldown.

Plots for typical cooldown data for the Model 1050C Cryodyne refrigeration system are shown in Figure 3.1. The sharp increase in the helium supply pressure and return pressure that occur immediately after startup are limited by the compressor differential-pressure relief valve.

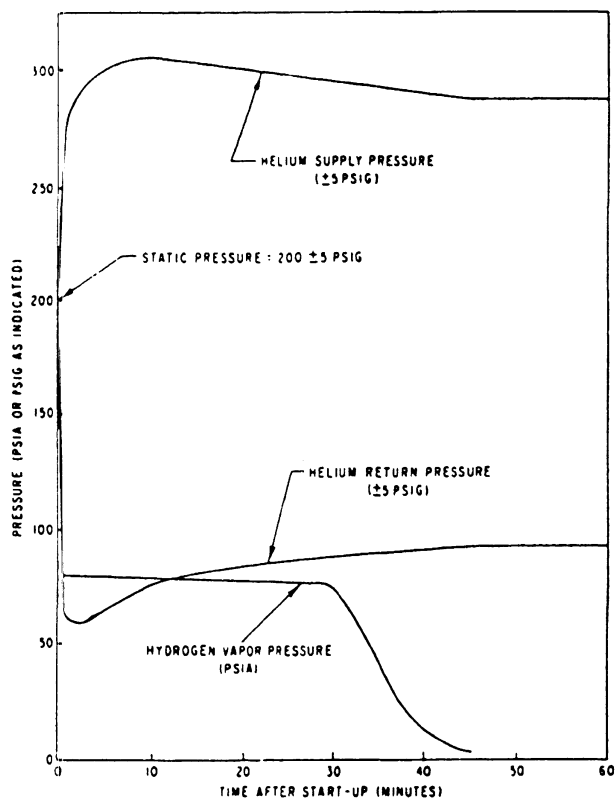


Figure 3.1 Typical cooldown data

3.3 Normal Operation

The Cryodyne refrigeration system is designed to operate without operator assistance.

During the first 100 hours of operation, a slight drop in compressor pump oil level may occur, but a drop is of no concern as long as the oil level is visible. If oil level is not visible, contact the Product Service Department.

The helium return pressure gauge should be checked once a week and the reading noted in the operating log. If the gauge reading falls outside the satisfactory operating range between 60 and 85 psig (415-590 kPa) on the gauge, refer to Section 4, Troubleshooting Procedures.

⚠ CAUTION

Never exceed operating compressor return pressure higher than 115 psig (790 kPa). Compressor damage can occur.

3.4 Cryodyne Refrigerator Shutdown Procedures

1. Close the Hi-Vac valve in your vacuum system.
2. Turn off the system power ON/OFF switch on the compressor.
3. Allow the cold head to warm up to ambient temperature.

For Your Information —

It will take many hours to warm the cold head cylinder to ambient temperature with no heat load present. If you desire a rapid warmup, break the vacuum with a clean dry gas, such as nitrogen or argon. If this method is used, leave the valve open to allow the expanding gas to escape as the cylinder warms.

3.5 Storage

The Cryodyne refrigeration system is fully protected during storage if kept under positive helium pressure and all component connections left connected. Periodically check the helium return pressure gauge on the compressor. If the gauge reads below 195 psig (1345 kPa),

add helium as described in the Maintenance section of the manual for your CTI-CRYOGENICS compressor.

If the cold head is removed from your vacuum system, be careful not to damage the cold head cylinder and sealing surfaces.

For Your Information —

How the Cold Head Operates

Refer to Figure 1.1, while reviewing this subsection.

The cold head consists of a two-stage cold head cylinder and drive-unit displacer assembly that together produce closed-cycle refrigeration at temperatures that range from 40 to 100K for the first-stage cold station to 10 to 20K for the second-stage cold station, depending on operating conditions. Within the drive unit displacer assembly, the drive unit actuates the displacer-regenerator assembly located in the cold head cylinder and thereby controls the flow of helium into the cold head. Within the drive unit are located the crankcase (8) and drive motor (9), which is a direct-drive constant-speed motor operating at 72 rpm on 60 Hz power and 60 rpm on 50 Hz power.

During operation, high pressure helium from the compressor enters the cold head at the helium supply connector (12), and flows through the displacer-regenerator assembly, crankcase, and motor housing before exiting through the helium gas-return connector (11) and returning to the compressor. Helium expansion in the displacer-regenerator assembly provides cooling at the first and second-stage cold station.

The temperature of the second-stage cold head station is measured by a temperature sensor and transmitted to a temperature indicator, cryopump monitor or vapor pressure gauge.

Refer to Appendix B, for detailed information on the principles of operation.

Compressor Gas and Oil Flows

Helium returning from the cold head enters the compressor, and a small quantity of oil is injected into the gas stream, thereby overcoming helium low specific heat and inability to carry heat produced during compression. Helium is then compressed and passed through a heat exchanger for removal of compression-caused heat. The helium flows through a bulk oil separator, oil-mist separator, and charcoal filter adsorber, where oil and contaminants are removed.

A differential pressure relief valve in the compressor limits the operating pressure differential between the helium supply and return lines, thereby allowing compressor operation without cold head operation. When cold head operation reaches a steady-state condition, further pressure regulation is unnecessary.

Section 4

Troubleshooting Procedures

4.1 Troubleshooting the Cold Head

The problems in the troubleshooting table are all followed by a number of 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 the readings (see Appendix A) of the temperature indicator during normal operation is a valuable tool in troubleshooting the cold head. Values higher than 20K indicate that the second-stage cold station is too warm. A temperature below 20K means the cold head is cold enough for operation.

4.2 Technical Inquiries

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

Table 4.1 Cold Head Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
1) Cold head fails to cool down to the required operating temperature or takes too long to reach that temperature.	1) Low system charge pressure in the compressor.	1) Add helium gas per the maintenance instructions of your compressor manual.
	2) Vacuum leak in your vacuum system.	2) Check your vacuum system for leaks.
	3) Excessive heat load.	3) Eliminate excessive heat load.
	4) Contamination of the helium gas.	4) Refer to Decontamination Procedures, Section 5.4, page 5-2.
	5) Compressor problem.	5) Refer to Troubleshooting Procedures in your compressor manual.
2) The cold-head drive unit fails to run, even though the compressor is operating.	6) Internal malfunction in the compressor.	6) Contact the Product Service Department.
	1) Lack of power from the compressor.	1) a. Ensure that the system power ON/OFF switch on the rear panel of the compressor is ON. b. Ensure that the cold head power cable is properly attached to the electrical power connector of the cold head drive unit. c. Ensure the integrity of the control power fuses in the electrical control chassis of the compressor. (See Figure B.2 of the compressor manual for the location of these fuses.) d. Contact the Product Service Department for assistance.
	2) An internal malfunction.	2) Contact the Product Service Department for assistance.

Table 4.1 Cold Head Troubleshooting Procedures (Cont.)

Problem	Possible Cause	Corrective Action
3) The cold-head drive unit operates erratically, usually accompanied by considerable noise.	1) Contamination of the helium gas.	1) Refer to Decontamination Procedures, Section 5.4, page 5-2.
	2) Incorrect wiring connection to transformer T2 and T3 (8500 Compressor only).	2) Confirm correct transformer (T2 and T3) preparation as described in Figure 3.6 of the compressor manual.
	3) Low input voltage (8500 Compressor only).	3) Measure and compare input voltage to operating voltage range, Table 1.1 of the compressor manual. If necessary, adjust transformer tap settings.
	4) Internal malfunction of the cold head.	4) Contact the Product Service Department for assistance.

Section 5

Unscheduled Maintenance

Two types of unscheduled maintenance may be required from time to time. These are 1) the addition of helium gas to the cryodyne cryocooler, and 2) helium circuit decontamination.

5.1 Maintenance Equipment

Your CTI-CRYOGENICS compressor is supplied with appropriate maintenance equipment and disposable supplies for servicing this unit. In addition, you should have a Maintenance Tool Kit, P/N 814000K001, that provides wrenches, etc. for connecting self-sealing Aeroquip couplings between the cold head(s) and the compressor.

5.2 Adding Helium Gas

Refer to the Maintenance section of the manual for your CTI-CRYOGENICS compressor for detailed instructions on adding helium gas to your Cryodyne cryocooler.

5.3 Helium Circuit Decontamination

Contamination of the helium-gas circuit is indicated by sluggish or intermittent operation (ratchetting) of the cold head drive mechanism. With severe contamination the cold head drive may seize and fail to operate. One of the major sources of contamination is using helium gas of less than the required purity. When performing the decontamination process, use only 99.999% pure-helium gas, and the regulator and charging line must be properly connected and purged.

This decontamination procedure will remove contaminants from the cold head and/or compressor, thereby restoring system performance. The cold-trapping of contaminants inside the cold head during this procedure will also decontaminate the compressor if the contamination of the system is not severe. Separate decontamination of the compressor is required whenever the compressor has been opened to atmosphere, or the pressure has dropped to zero.

5.4 Cold Head Decontamination Procedures

1. Cool down the cold head and operate it for one to three hours. If the system will not cool down, proceed to step 2. Operating the cold head will isolate the contaminants by "freezing" them in the cold head. The contaminants in the helium-gas circuit of the refrigerator tend to become frozen inside the cold head. The longer the cold head is operated beyond the one-hour period, the greater is the amount of contamination that becomes isolated inside the cold head.
2. Shut down the refrigerator per Section 3.4, page 3-2.
3. *Immediately* disconnect the helium supply and return lines from the gas-supply and gas-return connectors at the rear of the compressor. Leave them attached to the cold head.
4. Attach the maintenance manifold to the disconnected ends of the helium return and supply lines.
5. Reduce the pressure in the cold head to a level of 30 psig by using the maintenance manifold. Reducing the pressure in the cold head below 30 psig (200 kPa) may introduce more contaminants into the helium circuit.

6. Allow the second-stage of the cold head to warm up to room temperature. The warmup time can be decreased by backfilling the vacuum chamber to one atmosphere with dry argon or nitrogen gas. Using the gas heater, CTI P/N 8080250K020, will reduce the warmup time about 50 percent, and will maintain the gas temperature below the 150°F (66°C) limit.
7. Once the cold head 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 VALVE AT THIS TIME.** Purge the regulator and charging line 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 counterclockwise until the helium stops flowing.
 - c. Loosely connect the charge line to the 1/8-inch Hoke 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 Hoke 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 and that the air trapped in the regulator will not diffuse back into the helium bottle. For best results, CTI 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 195-205 psig (1345-1415 kPa) by adjusting the regulator to the required pressure, and opening the Hoke valve on the manifold. Close the Hoke valve when the pressure is correct.
 - b. Depressurize the cold head to between 30 and 50 psig (200 and 330 kPa) by slowly opening the ball valve and allowing the helium to bleed out slowly. Do *not* reduce the pressure to *less than* 30 psig or the cold head may be further contaminated.
 - c. Perform flushing steps a and b four more times.
 - d. Pressurize the cold head to the static charge pressure of 195-205 psig (1345-1415 kPa) and run the cold head drive motor for 10 to 30 seconds by actuating the system ON/OFF switch to ON.
 - e. Perform steps b through d four more times for a total of 25 flushes and a total of 5 drive-motor runs.
9. Verify that the cold head is pressurized to the static charge pressure of 195-205 psig (1345-1415 kPa).
10. Disconnect the maintenance manifold from the helium return and supply lines.
11. Reconnect the helium return and supply lines to the return and supply connectors on the rear of the compressor. The cold head is now ready for operation.

Appendix A

Operating log

The operating log included as Figure A.1 in this Appendix should be reproduced for your use with the Model 1020C or 1050C Cryodyne Refrigeration System. It is important to maintain an operating log, especially when operating the system for the first time or in a new installation. Readings of the compressor pressure gauge and the vacuum in the vacuum chamber should be recorded during cooldown, and also while the system is operating under normal load conditions. (Readings of the cold-station temperature – as well as the cooldown time from ambient temperature to 20K– should also be recorded, if a means of obtaining such data is available.)

These records may be extremely useful later, both in recognizing degradation of performance and in troubleshooting, in case problems arise. During startup and cooldown, data should be recorded at 15-minute intervals. During normal operation, these data should be recorded daily.

Appendix B

Principles of Operation

TECHNICAL DATA CRYODYNE® CLOSED-CYCLE HELIUM REFRIGERATORS

The cooling process (cycle) of CRYODYNE Helium Refrigerators is analogous to that of common household refrigerators. In the latter, a working fluid (freon gas) is compressed, the heat of compression removed by air-cooled heat exchangers, and the gas is then expanded to produce cooling below the ambient temperature. This simple compression-expansion process will suffice for the household refrigerator, where temperatures in the sub-zero fahrenheit range are required. However, CRYODYNE systems must operate effectively and routinely at temperatures down to 6 K (-449°F). Attainment of such extreme low levels requires highly efficient heat exchangers, and the use of a working fluid (helium gas) that remains fluid at temperatures approaching absolute zero (-459.6°F , -273.1°C , 0 K).

All CRYODYNE systems comprise an air-cooled or water-cooled, oil-lubricated compressor unit with oil separation system (carry-over oil vapors would solidify at cryogenic temperatures and plug the heat exchangers of the refrigerator); and a refrigerator unit (remotely located from the compressor), which operates at slow speeds, has

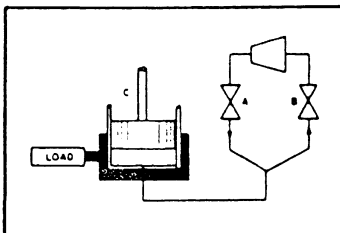


Figure 1 Elementary Cooling Circuit

ample clearances, and has room-temperature valves and seals.

The flow of helium in the refrigerator is cyclic. The sequence of operations can be illustrated by a single cylinder and piston (Figure 1).

A source of compressed gas is connected to the bottom of cylinder C through inlet valve A. Valve B is in the exhaust line leading to the low-pressure side of the compressor. With the piston at the bottom of the cylinder, and with valve B (exhaust) closed and valve A (inlet) open, the piston is caused to move upward and the cylinder fills with compressed gas. When valve A is closed and valve B is opened, the gas expands into the low-pressure discharge line and cools. The resulting temperature gradient across the cylinder wall causes heat

to flow from the load into the cylinder. As a result, the gas warms to its original temperature. With valve B opened, and valve A closed, the piston is then lowered, displacing the remaining gas into the exhaust line, and the cycle is completed.

This elementary system, while workable, would not produce the extreme low temperatures required for uses to which the CRYODYNE refrigerators are applied. Thus the

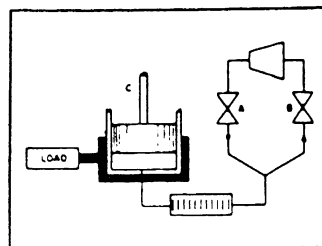


Figure 2 Cooling Circuit with Regenerator

incoming gas must be cooled with the exhaust gas before the former reaches the cylinder. This is accomplished in the CRYODYNE refrigerator by a regenerator, which extracts heat from the incoming gas, stores it, and then releases it to the exhaust stream (Figure 2).

A regenerator is a reversing-flow heat exchanger through which the helium passes alternatively in either direction. It is packed with a material of high surface area, high specific heat, and low thermal conductivity, that will readily accept heat from the helium (if the helium's temperature is higher) and give up this heat to the helium (if the helium's temperature is lower).

In steady-state operation, a system of this type exhibits the characteristic temperature profile of Figure 3. The steps of the cycle are as follows:

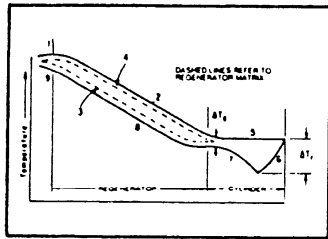


Figure 3 Temperature Profile of a Single-Stage Cryodyne Refrigerator

- a. With the piston at the bottom of its stroke, compressed gas enters through valve A at room temperature (1).
- b. As the piston rises, the gas passes through the regenerator. The matrix absorbs heat from the gas (warming from 3 to 4), and the gas cools.
- c. Still at inlet pressure, the cooled gas fills the space beneath the piston. The gas temperature at this point (5) is about the same as that of the load.
- d. Valve A closes and exhaust valve B opens, allowing the gas to expand and cool further as it

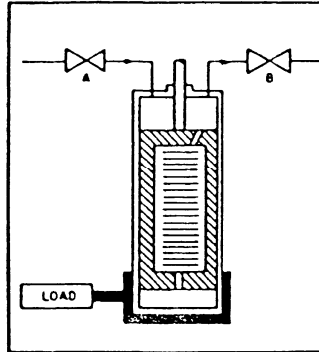


Figure 4 Improved Single Stage Refrigerator

does so (6). The temperature drop (ΔT_1) is responsible for the refrigerating effect.

- e. Heat flows from the load through the cylinder walls, warming the gas to a temperature slightly (ΔT_2) below that at which it entered the cylinder (7).
- f. As the gas passes through the regenerator, it warms up (8) as it receives heat from the matrix, and the matrix is cooled (4) to (3).
- g. The piston descends, pushing the remaining cold gas out of the cylinder and through the regenerator. However, because the regenerator is not 100 percent efficient, there is always a temperature difference between the gas and the matrix; thus, at any point shown in the diagram, the exhaust gas remains slightly cooler than the inlet gas.
- h. The low-pressure gas leaves through valve B at approximately room temperature (9).

In the system of Figure 2, the piston would require a pressure seal and would have to be designed to withstand unbalanced forces. A more practical version of this cycle is shown in Figure 4. This system uses a double-ended cylinder and

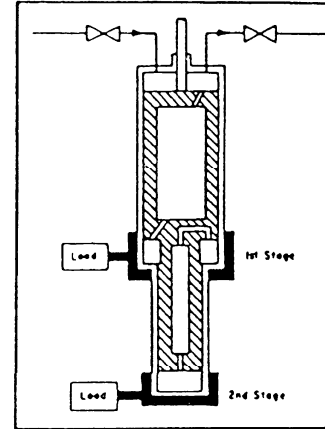


Figure 5 Two-Stage Cryodyne Refrigerator

an elongated piston made from a material of low thermal conductivity.

Since the pressures above and below the piston are substantially equal, the piston needs no pressure seal. The piston is now more correctly called a "displacer," because it merely moves gas from one end of the cylinder to the other; no mechanical work is introduced, and thus the system is said to use a "no-work" cycle. The regenerator is placed inside the displacer to avoid unnecessary piping and to minimize heat losses.

The refrigerator shown in Figure 4 can achieve temperatures in the 30-77 K range. Since many of the applications of the CRYODYNE refrigerator are below that temperature, we can add a second, and even a third stage to produce temperatures below 10K.

The addition of a second stage (Figure 5) permits useful refrigeration down to 6 K.

Appendix C

Cryopump Monitor and Temperature Indicator CRYOPUMP MONITOR



Description:

- Displays cryopump operating temperature range for cryopumps equipped with a silicon diode temperature sensor.
- Mounts directly on the cryopump in any orientation, or may be mounted remotely.
- Small, permanently mounted power pack may be plugged into any 117 VAC outlet.

Features:

- 3 light emitting diodes - Green, Yellow and Red

LED Condition

Green on
Yellow on
Red on

Pump Condition

Pump is cold (<20K) and operating.
Pump is cooling down or warming up.
Pump is warmed up sufficiently
(regenerated) to be rough pumped and
turned on again.

- Temperature range – 8 to 308 Kelvin

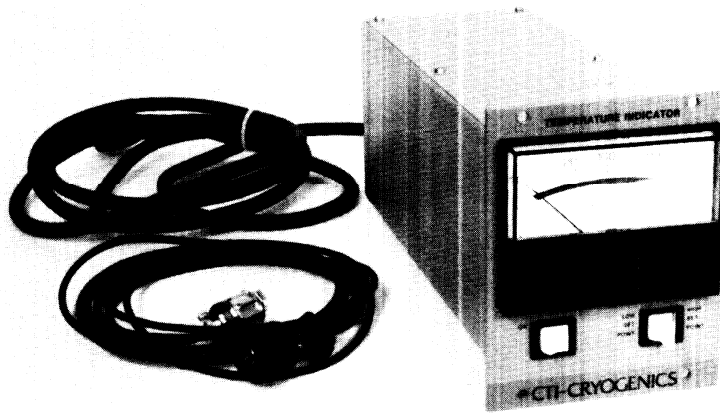
Specifications:

- Electrical Requirements:
117 VAC ($\pm 20\%$), 1 ϕ , 50/60 Hz
10 ft. power cord
- Weight: 15 oz. (423 g)
- Dimensions: 3.35 \times 1.5 \times 2.25 inches (85 \times 38 \times 57mm)

Cryo-Torr® cryopump accessories

TEMPERATURE INDICATOR

Part No. 8042001



Description

- Provides remote temperature reading of cryopump operating temperature for cryopumps equipped with a silicon diode sensor.
- Fits into a standard 5¼ in. high, 19 in. rack, one quarter panel.

Specifications

- Electrical Requirements:
115 VAC or 208/230 VAC, 1Ø, 60 Hz 200/220 VAC, 1Ø, 50 Hz
6 ft. power cord
¼ amp fuse
- Weight: 5 lbs.
- Dimensions: 5-½" x 4-¼" x 10-¾" inches
(132.5 x 104.7 x 265mm)

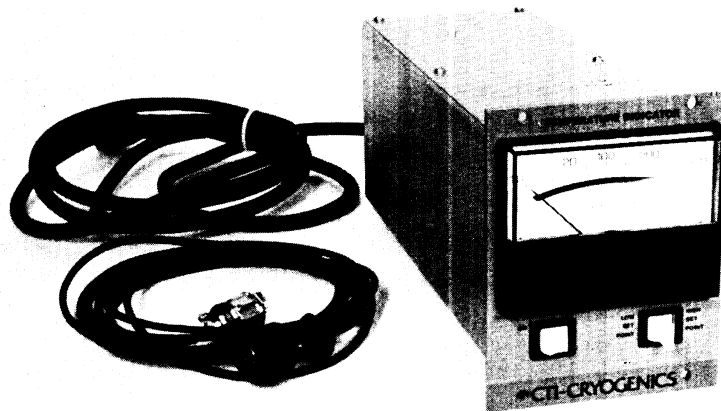
Features

- Analog panel meter with readout in Kelvin.
Range 10 to 320 Kelvin.
Accuracy: $\pm (2.5K + 2.5\%$ of meter reading).
- High and low temperature set points, adjustable range from 10 to 320 Kelvin.
- One temperature indicator can serve multiple Cryo-Torr cryopumps with a customer supplied selector switch.

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6 ft. power cord
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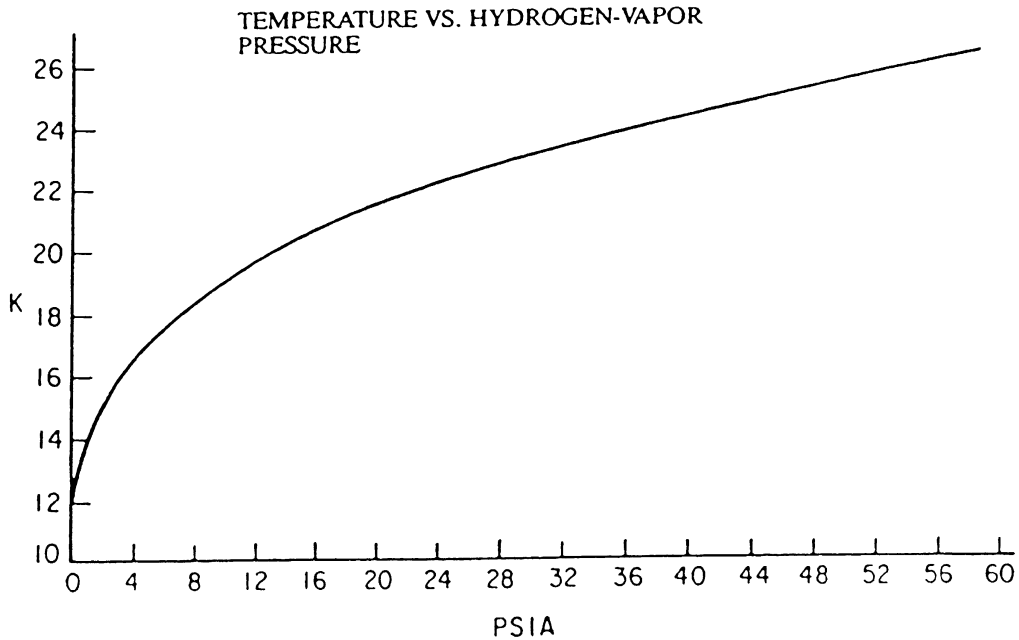
- Analog panel meter with readout in Kelvin.
Range 10 to 320 Kelvin.
Accuracy: $\pm(2.5K + 2.5\%$ of meter reading).
- High and low temperature set points, adjustable range from 10 to 320 Kelvin.
- One temperature indicator can serve multiple Cryo-Torr cryopumps with a customer supplied selector switch.

Appendix D

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 not be used to measure temperatures higher than 26K.



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

Appendix E

Remote Cryodyne Refrigerator Operation

Remote Operation

Note: Remote operation of the Cryodyne Refrigeration System is available when used with the 8500 Compressor; the Model 1020 R/RW Compressor does not provide this option.

An electrical schematic is provided, see Figure E.1, for fabrication of an external switching circuit. This feature provides the capability for remote ON/OFF switching of the complete system (8500 Compressor and all cold heads) and for individual switching of electrical power to each of the cold head connectors J2, J3 and J4. It is mandatory that all three remote switching features be utilized simultaneously. The switching circuit is connected into the control module of the 8500 Compressor by means of the fourteen-pin system remote connector J5, which is located at the rear of the control module. Note that J5 jumper connector is installed on the compressor as shipped.

Assembling the Switching Circuit

Assemble the remote switching circuit to suit your installation requirements as follows:

1. Uncouple the J5 jumper connector from the 8500 Compressor. Wire the remote connector using 18-gauge stranded copper wire and a remote switch or relay contact with a minimum rating of 150 mA at 24 VAC. Follow the schematic in Figure E.1, ensuring compliance with all national, state, and local standards.

2. After fabricating and checking the remote switching circuit, connect it to the system remote connector J5.
3. Ensure that the system power ON/OFF switch on the 8500 Compressor is off, and that all the remote switches are off before connecting the input power cable to the power source. The system power ON/OFF switch and circuit breaker safety features on the compressor will remain operational even with the remote switching circuit being utilized.
4. Turn the system power ON/OFF switch on the compressor module to the ON position and check for proper operation of the remote switching circuit.
5. If the use of the remote control switching circuit is to be discontinued, then simply disconnect the remote control switching circuit from J5 and reinstall the J5 jumper connector.

Note: The Cryodyne system will not operate if the jumper connector is not reinstalled.

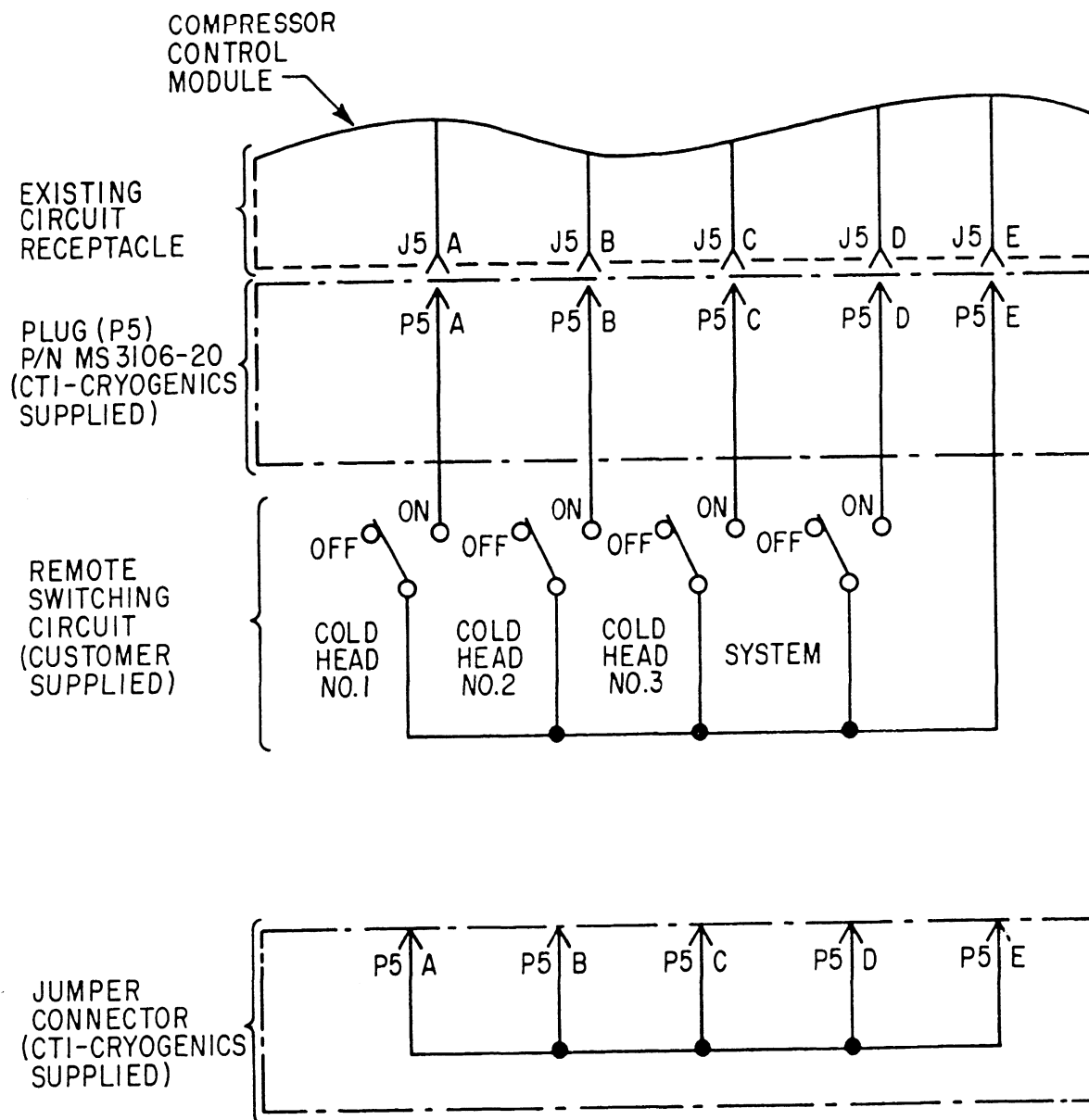
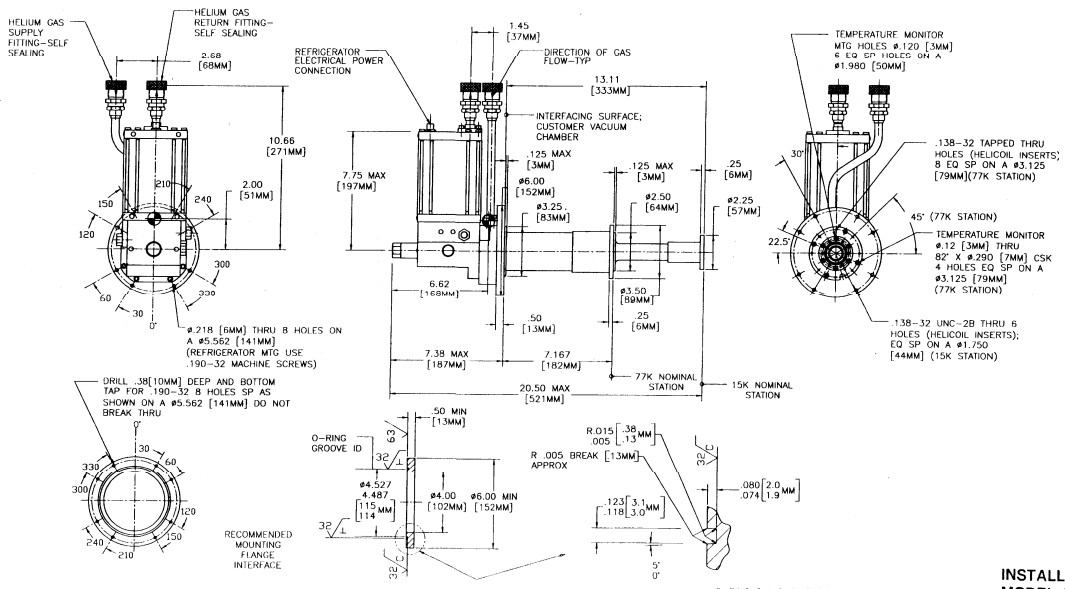


Figure E.1 Remote refrigerator switching schematic

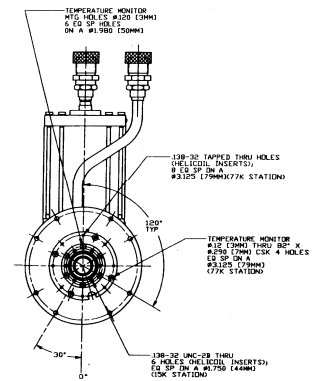
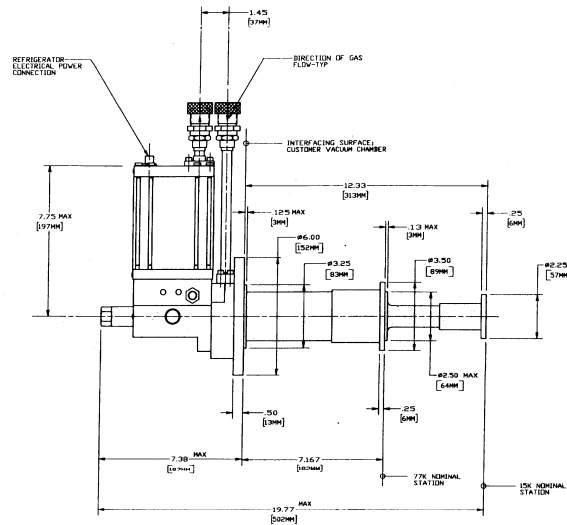
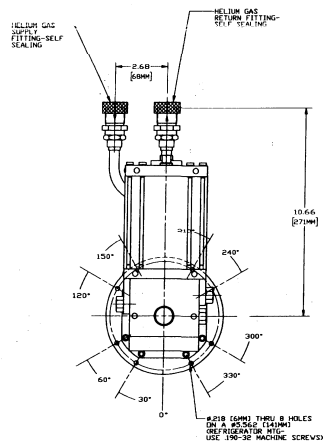
Appendix F

Cold Head Installation/Interface Drawings

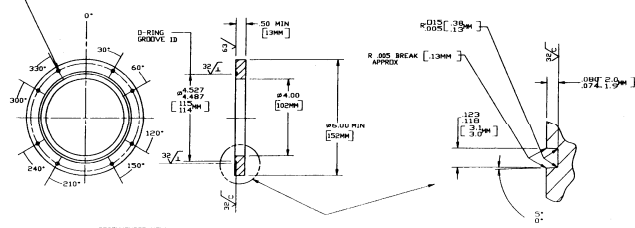


NOTES:
 1. DIMENSIONS ARE NOMINAL IN INCHES, UNLESS OTHERWISE SPECIFIED.
 2. ϕ DENOTES APPROXIMATE CENTER OF GRAVITY

INSTALLATION/INTERFACE
 MODEL 1020
 REFRIGERATOR
 Drawing 8018095 Rev. 100



REF. DIMENSIONS ARE APPROXIMATE
 Ø1119 TAP FOR 190-32
 Ø HOLES OF A
 SECTION ON A #5262 (141MM)
 DO NOT BREAK THRU



RECOMMENDED MOUNTING
 FLANGE INTERFACE

NOTES:
 1. DIMENSIONS ARE NOMINAL IN INCHES, UNLESS OTHERWISE SPECIFIED.

O-RING GLAND DIMENSION
 USE O-RING 62-157

INSTALLATION/INTERFACE
 MODEL 1050 REFRIGERATOR
 Drawing 8004047 Rev. H

Appendix G - Customer Support Information

Customer Support Center Locations

To locate a Customer Support Center near you, please visit our website www.helixtechnology.com on the world wide web and select *CONTACT* on the home page.

Guaranteed Up-Time Support (GUTS)

For 24 hour, 7 day per week Guaranteed Up-Time Support (GUTS) dial:

800-367-4887 - Inside the United States of America

508-337-5599 - Outside the United States of America

Product Information

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

E-mail

For your convenience, you may also e-mail us at:

techsupport@helixtechnology.com

Appendix G - Customer Support Information