Cold Head Models CH-204S, CH-208R and CH-208L

Operating Manual

Sumitomo (SHI) Cryogenics of America, Inc.
1833 Vultee Street
Allentown, PA 18103-4783
U.S.A.

Revision A: February 2009 **267456A**

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SAFETY

GENERAL

SCAI equipment is designed to operate safely when the installation, operation and servicing are performed in accordance with the instructions in this technical manual. Consult the nearest SCAI Service Center with any questions you may have concerning the use or maintenance of this equipment.

For Service Center locations, see the Service section in this manual.

SPECIAL NOTICES

Three types of special notices -- **WARNINGS, CAUTIONS** and **NOTES** are used in this technical manual.

⚠ WARNING

WARNINGS call attention to actions or conditions that can result in injury or death.

CAUTION

CAUTIONS call attention to actions or conditions that can result in damage to the equipment or in abnormal performance.

NOTE

NOTES give important, additional information, explanations or recommendations related to the appropriate topic or procedure.

WARNINGS and **CAUTIONS**, like other safety instructions, appear within rectangles in the text where they are applicable. Because of their importance, they are summarized in this Safety section, and should be read first.

NOTE

Parallel lines (||) in the right margins identify changes from the previous revision.

WARNINGS

HIGH PRESSURE GAS HAZARDS

Never use compressed helium gas from a cylinder without a proper regulator. Overpressure can cause serious injury if the system equipment ruptures.

Always wear eye protection when handling pressurized gas lines and other pressurized equipment. Never apply heat to a pressurized gas line or other pressurized components.

Disconnect gas lines only when the compressor is stopped. Disconnecting the cold head while it is cold can create excessively high internal pressure as the gas warms. Material failure and uncontrolled pressure release can cause serious injury.

Use two wrenches when disconnecting a gas line coupling to avoid loosening the shield cooler coupling. Gas pressure can project the coupling with enough force to cause serious injury.

The cold head is charged with helium gas. Vent both supply and return Aeroquip couplings to atmospheric pressure before disassembly, except when disconnecting gas lines. Uncontrolled pressure release can cause serious injury.

Always vent a gas-charged component before beginning to disassemble its couplings. Gas pressure can launch a loose coupling with enough force to cause serious injury.

When relieving the vacuum with dry air or nitrogen, backfill only to atmospheric pressure (zero psig). The vacuum shroud is not a pressure vessel. Serious injury and equipment damage can result.

HIGH VOLTAGE HAZARDS

All electrical supply equipment must meet applicable codes and be installed by qualified personnel.

Disconnect the power to the compressor before troubleshooting the electrical components.

Permit only qualified electrical technicians to open electrical enclosures, to perform electrical checks or to perform tests with the power supply connected and wiring exposed. Failure to observe this warning can result in serious injury or death.

AVOID INJURY FROM BURNS. During operation, some surfaces under the compressor's cover become hot. Allow the compressor to cool for 1/2 hour after shutdown before removing the cover for maintenance.

CAUTIONS

PRESERVE YOUR WARRANTY. Modification to equipment without the consent of the manufacturer will void the warranty.

Specifications require the use of 99.995% pure helium gas. Using a lesser quality of helium can damage the system and void the warranty.

AVOID GAS LEAKS. Check the condition of the gasket seal on the male half of each Aeroquip coupling. Be sure the gasket seal is in place and the sealing surfaces on both the male and female halves are clean before connecting. Replace the gasket seal if it is damaged or missing.

Keep the gas line couplings aligned when making or breaking a coupling connection. Leaks can occur due to the weight of the gas line or due to a sharp bend near the connection.

PREVENT EQUIPMENT DAMAGE. Damage to gas lines can result from crimping by repeated bending and repositioning.

Do not heat cold head assemblies above 80º C (176º F).
Do not heat cold head cylinders with instrumentation removed above 150º C (300º F).

The cold head's orifice has been factory set for optimal performance at customer's stated electrical frequency. This frequency, either 50 or 60 Hz is identified by the label on the cold head's motor housing. Check that the labeled frequency agrees with customer's frequency. Operating an cold head labeled "Factory set for 50 Hz operation" on 60 Hz electrical service may damage the displacer. The orifice in a cold head labeled "Factory set for 50/60 Hz operation" needs no adjustment.

AVOID A MALFUNCTION. Repeatedly charging the system with helium gas rather than locating and repairing gas leaks can cause a malfunction. Impurities are introduced at an abnormal rate and can freeze in the shield cooler.

Do not allow air to get into the helium gas refrigerant of the system. Moisture from the atmosphere can seriously degrade cold head performance.

Do not install a valve disc whose critical surface is dirty or blemished. Avoid damaging the critical surfaces of the valve stem and the valve disc. Degraded operation can result.

The O-rings used on the displacer are made of special material. Do not substitute standard O-rings. Do not apply a lubricant to any displacer O-rings, seal rings or seal grooves.

Avoid trapping contaminants inside the cold head. Do not assemble parts that are in questionable condition.

Never open the vacuum valve when the connected vacuum pump is not running. The cold cold head can cryopump oil into the shroud (non-MRI applications.)

AVOID CONTAMINATION. Follow the charging or venting procedures to prevent reversed flow of system gas. Do not charge through the supply coupling. Do not vent through the return coupling. Reversed flow can contaminate the system with compressor oil.

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SERVICE

HEADQUARTERS

Sumitomo (SHI) Cryogenics of America, Inc.
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Allentown, PA 18103-4783

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FAX: (610) 791-0440

Service

TEL: (800) 525-3071
or
TEL: (610) 791-6750

SERVICE CENTERS

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Sumitomo (SHI) Cryogenics of America, Inc.
1833 Vultee Street
Allentown, PA 18103-4783

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Sunnyvale, CA 94085

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INTRODUCTION

All the cold heads (expanders) described in this manual are two-stage cryogenic refrigerators that operate on the Gifford-McMahon refrigeration cycle. Each cold head uses helium gas from a helium compressor to produce the cold temperatures. Electricity to power the cold head's valve motor is supplied from the compressor by the cold head cable.

To be functional, the cold head is fitted with other parts or equipment so it can remove heat from the connected interfaces.

Applications include laboratory systems for test sample cooling, cryopumps for clean, high-vacuum service and shield coolers and recondensers for cryogenic conservation, as in magnetic resonance imaging (MRI) medical diagnostic instruments.

The typical, complete operating system, using SCAI standard components, consists of a helium compressor(s), interconnecting gas lines, the cold head with its interface attachments, and optional instrumentation.

Pressures are stated as gauge, not absolute. Psig is pounds per square inch gauge and kPa is Kilopascals gauge,

$$kPa = 6.895 \times psig.$$

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PRINCIPLES OF OPERATION

The major parts of the Displex™ Cold Head are shown in Figure 1. Figures 2, 3, 4 and 5 illustrate the valve and displacer movements, and the directions of gas flow.

The valve motor drives the rotating valve disc that controls the flow of the helium gas. The high-pressure helium gas drives the reciprocating displacer assembly within the cylinder assembly. Ports in the valve disc allow two complete cycles of the displacer for every revolution of the valve disc.

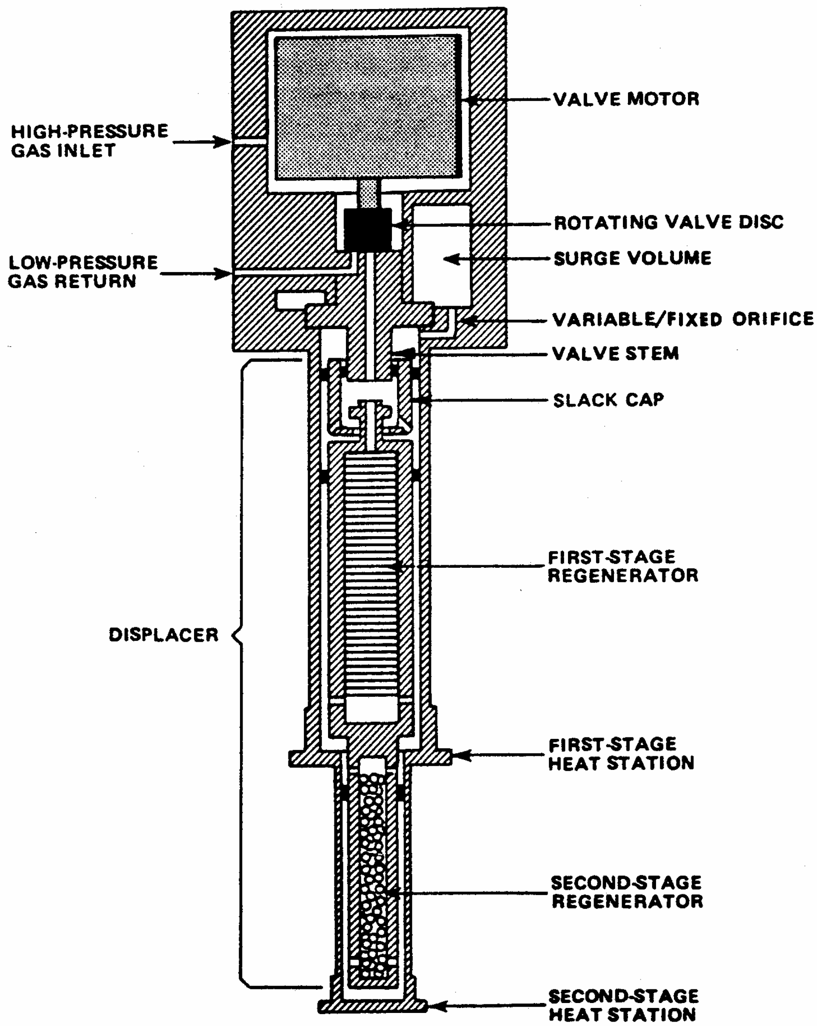

Figure 1 Simplified Cold Head Diagram

As shown in Figure 2, high-pressure helium admitted by the rotating valve disc flows through passages in the slack cap and enters the regenerators. The regenerators, cooled during the previous exhaust stroke, cool the incoming gas as it flows through.

Gas flowing through the slack cap passages raises the cap to engage and lift the displacer, creating expansion space at the heat stations for gas that has passed through the regenerators. See Figure 3. Also, as the displacer lifts, gas above the slack cap is partially compressed and pushed through the orifice into the surge volume.

Before the displacer reaches the valve stem, the valve closes. Compression of gas above the slack cap decelerates and stops the displacer before it can collide with the valve stem.

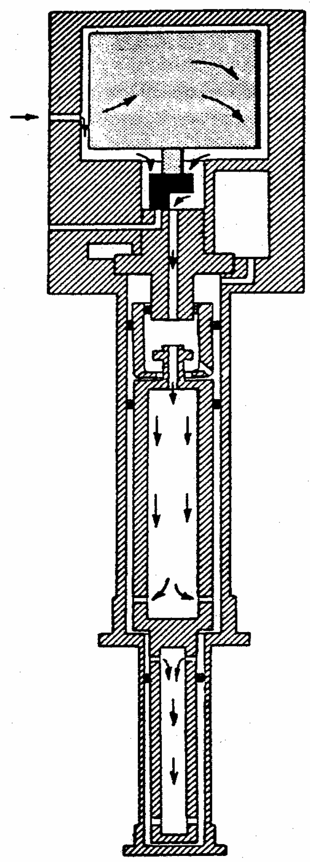

Figure 2 Cold Head Intake, Valve Open, Displacer Down

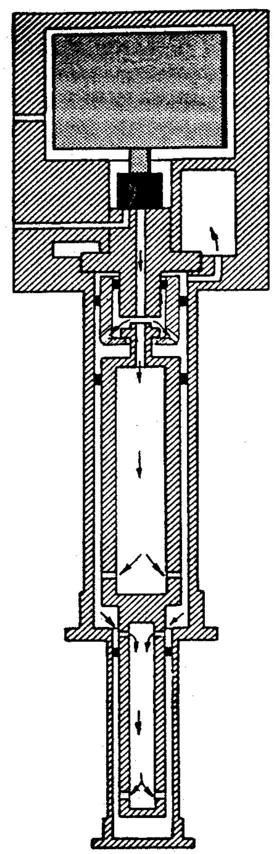

Figure 3 Cold Head Valve Closed, Displacer Moving Up

Figure 4 shows the exhaust stroke. When the valve opens to exhaust, high-pressure gas at the heat stations is free to expand and refrigerate them. The exhausting gas also cools the regenerators.

As the pressure drops, partially compressed gas bleeds from the surge volume, pushes the slack cap and displacer toward the heat stations, forces exhaust, and positions the displacer for the next cycle.

The valve closes again, and residual gas acts as a cushion to decelerate and stop the displacer before it collides with the heat stations. See Figure 5.

Heat station temperature is progressively reduced to provide refrigeration at cryogenic temperatures.

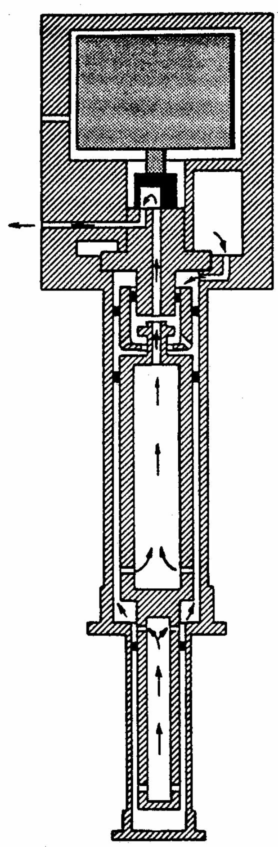

Figure 4 Cold Head Exhaust, Valve Open, Displacer Up

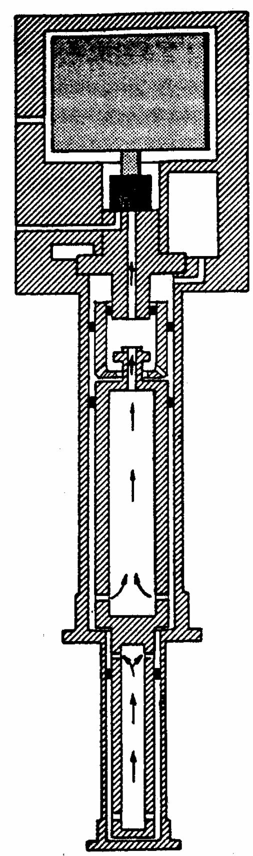

Figure 5 Cold Head Valve Closed Displacer Moving Down

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COMPONENTS

Figure 6 shows an external view of a typical cold head.

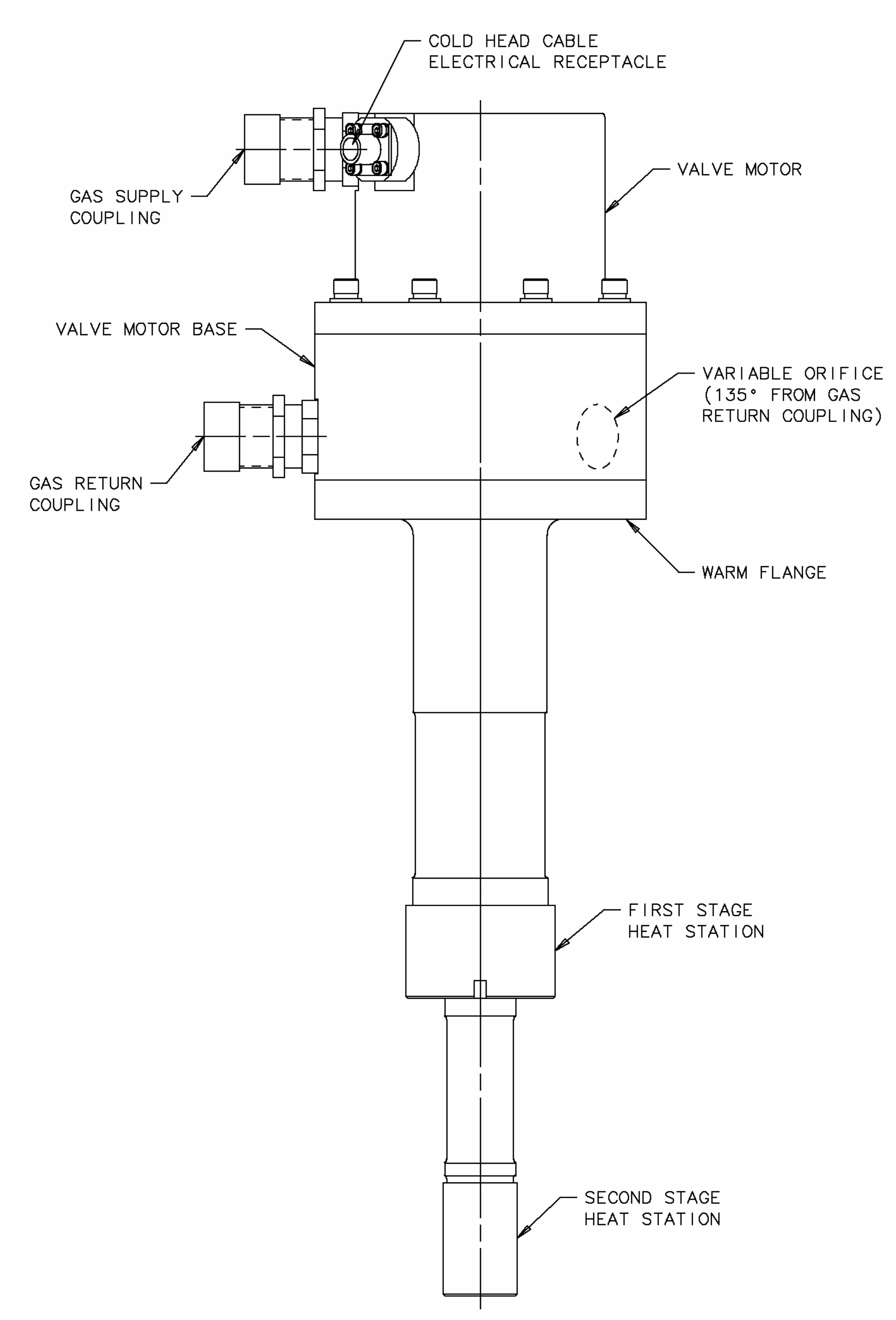


Figure 6 Typical Cold Head Assembly

Valve Motor Assembly

The valve motor assembly, Figure 7, includes the valve motor and motor base. The cold head cable electrical receptacle and the gas supply (red) coupling are mounted directly on the valve motor housing. The motor base includes the gas return (green) coupling.

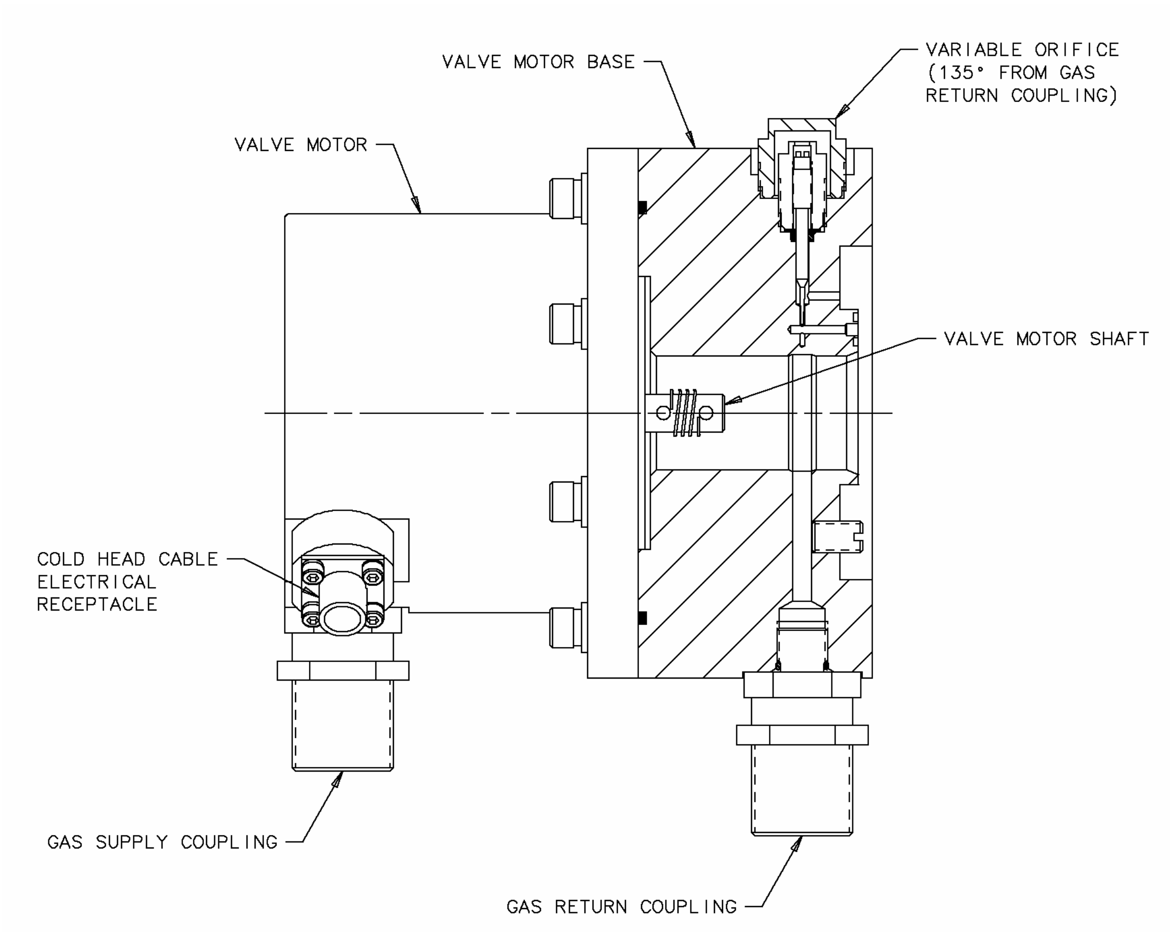


Figure 7 Valve Motor Assembly

There is an O-ring seal between the base and the valve motor. The motor shaft extends through a hole in the base and is fitted with roll pins and a compression spring which form a coupling for the valve disc. The only purpose of the motor is to turn the valve disc.

Bolts passing through the valve motor and base fasten the valve motor assembly to the warm flange of the cylinder assembly. There are no internal fasteners connecting the valve motor to the valve motor base.

Valve Disc

The valve disc, Figure 8, fits on the motor shaft and is held against the valve stem by the combination of a spring and gas pressure. Valve disc rotation and porting and valve stem porting combine to time and control the cold head's working cycle by reversing the gas flow.

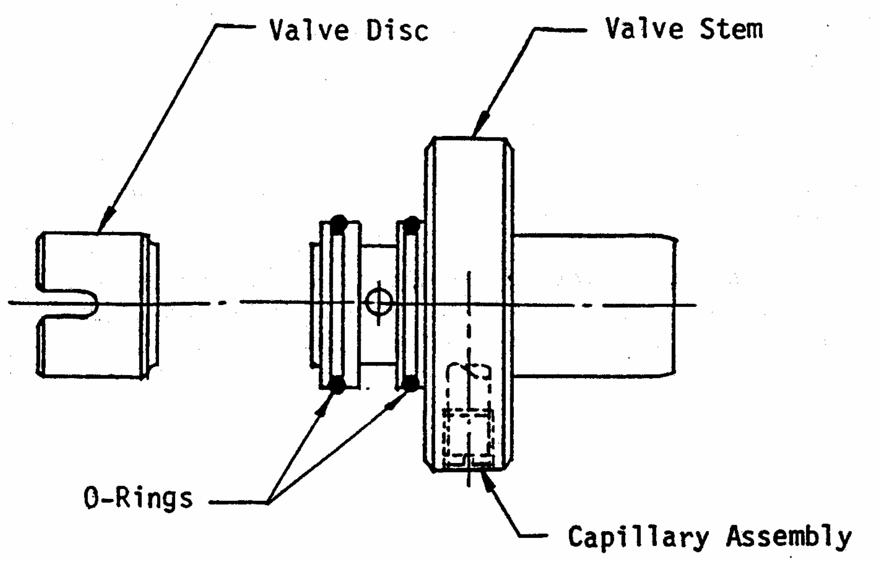


Figure 8 Valve Disc and Valve Stem

Cylinder Assembly

The cylinder assembly houses the displacer assembly. The cylinder assembly consists of:

Warm Flange - This is the main mounting base of the cold head. The valve motor assembly is bolted to this flange. O-rings seal the mating faces. When used, the skirt is attached to the warm flange. The standard lab cold head models have a flat warm flange without a skirt.

Heat Stations - These are the areas of concentrated refrigeration, located at the ends of the first- and second-stage regenerators. For a cryopump application, first- and second-stage cryopanels fasten to the first- and second-stage heat stations respectively. For a laboratory application, typically a sample holder is mounted to the second-stage heat station and a radiant heat shield mounts to the first stage.

Valve Stem/Displacer Assembly

The valve stem, Figure 8, seats in the motor base. The valve disc rotates against the valve stem. The mating surface of the valve stem is specially treated to resist wear. O-rings provide sealing between the valve stem and the motor base. The stem includes a capillary assembly. This capillary and an adjustable orifice in the valve motor base control the flow of gas to and from the surge volume.

The valve stem shank is also specially treated to resist wear and acts as a slide for the slack cap and a guide for the displacer. The mating surfaces on both the stem and the disc must be protected when these components are not in the cold head. See the Maintenance section.

The valve stem/displacer assembly, housed within the cylinder assembly, includes the first- and second-stage displacers, the valve stem, the slack cap and the seal rings. See Figure 9.

The displacer assembly must be protected from humidity whenever it is not in the cylinder assembly.

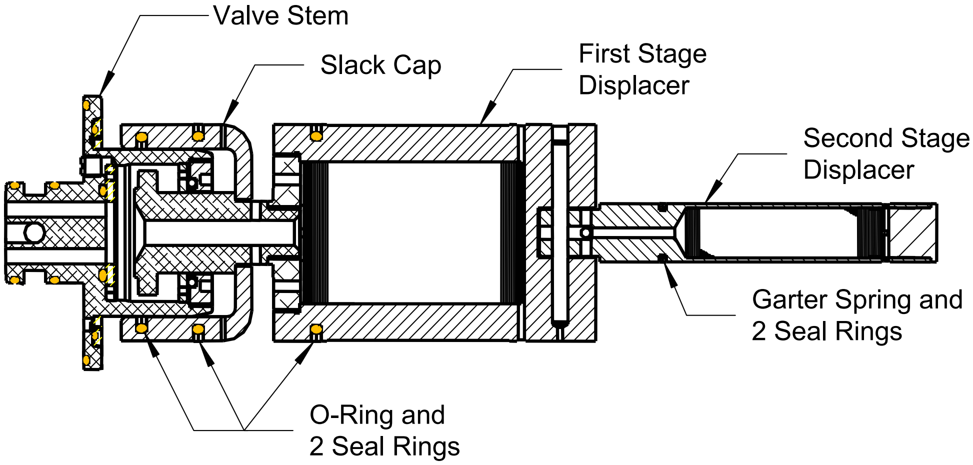


Figure 9 Valve Stem/Displacer Assembly

Displacer Seals

The displacer has four sets of seal rings: One set on each of the outsides of the second stage, the first stage, the slack cap and one set on the inside of the slack cap.

The second-stage seal rings are backed by a garter spring to maintain contact pressure. Pressure at the other three locations is maintained by special backing O-rings.

The seal rings are split for easy installation and removal.

Cold Head Orifice

The cold head orifice valve has been factory set for optimal performance at 50 or 60 Hz.

SPECIFICATIONS

Refrigeration Capacities (Typical)

Cold Head Model	Hz	First Stage Capacity	Second Stage Capacity
CH-204S	60 50	16.2 W @ 80 K 13.5 W @ 80 K	7.1 W @ 20 K 6.7 W @ 20 K
CH-204SFF	60 50	– –	9.0 W @ 20 K 7.5 W @ 20 K
CH-204S-N	60 50	– –	3.0 W @ 10 K 2.5 W @ 10 K
CH-208R	60 50	80 W @ 77 K 65 W @ 77 K	7.5 W @ 20 K 6.0 W @ 20 K
CH-208L	60 50	35 W @ 77 K 28 W @ 77 K	10.0 W @ 20 K 8.0 W @ 20 K

Pressure Relief Valve

The cold head shall be connected to a gas supply source having a pressure relief valve set at 2760 kPa (400 psig) gauge maximum.

NOTE

SCAI compressors are supplied with properly set pressure relief valves.

Weight

Cold Head M/N	Weight
CH-204S	7.8 kg (17 lbs.)
CH-208R	11.6 kg (25.6 lbs.)
CH-208L	11.8 kg (26.0 lbs.)

Electrical Characteristics

220 V3~, 0.2 ampere, 50/60 Hz, or
220 V~ with 2.0 Mfd capacitor, 0.2 ampere, 50/60 Hz

This cold head can be operated from either a single phase or a three phase compressor.

The cold head cable from the compressor supplies power for the valve motor.

0.63-ampere over-current protection shall be provided in the cold head power supply.
A time-lag fuse shall be provided in each ungrounded supply conductor.

NOTE

The appropriate over current protection is provided when SCAI Cold Heads are operated with SCAI compressors.

Mounting Position

Functions normally in any position. Position is determined by customer's application.

Insulating Vacuum

1 x 10^{-3} torr. See Evacuate Shroud in the Installation section.

Color Codes

Aeroquip self-sealing couplings on the cold head and on the gas lines are color coded to identify their function as follows:

Red - Helium gas supply to the cold head from the compressor.

Green - Helium gas return from the cold head to the compressor.

Refrigerant Quality

Refrigerant is 99.995% pure helium gas with a dew point less than -50° C (-58° F) at 2070 kPa (300 psig).

Maintenance Interval

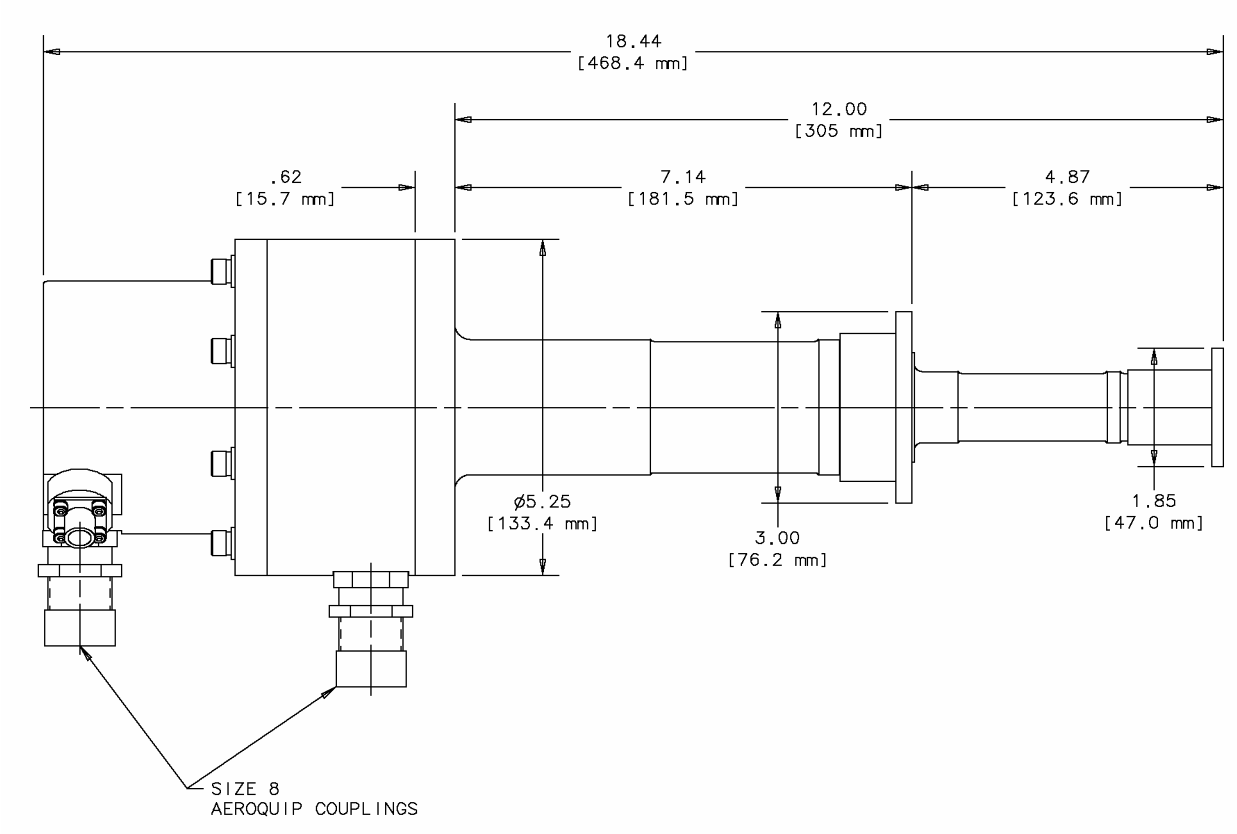
Parts	Typical Maintenance Interval
Valve Stem/Displacer	13,000 operating hours
Valve Disc	13,000 operating hours

Supplier Name and Address

Sumitomo (SHI) Cryogenics of America, Inc.
1833 Vultee Street
Allentown, PA 18103-4783
U.S.A.

(610) 791 - 6700

Dimensions



Dimensions are in inches and (millimeters). See Figures 10, 11, 12 and 13.

Figure 10 CH-204S Cold Head Outline Dimensions

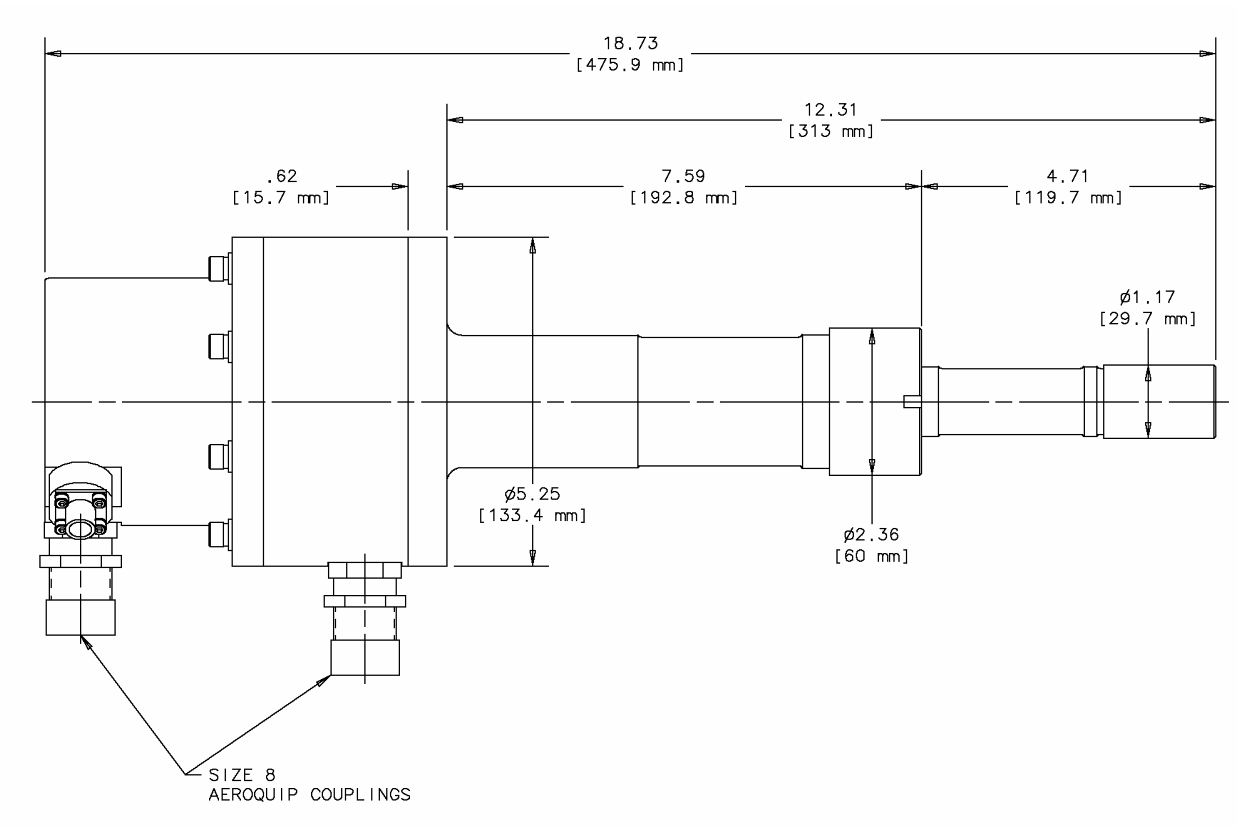


Figure 11 CH-204SFF Cold Head Outline Dimensions

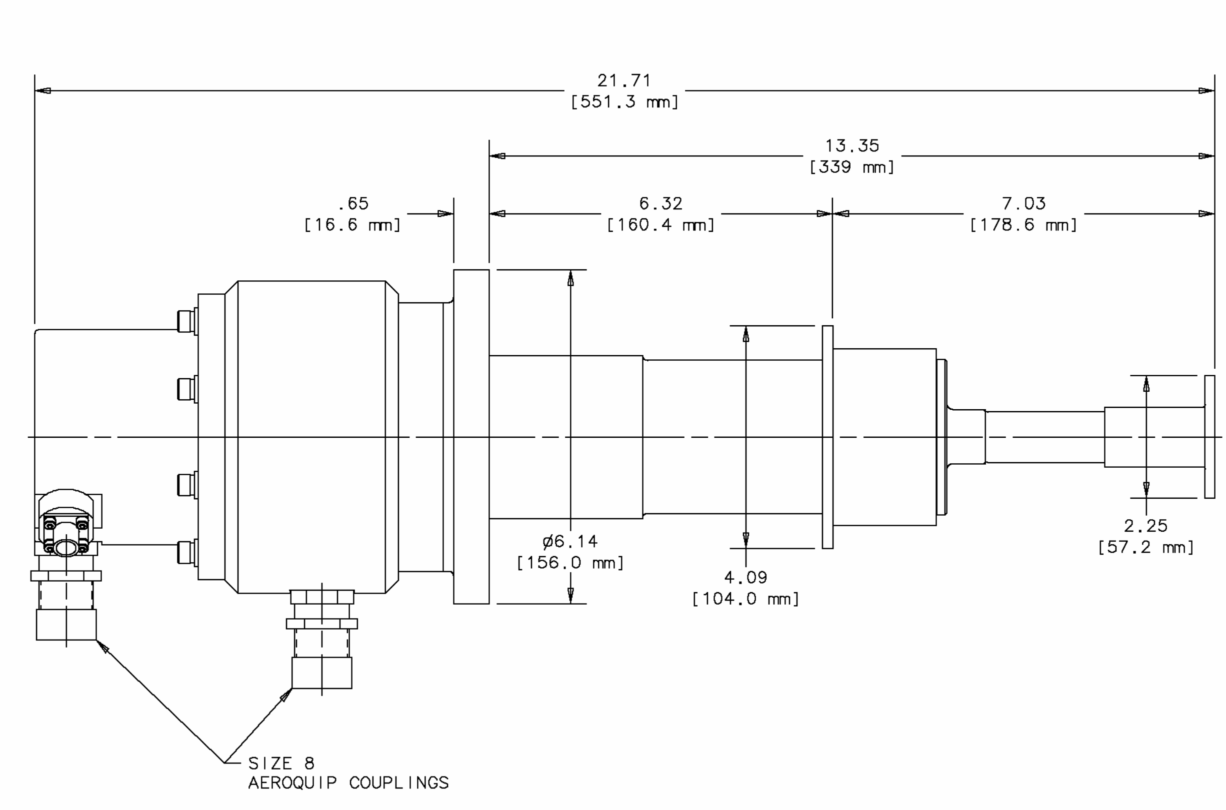


Figure 12 CH-208R Cold Head Outline Dimensions

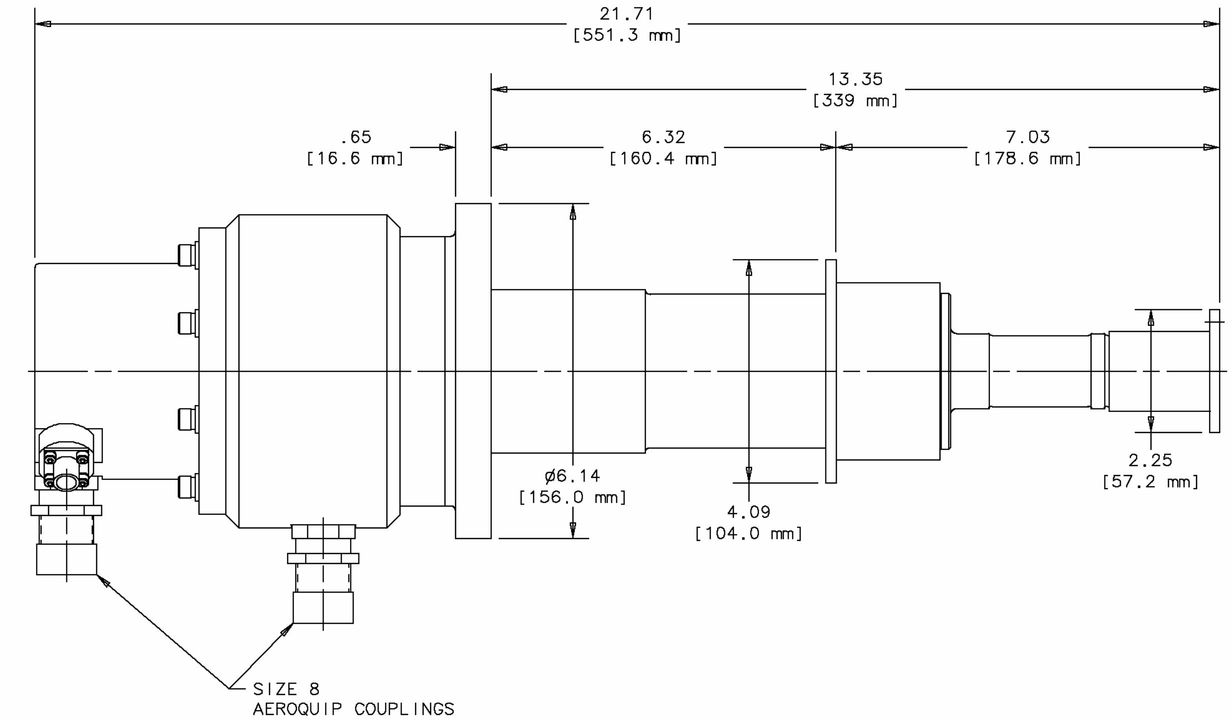


Figure 13 CH-208L Cold Head Outline Dimensions

Regulatory Compliance

Declaration of Conformity

Manufacturer’s Name	Sumitomo (SHI) Cryogenics of America, Inc.
Manufacturer’s Address	1833 Vultee Street Allentown, PA 18103 U.S.A.
Authorized Representative’s Name	Sumitomo (SHI) Cryogenics of Europe, Ltd.
Authorized Representative’s Address	3 Hamilton Close Houndmills Industrial Estate Basingstoke Hampshire RG21 6YT United Kingdom
Type of Equipment	Cryogenic Refrigeration Systems

Application of Council Directives 2004/108/EC, 2006/95/EC, 98/37/EC

CH-204S Cold Head CH-208R Cold Head CH-208L Cold Head	IEC 60204-1 Edition 4.1, 2000-05 EN 61000-6-4:2001, part 2 CISPR 11:2004 EN 61000-6-2:2001 EN 61000-4-2:2001 EN 61000-4-3:2006 EN 61000-4-4:2004 EN 61000-4-5:2005 EN 61000-4-6:2004 EN61000-4-8 A1:2001 EN 61000-4-11:2004

I, the undersigned, hereby declare that the equipment specified above conforms to the Directives 2004/108/EC, 2006/95/EC, and 98/37/EC.

By: ______________
Yehuda Bentov
Operations Manager

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INSTALLATION

Inspection

Unpack the equipment and inspect it for damage.

Cold heads are shipped fully charged with helium gas. After all system components have been connected, the equalization pressure indicated by the compressor gauge will determine if charging or venting of the system is required.

Mounting

Customer's application determines the mounting position and method. The cold head will function in any position.

Allow sufficient space for installing and removing the interfacing attachments, connecting the gas lines.

Interconnections

Gas Lines

Tools required: Open-end wrenches, 1", 1 1/8", 1 3/16".

⚠ **WARNING**

AVOID INJURY. When handling pressurized gas lines and other pressurized equipment, always wear eye protection. Never apply heat to a pressurized gas line or other pressurized components.

CAUTION

AVOID GAS LEAKS. Check the condition of the gasket seal on the male half of each Aeroquip coupling. Be sure the gasket seal is in place and the sealing surfaces on both the male and female halves are clean before connecting. Replace the gasket seal if it is damaged or missing.

CAUTION

AVOID GAS LEAKS. Keep the gas line couplings aligned when making or breaking a coupling connection. Leaks can occur due to the weight of the gas line or due to a sharp bend near the connection.

NOTE

Retain the threaded dust caps and plugs to re-cover the couplings when they are not in use. They protect the couplings from damage and prevent entry of contaminants.

1. Using two wrenches, connect one end of the cold head supply gas line to the supply (red) coupling on the cold head. Tighten all Aeroquip couplings to 4.8 ± 0.7 kgf m (35 ± 5 ft. lbs.). See Figure 12.

Tighten each coupling before proceeding to the next one.

.

2. Connect the other end of this gas line to the supply coupling on the compressor.
3. Connect one end of the cold head return gas line to the return (green) coupling on the Cold Head.
4. Connect the other end of this gas line to the return coupling on the compressor.

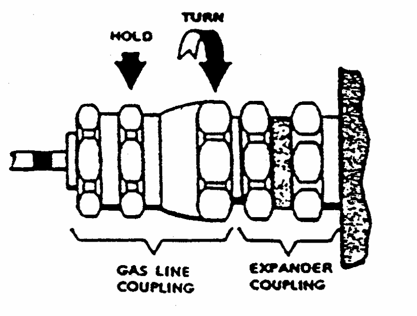

Figure 14 Connect Aeroquip Coupling

<u>Install the Cold Head Cable</u>

1. Connect the cold head cable to the cold head electrical receptacle on the valve motor housing.
2. Connect the other end to the cold head receptacle on the compressor.

NOTE

For some applications, the cold head cable from the compressor is connected to an outboard electrical box. The cold head cable(s) from the outboard electrical box then connect(s) to the cold head cable receptacle on the cold head(s).

<u>Evacuate Shroud</u>

The insulating, vacuum shroud should be pumped down to about 1 x 10^{-3} torr. A two-stage, oil-sealed mechanical vacuum pump with an ultimate pressure capability in the 10^{-4} torr range is satisfactory but mechanical pumps begin to backstream oil when operated close to the molecular flow range. Backstreaming must be prevented to avoid contaminating the shroud by pumping to a pressure no lower than 1 x 10^{-3} torr.

Cleaner types of vacuum pumps, such as liquid nitrogen cold-trapped diffusion pumps, turbo molecular pumps and cryopumps, allow pumping to lower pressures such as 10^{-6} torr. The lower pressures reduce the residual heat load on the refrigerator at the start of the cooldown.

CAUTION

AVOID A MALFUNCTION. Never open the vacuum valve when the connected vacuum pump is not running. The cold cold head can cryopump oil into the shroud (non-MRI applications).

OPERATION

Startup

Starting the compressor(s) starts the cold head's valve motor.

NOTE

Breaking the insulating vacuum while the cold head is below room temperature will cause frosting of the outside vacuum vessel. It is preferable to break the vacuum with dry nitrogen or dry air. This prevents the accumulation of moisture in the vacuum space, facilitating faster, subsequent pumpdowns.

⚠ WARNING

AVOID INJURY. When relieving the vacuum with dry air or dry nitrogen, backfill only to atmospheric pressure (zero psig). The vacuum shroud is not a pressure vessel. Serious injury and equipment damage can result.

⚠ WARNING

AVOID INJURY Never use compressed helium gas from a cylinder without a proper regulator. Overpressure can cause serious injury if the system equipment ruptures.

NOTE

During cooldown, the cold head may be noisy. When the unit is cooled down, the noise level will decrease to normal. If this does not occur, refer to the procedure in Cold Head Orifice Adjustment that follows.

Vacuum Bake the Cold Head

CAUTION

PREVENT EQUIPMENT DAMAGE. Do not heat cold head assemblies above 80° C (176° F).

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TROUBLESHOOTING

The Troubleshooting Guide that follows lists problems that can occur and suggests causes and corrective actions. Consult also the Troubleshooting section of the Technical Manual for the Compressor.

⚠ WARNING

AVOID ELECTRIC SHOCK. Permit only qualified electrical technicians to open electrical enclosures, to perform electrical checks or to perform tests with the power supply connected and wiring exposed. Failure to observe this warning can result in serious injury or death.

CAUTION

PRESERVE YOUR WARRANTY. Modification to equipment without the consent of the manufacturer will void the warranty.

Troubleshooting Guide

Problem	Possible Cause	Corrective Action
Valve motor does not start when the compressor starts.	Cold head cable is not connected.	Stop the compressor. Connect the cable.
	Open circuit in the cold head cable.	Disconnect the cold head cable. Check each conductor for continuity. Replace the cable if necessary.
	Defective valve motor.	Consult a SCAI Service Center.
	Blown fuse in the compressor's electrical box.	See the Troubleshooting section in the Compressor Technical Manual.
Valve motor hums but does not start.	Defective valve motor.	Consult a SCAI Service Center.
	Open circuit in the cold head cable.	Disconnect the cold head cable. Check each conductor for continuity. Replace the cable if necessary.
	Valve disc has stalled.	Check system operating pressures are within specification, or valve is worn and needs replacement.

Problem	Possible Cause	Corrective Action
Valve motor runs but there is no cooldown.	No insulating vacuum.	Check the vacuum system for operation and leaks.
	Gas line couplings are not fully engaged.	Be sure that all Aeroquip couplings are fully engaged and torqued.
	Gas lines are connected wrong.	Reconnect. See the Installation section.
	Compressor output is inadequate.	Troubleshoot the compressor. See the Compressor Technical Manual.
Shroud is sweating or abnormally cold.	Loss of insulating vacuum.	Check the vacuum system for operation and leaks.
Abnormally noisy operation after a sustained period of five to fifteen minutes.	Incorrect compressor pressures.	Troubleshoot the compressor. See the Compressor Technical Manual.
	Contaminants in the gas.	Perform Gas Cleanup and Recharging procedure on the cold head, compressor and the gas lines. Refer to the appropriate Technical Manuals. If the problem remains, consult a SCAI Service Center.
	Mismatch of electric service frequency with the frequency on the label adjacent to the cold head's electrical receptacle.	Consult a SCAI Service Center.
Intermittent operation.	Compressor is cycling on and off.	Troubleshoot the compressor.
Temperature cycling.	Contaminated gas is causing an Cold Head freezing-thawing cycle.	Perform Gas Cleanup and Recharging procedure on the cold head, compressor and the gas lines. Refer to the appropriate Technical Manuals. If the problem remains, consult a SCAI Service Center.
Sudden loss of refrigeration capacity.	Loss of insulating vacuum.	Check the vacuum system for operation and leaks.

Problem	Possible Cause	Corrective Action
Sudden loss of refrigeration capacity. (continued)	Compressor malfunction.	Troubleshoot the compressor. See the Compressor Technical Manual.
	Defective valve motor or capacitor.	Perform all the electrical checks.
Slow loss of refrigeration capacity.	Small insulating vacuum leak.	Leak check and repair the vacuum system.
	Worn seals in the Cold Head.	Consult a SCAI Service Center.
	Cold Head is leaking.	Consult a SCAI Service Center.

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