Sumitomo
(SHI) CRYOGENICS OF AMERICA, INC.

CH-210 Cold Head

Operating Manual

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

Revision B: April 2007 **266003A**

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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. For Service Center locations, see the Service section of 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 in the text where they are applicable. Because of their importance, they are summarized in this Safety section, the first section to be read.

NOTE

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

WARNINGS related to Magnetism

AVOID INJURY. When released in a high magnetic field, ferrous tools and parts can become hazardous projectiles. Do not use ferromagnetic tools when the magnet is at field.

AVOID EXPOSURE. People with pacemakers, defibrillators or ferrous implants should avoid exposure to strong magnetic fields. The long-term effects of high magnetic fields are not well understood. Keep personal exposure to a minimum.

WARNINGS related to Cryogenics

AVOID INJURY. Extreme cold can cause frostbite. When handling system components, be careful not to touch any frosted parts.

Do not splash cryogenic liquids on any areas of clothing or exposed skin. Damage to skin tissue will result. Always wear eye protection.

AVOID ASPHYXIATION. Be sure the work area is well ventilated.

General WARNINGS

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

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

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.

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 cold head coupling. Gas pressure can project the coupling with enough force to cause serious injury.

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 cause damage to the system and void the warranty.

PREVENT EQUIPMENT DAMAGE. Cold head installation and removal should be performed by trained personnel only.

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

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.

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

SERVICE

	SERVICE CENTERS	HEADQUARTERS
Eastern U.S.A.	Sumitomo (SHI) Cryogenics of America, Inc. 1833 Vultee Street **Allentown, PA 18103-4783** TEL: (800) 525-3071 or (610) 791-6750 FAX: (610) 791-3904	Sumitomo (SHI) Cryogenics of America, Inc. 1833 Vultee Street **Allentown, PA 18103-4783** Sales and Parts TEL: (800) 525-3072 or (610) 791-6700 FAX: (610) 791-0440 Service TEL: (800) 525-3071 or TEL: (610) 791-6750

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INTRODUCTION

The cold head described in this manual is a two-stage cryogenic refrigerator that operates on the Gifford-McMahon refrigeration cycle. It uses helium gas from a helium compressor(s) 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 and MRI shield coolers.

The typical, complete operating system, using SCAI standard components, consists of a CH-210 cold head, a helium compressor with its power supply cable, interconnecting gas lines and a cold head power cable.

Pressures are stated as gauge, not absolute. Pressure units are bar and pounds per square inch gauge (psig). For reference:

1 bar = 14.5 psig
1 MPa = 10 bar

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.

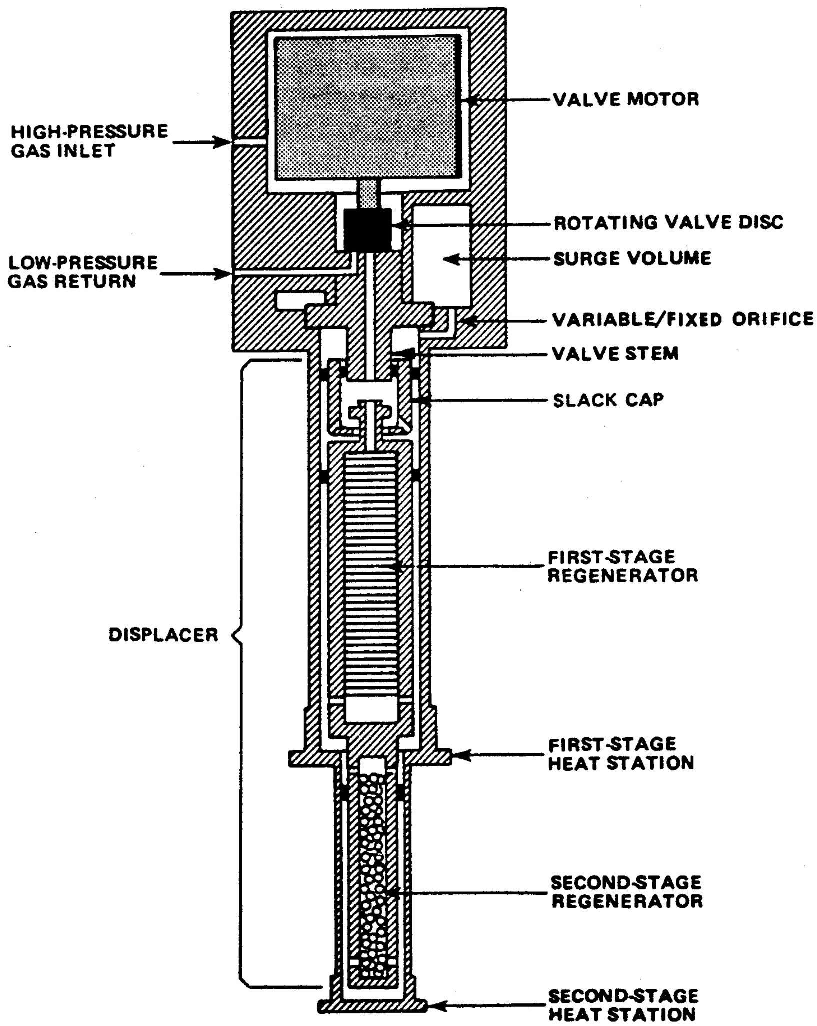

Figure 1 Simplified Cold Head Diagram

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.

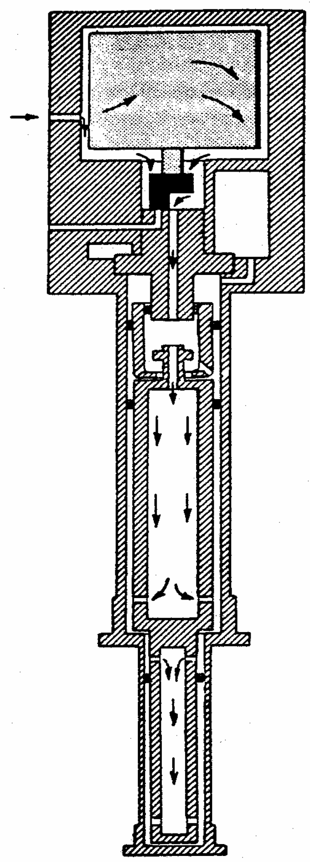

Figure 2 Cold Head Intake, Valve Open, Displacer Down

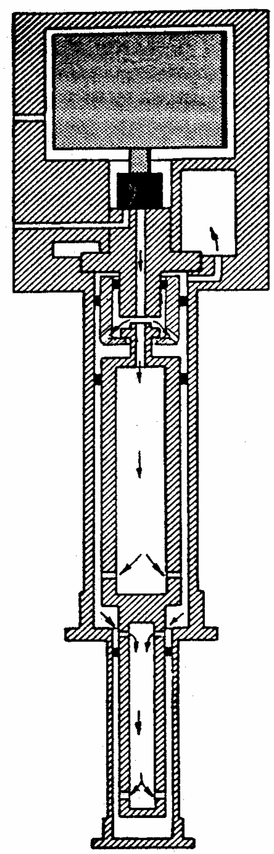

Figure 3 Cold Head Valve Closed, Displacer Moving Up

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 cools 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.

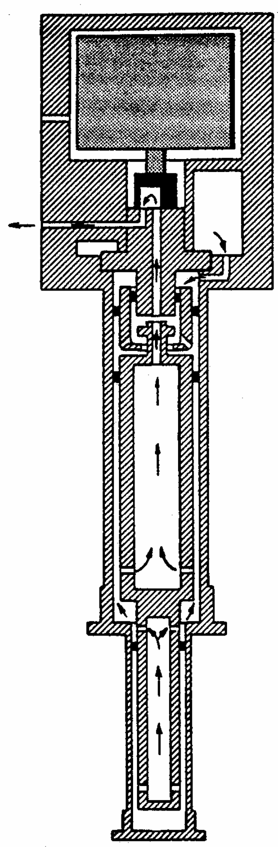

Figure 4 Cold Head Exhaust, Valve Open, Displacer Up

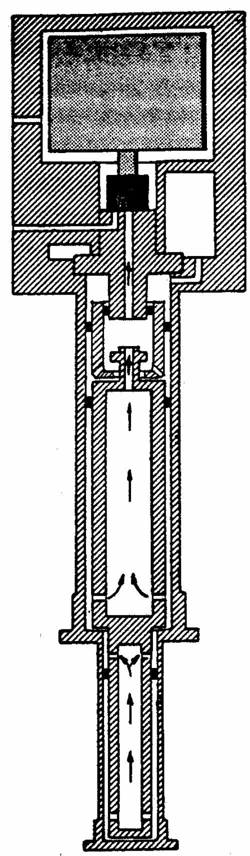

Figure 5 Cold Head Valve Closed, Displacer Moving Down

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

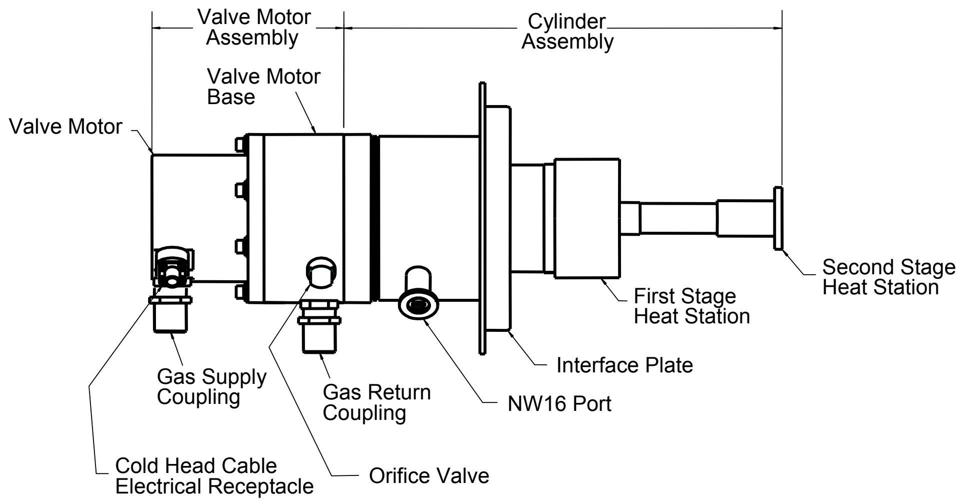

Figure 6 Typical Cold Head Assembly

Valve Motor Assembly

The valve motor assembly, shown in Figure 6 includes the 3-phase valve motor and motor base. See Figure 7. 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.

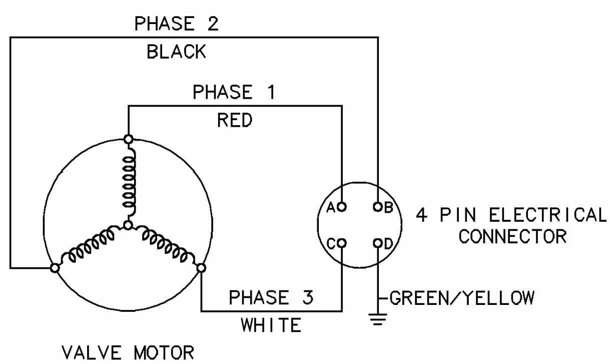

Figure 7 Valve Motor Electrical Schematic

There is an O-ring seal between the motor 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 that form a coupling for the valve disc. The motor's only purpose is to turn the valve disc.

Bolts passing through the valve motor housing and base fasten the valve motor assembly to 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.

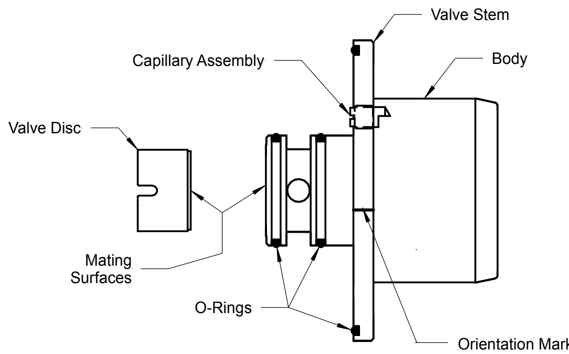

Figure 8 Valve Disc and Valve Stem

Valve Stem

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. Three 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 motor base control the flow of gas to and from the surge volume.

The valve stem body 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.

The valve stem is assembled to the displacer. See Figure 9.

Cylinder Assembly

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

> Heat stations – These are the areas of concentrated refrigeration located at the ends of the first- and second-stages. The heat stations have holes for mounting customer supplied interface components. 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.
>
> Skirt - Is equipped with an MW16 ISO vacuum pumpout port and mounting flange.

Valve Stem/Displacer Assembly

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

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

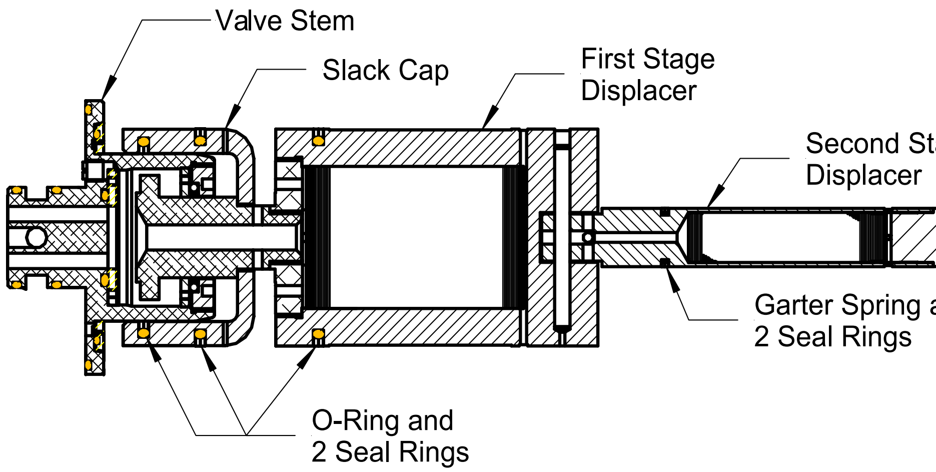

Figure 9 Valve Stem/Displacer Assembly

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. See Figure 9.

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

NOTE

> The cold head's orifice valve has been factory set for optimal performance at 50 or 60 Hz. Normally, no adjustment is required.

The orifice valve has been set at the factory for maximum refrigeration capacity. The orifice is located in the edge of the valve motor base, near the return gas coupling. See Figure 6.

In most systems tested, minimum temperature was achieved with the orifice valve stem about ten (10) turns in from full out position.

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SPECIFICATIONS

Refrigeration Capacity, 50/60 Hz (Typical, without attachments).

First stage	110 W @ 77K
Second stage	6 W @ 20K

See Typical Capacity Maps for 60 and 50 Hz, Figures 10 and 11.

Cooldown Time (Typical, without attachments) 35 minutes to 20K.

Weight 10.9 kg to 13.8 kg (24 to 30.4 pounds), depending upon the configuration.

Pressure Relief Valve

The cold head shall be connected to a gas supply source having a pressure relief valve set at 27.8 bar (400 psig) gauge maximum.

NOTE

SCAI compressors are supplied with properly set pressure relief valves.

Electrical Characteristics

220 V3~, 0.2 amperes, 50/60 Hz.

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

0.4-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

Size 8, male (8M), Aeroquip self-sealing couplings on the cold head and female (8F) couplings 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.

Maintenance Intervals

Valve disc	13,000 operating hours (18 months)
Valve stem/displacer assembly	13,000 operating hours (18 months)

Refrigerant Quality

Refrigerant is 99.995% pure helium gas with a dew point less than -50° C (-58° F) at 20.7 bar (300 psig).

Helium Gas Pressures

Equalization pressure at 20° C (68° F) for 15.5 m (50 feet) long gas lines:

60 Hz system: 14.9-15.2 bar (216-220 psig)
50 Hz system: 15.6-15.9 bar (226-230 psig)

Typical operating pressures: Supply 20.0-22.8 bar (290-330 psig)
Return 5.5-6.6 bar (80-95 psig)

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 millimeters.

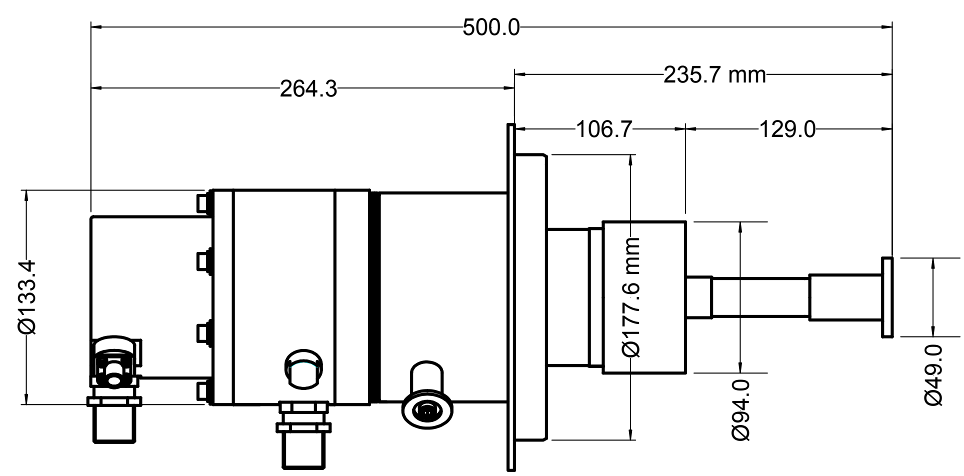

Figure 10 CH-210 Cold Head Outline Dimensions

Note: The 177.6 mm diameter is the sealing surface.

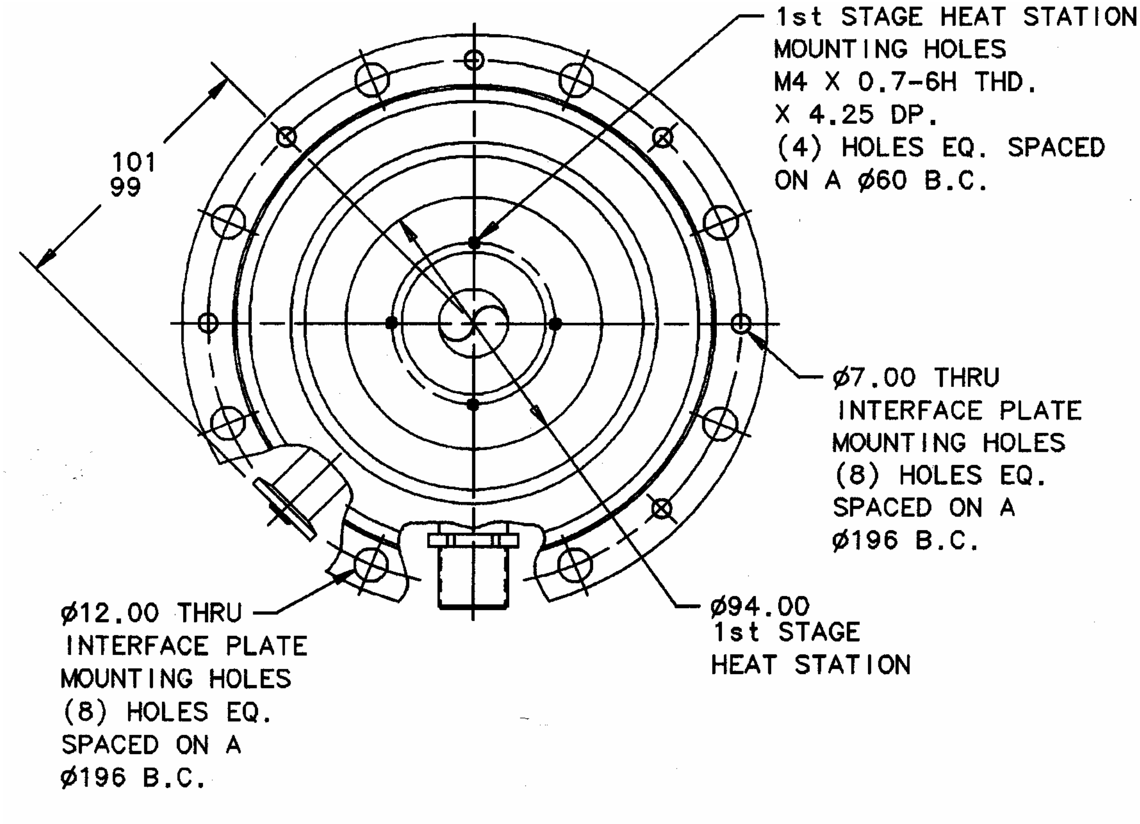

Figure 10a Interface Plate and First-Stage Heat Station, Mounting Holes

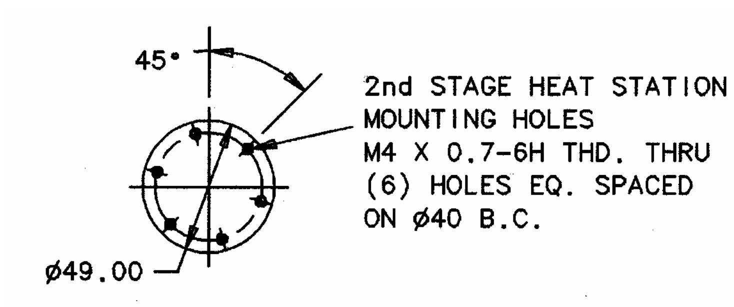

Figure 10b Second-Stage Heat Station, Mounting Holes

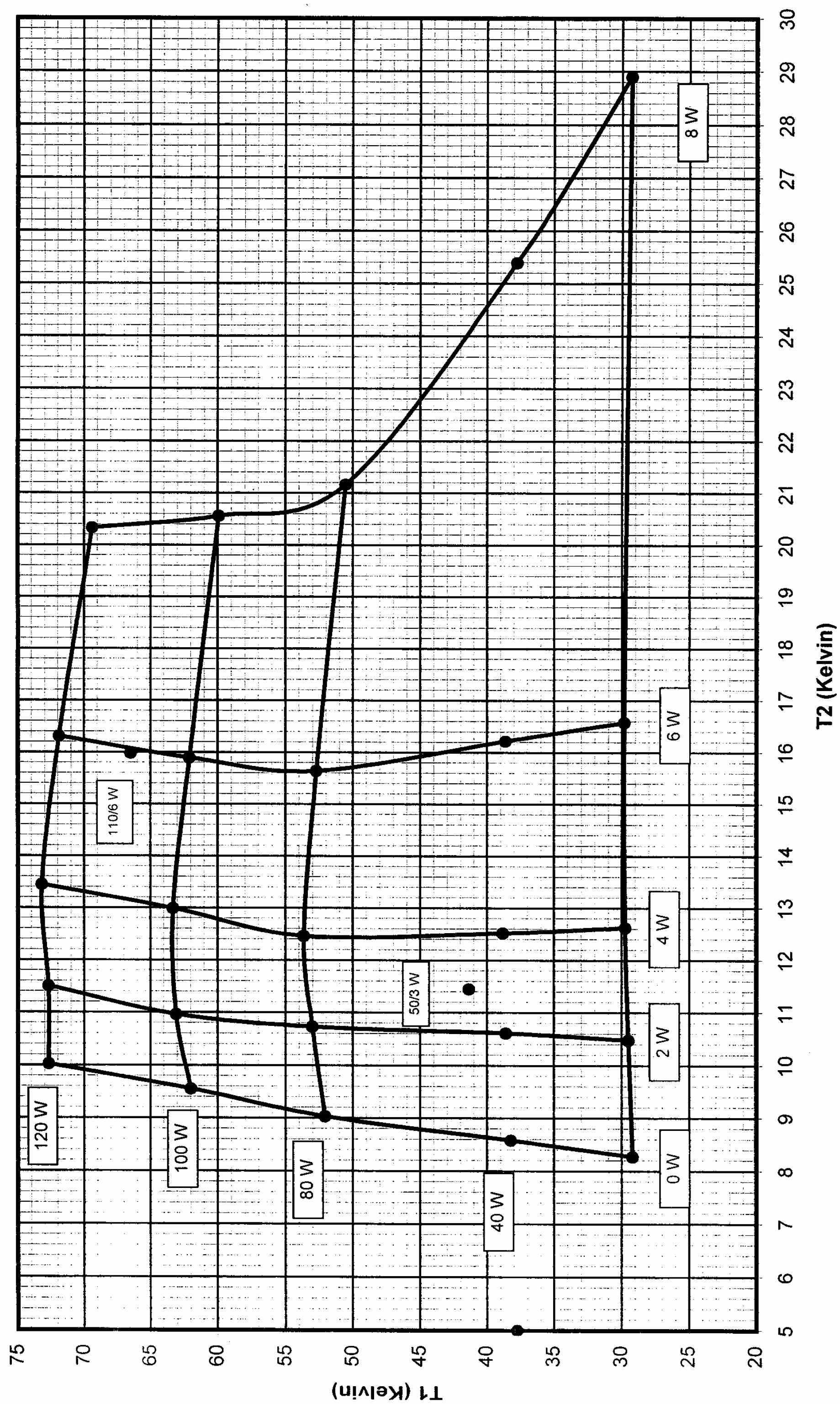

Figure 11 Typical Capacity Map, 60 Hz

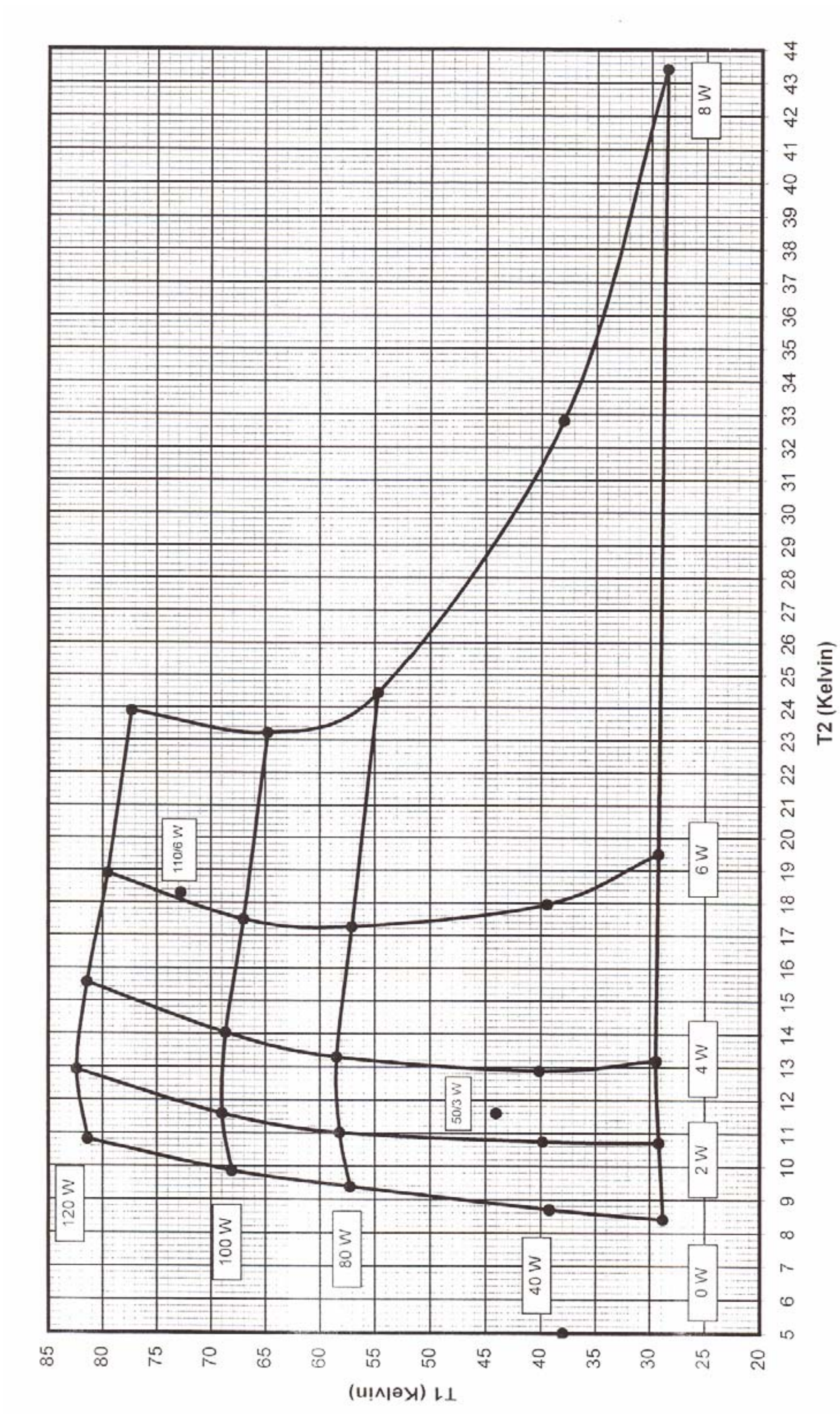

Figure 12 Typical Capacity Map, 50 Hz

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	2 Eros House Calleva Industrial Park Aldermaston Berkshire RG7 8LN, England
Type of Equipment	Cryogenic Refrigeration Systems

Application of Council Directives 89/336/EEC, 73/23/EEC, 98/37/EC

CH-210 Cold Head	UL 471: 1995 EN60204-1 Edition 4.1, 2000-05 EN60601-1-2-2001 EN60601-1 CISPRII, 4th Edition, 2003-03, AM1 2004-05 IEC 1000-4-2 IEC 1000-4-3 IEC 1000-4-4 IEC 1000-4-5, IEC 1000-4-6, IEC 1000-4-8 IEC 1000-4-11

CE

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directives.

By: Yehuda Bentov
Yehuda Bentov
Operations Manager

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 and connecting the gas lines.

Install the 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 (expander). Tighten all Aeroquip couplings to 4.8 ± 0.7 kgf m (35 ± 5 ft. lbs.). See Figure 13.

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.

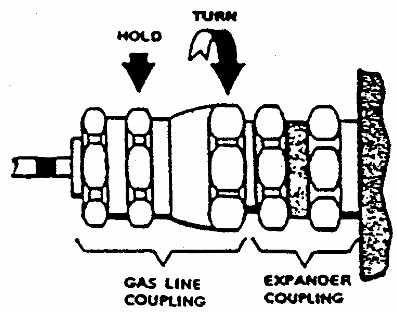

Figure 13 Connect Aeroquip Coupling

Install the Cold Head Cable

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.

Evacuate the Shroud

The insulating, vacuum shroud should be pumped down to about 1×10^{-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 back stream oil when operated close to the molecular flow range. Back streaming must be prevented to avoid contaminating the shroud by pumping to a pressure no lower than 1×10^{-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.

Disconnect the Gas Lines

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

> **⚠ WARNING**
>
> **AVOID INJURY.** Allow the cold head to warm to room temperature before disconnecting any gas lines. Cold gas trapped in the cold head can reach a dangerously high pressure as it warms.

> **⚠ WARNING**
>
> **AVOID INJURY.** Use two wrenches when disconnecting a gas line coupling to avoid loosening the cold head coupling. Gas pressure can project the coupling with enough force to cause serious injury.

1. Always use two wrenches. Use one wrench to hold the cold head (expander) coupling. Use the second wrench on the gas line coupling nut to break the connection. See Figure 14.

2. After breaking the connection, hold the coupling adapter with one wrench. Remove the gas line coupling from the cold head coupling with the second wrench. See Figure 15. Remove both gas lines from the cold head.

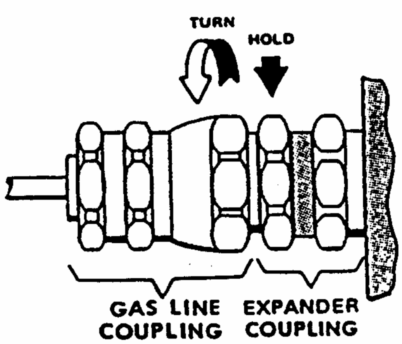

Figure 14 Break Gas Line Connection from the Cold Head

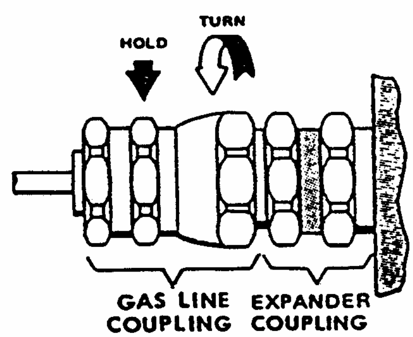

Figure 15 Disconnect Gas Line from the Cold Head

3. Screw a dust cap finger tight on to the cold head coupling.

4. If the cold head is not to be vented, screw dust caps on to its two Aeroquip couplings.

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OPERATION

Startup

Starting the compressor(s) starts the cold head's valve motor. When the cold head is used in laboratory systems, the sample and the interface must be attached to it.

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 Cold Head Orifice in the Components section of this manual.

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

⚠ 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.

Specifications require the use of 99.995% pure helium gas. Using a lesser quality of helium can cause damage to the system and 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.	Valve disc has stalled.	Check the system operating pressures. Consult a SCAI Service Center.
	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 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.

Problem	Possible Cause	Corrective Action
Valve motor runs, but there is no cooldown. (continued)	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.
Intermittent operation.	Compressor is cycling on and off.	Troubleshoot the compressor. See the Compressor Technical Manual.
Temperature is cycling.	Contaminated gas is causing a 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.
	Compressor malfunction.	Troubleshoot the compressor. See the Compressor Technical Manual.
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