

4K CRYOCOOLER Instruction Manual

UHE10F

UHE12F

UHE15F

Export Control Policy

When applying a refrigerator to a cryocooler for optical sensors, the cryocooler falls under row 6.A.2.d.2 of the control list established by The Wassenaar Arrangement, which is equal to row 10(2) of appended table 1 of Japan's Export Trade Control Order.

Customers must follow all related rules and regulations such as Foreign Exchange and Foreign Trade Act and take appropriate procedures when exporting or re-exporting our refrigerators.

Original Instructions

Introduction

Thank you for choosing our products. This instruction manual gives information and precautions on handling, installation, operation, and maintenance of the product.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. To ensure proper use of this product, read this instruction manual carefully and keep this manual close at hand so that you can use for reference during operation.

If you purchased our other products and/or optional devices with this product, read relevant instruction manuals carefully.

1. About the personnel who are involved in handling our products

All personnel involved in handling our products should take a general safety education and training that is officially accepted in the country where our product is used. The personnel are also required to have specialized knowledge/skills and qualification on the electricity, the machinery, the cargo handling, and the vacuum. Especially, the personnel should be familiar with handling a cryopump in order to use it safely. Since we offer a training session (which is subject to fees) as needed for people who use cryopumps for the first time, please do not hesitate to contact our Service Engineering Division to join the training session.

2. Warranty

2.1 Gratis warranty period and Warranty coverage

【Gratis warranty period】

Note that an installation period of less than one year after installation in your company or your customer's premises or a period of less than 18 months (counted from the date of production) after shipment from our company, which is shorter, is selected.

【Coverage】

(1) Failure diagnosis

As a general rule, diagnosis of failure should be done on site by customer.

However, ULVAC CRYOGENICS or our service network can perform this service for an agreed fee upon the customer's request. There will be no charge if the cause

of the breakdown is found to be a fault of ULVAC CRYOGENICS.

(2) Damage during transportation

When damage by delivery/transportation is admitted, the product will be repaired free of charge within the range of the guarantee expressed in the sales contract.

(3) Breakdown repairs

There will be a charge for breakdown repairs, replacements and on-site visits for the following seven conditions. In those cases the cost shall be your own expense even though the product is within the warranty period.

- ① Breakdowns due to improper storage or handling, careless accident, software or hardware design by the customer.
- ② Breakdowns due to modifications of the product without consent of the manufacturer.
- ③ Breakdowns due to maintenance of the product without authentic parts or breakdowns resulting from using the product outside the specified specifications of the product.
- ④ Breakdowns due to contamination or corrosion caused by user's use conditions.
- ⑤ Breakdowns due to natural disasters (such as fire, earthquake, flood, lightning, salt damage, and so on) , environmental pollution, irregular voltage, and /or usage of undesignated power source.
- ⑥ Breakdowns that are outside the terms of warranty.
- ⑦ Consumables and/or replacement service.

Since the above services are limited to within Japan, diagnosis of failures, etc are not performed abroad. If you desire the after service abroad, please contact ULVAC CRYOGENICS and consult us for details in advance.

2.2 Exclusion of opportunity loss from warranty liability

Regardless of the gratis warranty term, compensation to opportunity losses incurred to your company or your customers by failures of ULVAC CRYOGENICS products and compensation for damages to products other than ULVAC CRYOGENICS products and other services are not covered under warranty.

2.3 Repair period after production is discontinued

ULVAC CRYOGENICS shall accept product repairs for seven years after production of the product is discontinued.

3. Service Form

After the products are delivered, please fill out the following information in the blanks. If you have any questions or technical problems, please feel free to contact the nearest Customer Support Center or headquarters. Please refer to "Service Network".

| | | |
|---|---|-------|
| Cryopump/Super trap Model | : | _____ |
| Cryopump/Super trap Serial No. | : | _____ |
| Refrigerator Model | : | _____ |
| Refrigerator Serial No. | : | _____ |
| Compressor Model | : | _____ |
| Compressor Serial No. | : | _____ |
| Temperature controller/Thermal display Model | : | _____ |
| Temperature controller/Thermal display Serial No. | : | _____ |
| Option Part Model | : | _____ |
| Optional Part Serial No. | : | _____ |

4. Notes for repair and maintenance requests

We may decline your request for the repair or the maintenance of our products if you refuse to give us information about the presence of the hazardous substance and/or contaminant.

Also, please be aware that we do not accept liability for damages by the contaminant, which might be caused during transportation to our office or the nearest customer support center. To avoid such accident, please pay careful attention to packing of the product

5. In case of breakdown and accident

When breakdown or accident occurs, we may ask for keeping the product on site as it is or retrieving the product to investigate its cause. Also we may ask for reporting the detailed process and/or the operating condition. When unidentified malfunction was generated, please contact our Service Engineering Division or

the nearest customer support center with reference to the chapter of Service Network. We ask for cooperation about the above.

6. General Precautions

- (1) It is strictly prohibited to duplicate, open, and transfer this instruction manual or any of its parts to a third person without written permission from ULVAC CRYOGENICS.
- (2) Information in this document might be revised without a previous notice for the specification change and the improvement of the product.
- (3) If you have any questions or comments on this document, please do not hesitate to contact us. The phone numbers of local customer support centers are listed at the end of this manual.

Safety Considerations

Our products have been designed to provide extremely safe and dependable operation when properly used. Following safety precautions must be observed during normal operation and when servicing them.

**WARNING**

A warning describes safety hazards or unsafe practices which could result in severe injury or loss of life.

**CAUTION**

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

**Toxic gas or chemicals used.**

There is a risk of severe injury upon contact.

**Corrosive chemicals used.**

There is a risk of severe injury upon contact.

**Flammable gas used.**

There is a danger of fire or burn injury.

**Explosive gas used.**

There is a risk of fire or explosion.

**Hazardous voltage .**

Electric shock may cause severe injury or loss of life.

**Hot heating part present.**

There is a risk of burn injury.

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Table of Contents

| | |
|---|------------|
| Safety Instructions | S-1 |
| Disposal Considerations..... | IW-1 |
| 1. INTRODUCTION..... | 1-1 |
| 1.1. General | 1-1 |
| 1.2. Specifications | 1-3 |
| 1.3. Vacuum Chamber Specifications..... | 1-4 |
| 1.4. Regulations applicable (Cryocooler)..... | 1-5 |
| 2. INSPECTION | 2-1 |
| 2.1. Shipping List..... | 2-1 |
| 2.2. First Inspection of 4K Cryocooler..... | 2-2 |
| 3. INSTALLATION | 3-1 |
| 3.1. Auxiliary Equipments Required..... | 3-1 |
| 3.2. Mounting the 4K Cryocooler to the Vacuum Chamber | 3-3 |
| 3.3. Connecting Roughing Pump..... | 3-4 |
| 3.4. Connecting Cooling Water Pipe..... | 3-4 |
| 3.5. Connecting 4K Cryocooler to Compressor Unit (Connecting Flexible Hose) | 3-4 |
| 3.6. Connecting Remote Wiring..... | 3-5 |
| 3.7. Connecting Electrical Cables..... | 3-5 |
| 4. OPERATION | 4-1 |
| 4.1. Prior to Startup | 4-1 |
| 4.2. Mounting Samples (load)..... | 4-1 |
| 4.3. Rough Pumping | 4-1 |
| 4.4. Startup and Cooldown..... | 4-2 |
| 4.5. Normal Operation..... | 4-2 |
| 4.6. Shutdown Procedures..... | 4-3 |
| 4.7. Handling of Hazardous Materials..... | 4-4 |

| | |
|--|-------------|
| 5. Disconnection and Storage..... | 5-1 |
| 5.1. Disconnecting Flexible Hose | 5-1 |
| 5.2. Storage..... | 5-2 |
| | |
| 6. MAINTENANCE..... | 6-1 |
| 6.1. Scheduled and Unscheduled Maintenance..... | 6-1 |
| 6.2. Charging Helium Gas..... | 6-2 |
| | |
| APPENDICES | |
| A. Troubleshooting..... | A-1 |
| B. Flexible Hose..... | B-1 |
| C. Principles of Refrigerator Operation | C-1 |
| D. Dimensional Drawing | D-1 |
| E. Self-Certification | E-1 |
| | |
| SERVICE NETWORK..... | CS-1 |

Figures

| | | |
|------------|---|-----|
| Figure 1-1 | Typical Diagram of 4K Cryocooler System | 1-2 |
| Figure 3-1 | Recommended Mounting Flange for UHE10F,UHE12F and UHE15F .. | 3-1 |
| Figure 3-2 | Maintenance Space for UHE10F, UHE12F and UHE15F | 3-3 |
| Figure 3-3 | Connecting helium flexible hoses correctly..... | 3-6 |
| Figure 3-4 | Flexible hoses connection order | 3-7 |
| Figure 3-5 | Using two spanners to connect / disconnect flexible hoses | 3-8 |
| Figure 5-1 | Disconnecting Flexible Hose..... | 5-1 |
| Figure 6-1 | Charging helium gas | 6-3 |
| Figure C-1 | Principle of Refrigeration | C-1 |
| Figure C-2 | Principle of G-M Crycle Operation | C-4 |
| Figure C-2 | Two-stage Refrigerator..... | C-4 |
| Figure D-1 | External Drawing UHE10F | D-2 |
| Figure D-2 | External Drawing UHE12F | D-3 |
| Figure D-3 | External Drawing UHE15F | D-4 |

Tables

| | | |
|-----------|--|-----|
| Table 1-1 | 4K Cryocooler System Standard Composition..... | 1-3 |
| Table 1-2 | 4K Cryocooler Standard Capacity | 1-3 |
| Table 1-3 | 4K Cryocooler Composition Standard Specifications..... | 1-4 |
| Table 2-1 | Shipping List for 4K Cryocooler System | 2-1 |
| Table 2-2 | Shipping List for 4K Cryocooler..... | 2-1 |
| Table 6-1 | Maintenance Intervals | 6-2 |
| Table A-1 | Fault Diagnosis..... | A-1 |

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Safety Instructions

This chapter describes safety information for the customer when using our cryocooler. Before designing cryostat or other systems incorporating our cryocooler, or before using the cryocooler, read this section carefully for using the product safely.

1. Pressure relief valve must be attached to the cryostat and other cryogenic devices.



When using a cryogenic device such as a cryostat, heat transfer by gases is blocked normally by making the surrounding area of the cooling section vacuum. Customers are requested to supply a vacuum chamber around the cooling section (coldhead).

If gas is introduced into the vacuum chamber during the operation of the cryocooler, the gas is condensed and accumulated in the low-temperature section of the cryocooler. When the cryocooler is suspended operation, the gas condensed in the low-temperature section finally returns to the room-temperature gas as the cryocooler warms up. Accordingly, the pressure in the vacuum chamber increases. Positive pressure (pressure greater than atmospheric pressure) may be created in the vacuum chamber depending on the volume of the condensed gas. If it occurs, there is a potential risk of burst and shattering of a vacuum gauge attached on the vacuum chamber or a glass window for observation.

Be sure to attach an appropriate pressure relief valve to the vacuum chamber so that the pressure can be released immediately even in case the pressure of the vacuum chamber becomes positive (Figure 1).

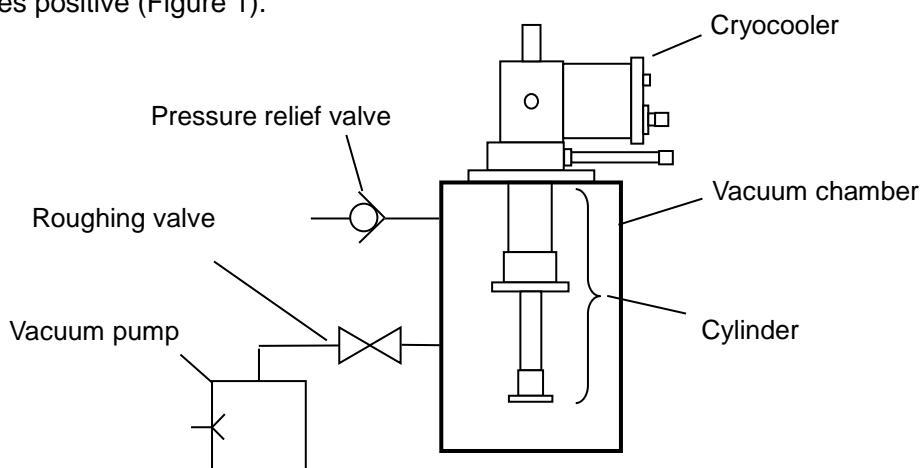


Figure 1 Attaching a pressure relief valve to the vacuum chamber

☆ **When flammable, explosive, combustion enhancing, toxic, or corrosive gas is pumped, connect a dedicated duct on the exhaust side of the pressure relief valve to prevent gas leak from the pressure relief valve to indoor circumference while the Cryocooler is suspended. (Refer to “5. Shutdown and warm up cryocooler after pumping flammable, explosive, or combustion enhancing gas.”)**

2. Check the safety of secondary-generated gases in process



Some gases would be secondarily generated in vacuum processes. They might contain flammable gas, explosive gas, toxic gas, or combustion enhancing gas.

For example, moisture in vacuum chamber, which comes from the atmosphere or the substrate, dissociates into hydrogen and oxygen in plasma. Those gases may be also discharged in large amounts from some evaporants or sputtering targets. **Oxygen is one of the gases which increase the susceptibility to burn, and hydrogen is flammable and explosive.** At atmospheric pressure, the mixed gas of hydrogen of 4% or more and oxygen of 5% or more are sure to cause the explosion momentarily if there is a cause (refer to “3.When flammable or explosive gases pumped”).

In addition, ozone might be secondarily generated when oxygen (O_2) or carbon dioxide (CO_2) is resolved in plasma. Ozone is toxic gas, and moreover liquid ozone might explode by the reaction with organic substances or any impact when it is in high concentration.

Therefore, it is necessary to check the safety of the secondarily generated gas as well as that of process gases.

For handling flammable or explosive gases, refer to “3.When pinging flammable or explosive gases” and “4.When pumping oxygen” in this chapter. Implement safety precaution and preventive maintenance as necessary.

For handling toxic gases, specific safety measures to the gases are sometimes required in addition to the safety measures for flammable or explosive gases, for example, purge of pump or dilution of exhaust duct with inert gases.

The customers are requested to take appropriate safety measures for managing the cryocooler operation in a safe manner appropriate for the system hardware or processes.

Table 1 Combustion range and detonation range of major gases
(Volume percentage against air)

| Gas | | Molecular Weight | Specific Gravity 0°C, 1atm | Boiling Point K | Combustion Range Vol. % | Detonation Range Vol. % |
|------------------|-------------------------------|------------------|-------------------------------|--------------------|----------------------------|----------------------------|
| Hydrogen | H ₂ | 2.016 | 0.070 | 20.3 | 4.0-75.0 | 18.3- 59 |
| Carbon Monoxide | CO | 28.01 | 0.970 | 81.7 | 12.5-74.0 | |
| Hydrogen Sulfide | H ₂ S | 34.08 | 1.190 | 213.6 | 4.3-45.0 | |
| Silane* | SiH ₄ | 32.14 | 1.107 | 161.2 | 0.8-98 | |
| Arsine* | AsH ₃ | 77.94 | 2.692 | 210.7 | 0.8-98 | |
| Phosphine* | PH ₃ | 34.00 | 1.146 | 185.5 | 1.3-98 | |
| Diborane* | B ₂ H ₆ | 27.67 | 0.955 | 180.7 | 0.8-98 | |
| Ammonium | NH ₃ | 17.03 | 0.590 | 239.8 | 15-28 | |
| Methane | CH ₄ | 16.04 | 0.555 | 111.6 | 5.3-14 | |
| Ethane | C ₂ H ₆ | 30.07 | 1.040 | 184.6 | 3.0-12.5 | |
| Propane | C ₃ H ₈ | 44.10 | 1.550 | 231.1 | 2.2-9.5 | |
| Etylene | C ₂ H ₄ | 28.05 | 0.978 | 169.5 | 3.1-32 | |
| Acetylene | C ₂ H ₂ | 26.04 | 0.907 | 198.2 | 2.5-100 | 4.2- 50 |

(*): Hikaru Harada; "Handotai-gas Anzen-ka Souran 1st Edition" (The 1st edition of Semiconductor gas safing comprehensive manual) published by Science Forum Inc. 1984
 Except (*): The high pressure gas safety institute of Japan; "Koatsu-gas Kogyo Gijyutu" (High pressure gas industrial technology) published by Kyoritsu Shuppan Co., Ltd. 1977

Table 2 Combustion range and detonation range of mixture of oxygen and inflammable gas

| Gas | Combustion Range (Vol. %) | Detonation Range (Vol. %) |
|-----------------|------------------------------|------------------------------|
| Hydrogen | 4 - 94 | 15 - 90 |
| Acetylene | 2.3 - 94.5 | 3.5 - 93 |
| Methane | 5.1 - 61 | - |
| Propane | 2.3 - 55 | 3.7 - 37 |
| Carbon Monoxide | 15.5 - 94 | 38 - 90 |
| Ammonium | 15 - 79 | 25.4 - 75 |

The high pressure gas safety institute of Japan; "Koatsu-gas Kogyo Gijyutu" (High pressure gas industrial technology) published by Kyoritsu Shuppan Co., Ltd. 1977

3. When pumping flammable or explosive gases



When flammable or explosive gas is pumped with the cryocooler, it must be done safely from the vacuum chamber while the cryocooler is suspended. Be sure to take the following safety measures.

- (1). Control and manage the process condition, the time period and method of regeneration in order to keep the concentration of the hazardous gases discharged to the exhaust duct below the allowable level.
- (2). Eliminate ignition factors completely from the vacuum chamber and ducts.
- (3). Make sure that the safety measures mentioned above to be conducted in case of abnormal events.

Possible causes of ignition in the vacuum chamber are as follows;

- Ignition by a vacuum gauge filament being turned on
- Ignition by a heater with heating element(s) exposed into the process circumstance or the like
- Ignition by static electricity
- Ignition by liquid ozone

If a roughing pipe or exhaust line is made of plastic such as vinyl chloride, static electricity is likely to be generated.

Ozone is occasionally generated under the process utilizing plasma with oxygen or CO_x gas. Captured and condensed ozone in the vacuum chamber liquefies in the warm-up process of regeneration. Note that liquid ozone is regarded as so unstable that it might explode by impact or ignition resulting from the reaction with organic matter.

When pumping flammable or explosive gas(es), appropriate safety precaution must be taken with reference to "5. Stop and warm up cryocooler after pumping flammable, explosive, or combustion enhancing gas".

4. When pumping oxygen



It is very dangerous to mix oxygen and flammable gases.

Oxygen is the gas that enhances combustion. Use the Cryocooler after confirming the safety precautions or measures when pumping the mixture of oxygen and flammable gas. In particular, the mixture of oxygen and hydrogen, which has a broad range of combustion/detonation, is extremely dangerous.

The mixes gas with hydrogen of 4% or more and oxygen of 5% or more at atmospheric pressure could cause explosion momentarily (refer to “3.When flammable or explosive gases pumped”).

Therefore, when oxygen is used as a process gas the appropriate safety precautions must be taken with reference to “5. Stop and warm up cryocooler after pumping flammable, explosive , or combustion enhancing gas”.

Oxygen may generate ozone.

Ozone may be unknowingly generated in plasma production process (e.g., sputtering, etching, glow discharge, EB deposition).

Captured and solidified ozone in the vacuum chamber liquefies in the warm-up process of regeneration. The liquid ozone at high concentrations might explode by impact or ignition by the reaction with organic matter.

In case that a remarkable amount of ozone is generated in the process and accumulated in the Cryocooler, the following phenomena could be occurred around the Cryocooler at the initial stage of regeneration:

- 1) Cracking/popping sounds (as in electrical arching) occurring within the first few minutes of regeneration.
- 2) Gases exhausted from vacuum chamber during regeneration has a pungent odor, similar to that produced in arc welding operation.

A large volume of ozone causes an intense explosion, and is very dangerous.

In case of pumping ozone by the cryocooler, following safety measures must be taken.

1. Make sure that the amount of captured of ozone in the vacuum chamber is below an allowable level by increasing the frequency of regeneration. A required regeneration cycle differs depending on the flow rate of oxygen and other process conditions.
2. Reduce the flow rate of oxygen to the minimum as far as it does not influence the process performance.
3. Reconfirm the safety required if the process condition is changed, as it might increase ozone generation.

When using oxygen as a process gas, appropriate safety precaution and measures must be taken with reference to “5. Stop and warm up Cryocooler after pumping flammable, explosive, or combustion enhancing gas”.

5. Shutdown and warm up the cryocooler after pumping flammable, explosive, or combustion enhancing gases



When pumping flammable, explosive, or combustion enhancing gas, those gases must be safely vaporized again and exhausted. Following safety measures on the method of stop and warm up method are extremely important for operating Cryocooler safely. Please take proper safety measures on both hardware and process software. Also, be aware that there is a risk that some hazardous gas would be secondarily produced in the vacuum chamber as a result of plasma reaction or the like.

1. Safety measures for normal shutdown and warm up

Following are the safety measures which customers are requested to take in the regeneration process after pumping flammable, explosive, or combustion enhancing gas. Refer to figure 2 and take necessary measures. In addition, you may have to take additional safety measures depending on the kind of the gas used, the process conditions, or the environment used.

- 1) Both the purge of the cryopump and the dilution of the exhaust duct with inert gas are required to reduce the concentration of flammable gas or explosive gas and keep it under a certain level where the gas does not burn or explode even when it evaporates when the Cryocooler has been stopped or during warm-up time. For inert gas use nitrogen gas that its dew point temperature is -40°C or below or argon. (In this instruction manual, the terms “inert gas” or “dry nitrogen or argon” mean “nitrogen gas that its dew point temperature is -40°C or below or argon”.)

Please determine the purge flow rate, the dilution flow rate, and shutdown and warm up cycle (which depends on the pumping capacity of flammable gas) and take appropriate safety measures before operation.

- 2) Eliminate ignition factor. Make sure that there are no sources of ignition (refer to “3. When pumping flammable or explosive gases”) while the cryocooler is suspended or being warmed up.
- 3) Be sure to use metallic pipes for the roughing system and exhaust lines in order to prevent generation of static electricity. Ground the pipes with the grounding resistance of $100\ \Omega$ or less.

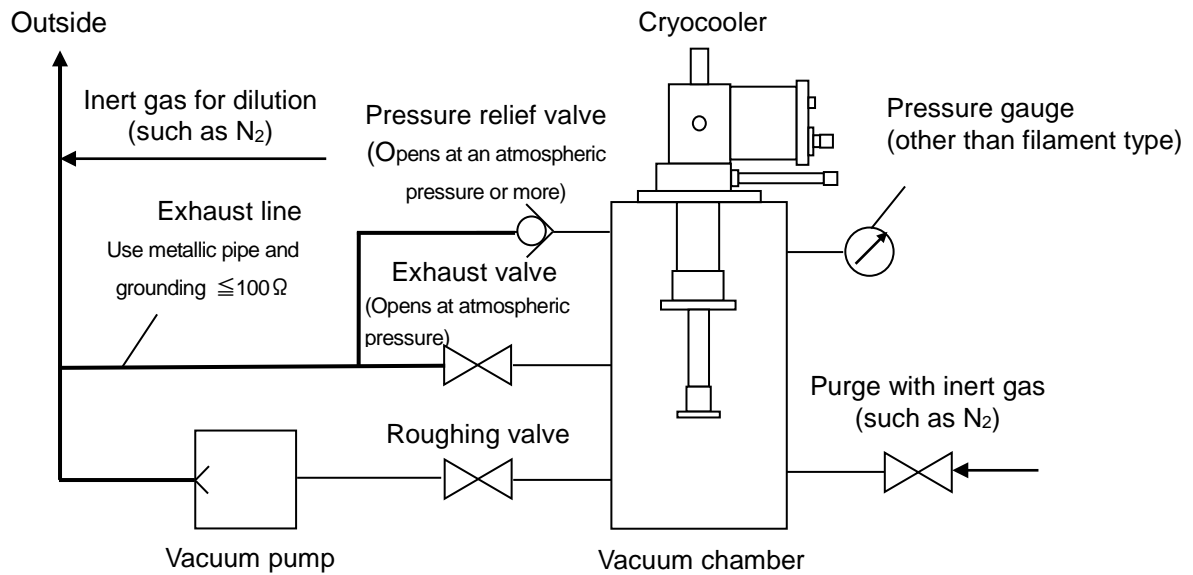


Figure 2 Dilution of oxygen/inflammable gas

- 4) In case that the gas to be exhausted is hazardous and lighter than the dilution gas (such as hydrogen gas), design and install the exhaust pipes so that its lighter gas should not be accumulated in the pipes.
 - 5) Perform inert gas purge into the exhaust line in order to reduce the flammable gas concentration below its combustion range before exhausting them away to atmosphere.
 - 6) Perform inert gas purge as the stop and warm up start.
 - 7) Assuming the pressure relief valve would work, connect the pressure relief valve to the exhaust line in order to dilute the gases which might spout out from the valve.
 - 8) Be sure not to rough pump the vacuum chamber without inspecting the state of the chamber just after power failure. Reduce the concentration of hazardous gases in the chamber and exhaust line by adding inert gas before rough pumping. It helps to exhaust the vaporized gas safely out of the chamber in case power failure occurred.
 - 9) When adopting a oil-sealed rotary pump as a roughing pump, change lubricating oils with Fomblin grease which is insensitive to oxygen. Instead, a drypump will be fully recommended.
2. Safety measures in emergency
- If the cryocooler stops due to an abnormal event such as power or water supply failure or compressed air shutoff, pumped gas evaporates and fills the vacuum chamber as the temperature of the Cryocooler rises. The chamber filled with high concentration of flammable, explosive, or combustion enhancing gas may

immediately cause an explosion or high-temperature combustion by any ignition factor (refer to “3. When pumping flammable or explosive gases”). To prevent these hazards, install UPS, and make sure that inert gas purge into the vacuum chamber and dilution in the exhaust duct described in the previous item 1. can be performed even in case of an abnormal event.

UPS (Uninterruptible Power Supply system) installation

In case that the Cryocooler stops because of blackout etc, hydrogen explosion or high-temperature combustion which may occur if high concentration of O₂ or H₂ is filled up in the chamber with some source(s) of ignition such as O₃.

UPS is necessary to prevent those hazards.

6. When pumping toxic and corrosive gases



Toxic or corrosive gases must be appropriately detoxified or made inert before they are exhausted outdoors from the duct. Ask the safety manager for appropriate instructions.

7. Rupture of cylinder by corrosion



Major components of the cryocooler cylinders are stainless steel and copper.

Special precautions must be taken when pumping corrosive gas which may be produced by plasma reaction, sputtering, etc. in chamber, and corrodes cylinder materials.

For maximizing performance of the Cryocooler, the stainless steel cylinder thickness is very thin. During normal operation, the pressure of helium gas in the Cryocooler is approximately 2 - 2.5 MPaG and if the corrosion develops, the cylinder may rupture at weak portion.

☆If the cryocooler is used to pump corrosive gases, periodic pressure proof test is recommended.

☆ULVAC CRYOGENICS INC. conducts the pressure proof test of cylinders by applying gas pressure of 1.5 times as high as the normal operating pressure.

8. Assembly and disassembly of a Cryocooler



The refrigerator contains high-pressure and high-pure helium gas. When disassembling your refrigerator, please contact our Service Engineering Division or the nearest customer support center first for technical assistance.

If you will perform maintenance or disassembly of the refrigerator by yourself, take the following special precautions for maintenance or disassembly of the refrigerator.

1. Exhaust the helium gas completely from self-sealing couplings on both helium return and supply flexible hoses by using the charging adapter.
2. Make sure that the helium gas pressure has fallen on 0 MPaG and then loosen the bolts.

NOTE: Do not loosen the fixed components such as bolts or plugs pointed by arrows in Figure 3 before discharging helium gas. Ignoring this note may cause severe injury or equipment damage by damaged bolts due to residual pressure.

Use cautions to the following items when assembling the refrigerator.

1. Tighten the bolts of each part in the diagonal sequentially.
2. As heavy load of the high-pressure helium gas is applied to the cylinder bolts (M8 x 4), it is important to tighten them with torque of 22N·m.
3. Fill the refrigerator with helium gas slowly confirming that there is no defect or abnormal conditions.
4. When performing decontamination of helium circuit, follow the instructions described in "6.2 Charging Helium Gas" in this book.

Ensure that the bolts are securely tightened. Loose bolts or bolts tighten under the regulation torque may cause severe injury or equipment damage.

UHE10F

UHE12F

UHE15F

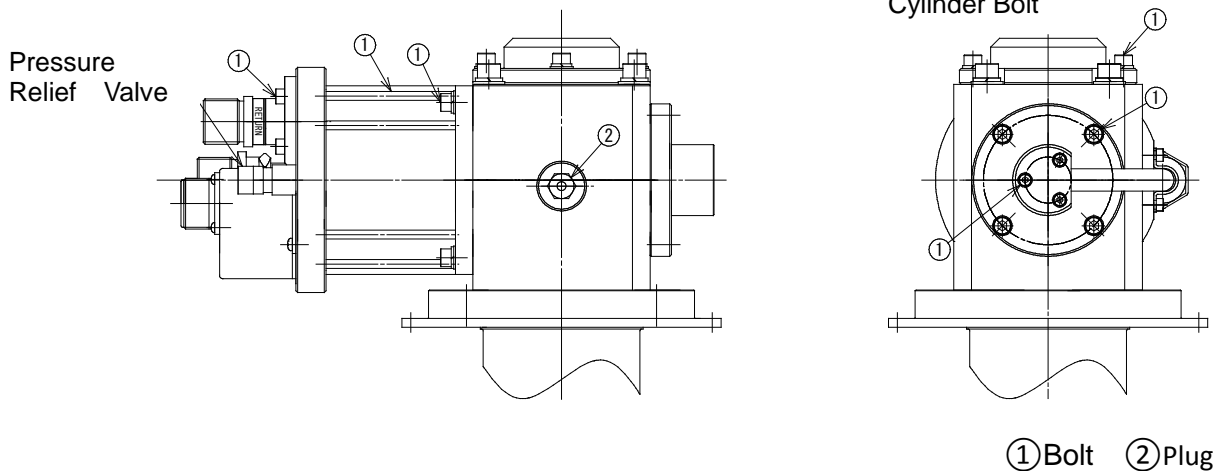


Figure 3 Bolt locations

9. Maintenance



Some of the inner parts need replacement at regular intervals (see Section 6 Maintenance). All the maintenance work including these replacements of UHE series are to be conducted by Ulvac Cryogenics. Please contact our service engineering division or nearest customer service center.

10. Do not charge the system with excessive helium gas



In our Cryocoolers, high-pressure helium gas is circulated in the system to get an effective refrigerating cycle. Charging with helium gas more than the specified value does not enhance the performance of Cryocooler. Conversely, if the helium gas pressure exceeds the specified value, the pressure relief valve could be open, and it would bring about the trouble of air leakage because particles would stick to the vacuum seal in the valve. Moreover, the excessive high-pressure gas might cause another trouble that the system would stop by hitting the high-pressure switch in the compressor unit.

Do not charge the Cryocooler with helium gas exceeding the regulated value.

11. Power source of Cryocooler system



Refer to the instruction manual of compressor unit for required power source.

- 1) Grounding conductor (earth wire) must be connected (D-class grounding with the ground resistance of 100 Ω or below).
- 2) Install a ground-fault interrupter at power supply of the compressor unit.
- 3) Use the UCI-supplied power cable. Do not connect other equipment to the same ground-fault interrupter for the Cryocooler system.

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Disposal Considerations

Disposal of our products must be done in accordance with applicable national and local laws and regulations.

| | | | | |
|---|---|---|---|----------------|
|  |  |  |  | WARNING |
| <p>The cryopumps or cryocoolers may contain residue of hazardous substances resulting from actual use. Contact your safety supervisor and follow the instructions to remove such toxic substances before disposing.</p> | | | | |

We provide Safety Data Sheet (SDS) of our products upon your request.
Please contact us if necessary.

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1. INTRODUCTION

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|------|---|-----|
| 1.1. | General..... | 1-1 |
| 1.2. | Specifications | 1-3 |
| 1.3. | Vacuum Chamber Specifications | 1-4 |
| 1.4. | Regulations applicable (Cryocooler) | 1-5 |

1.1. General

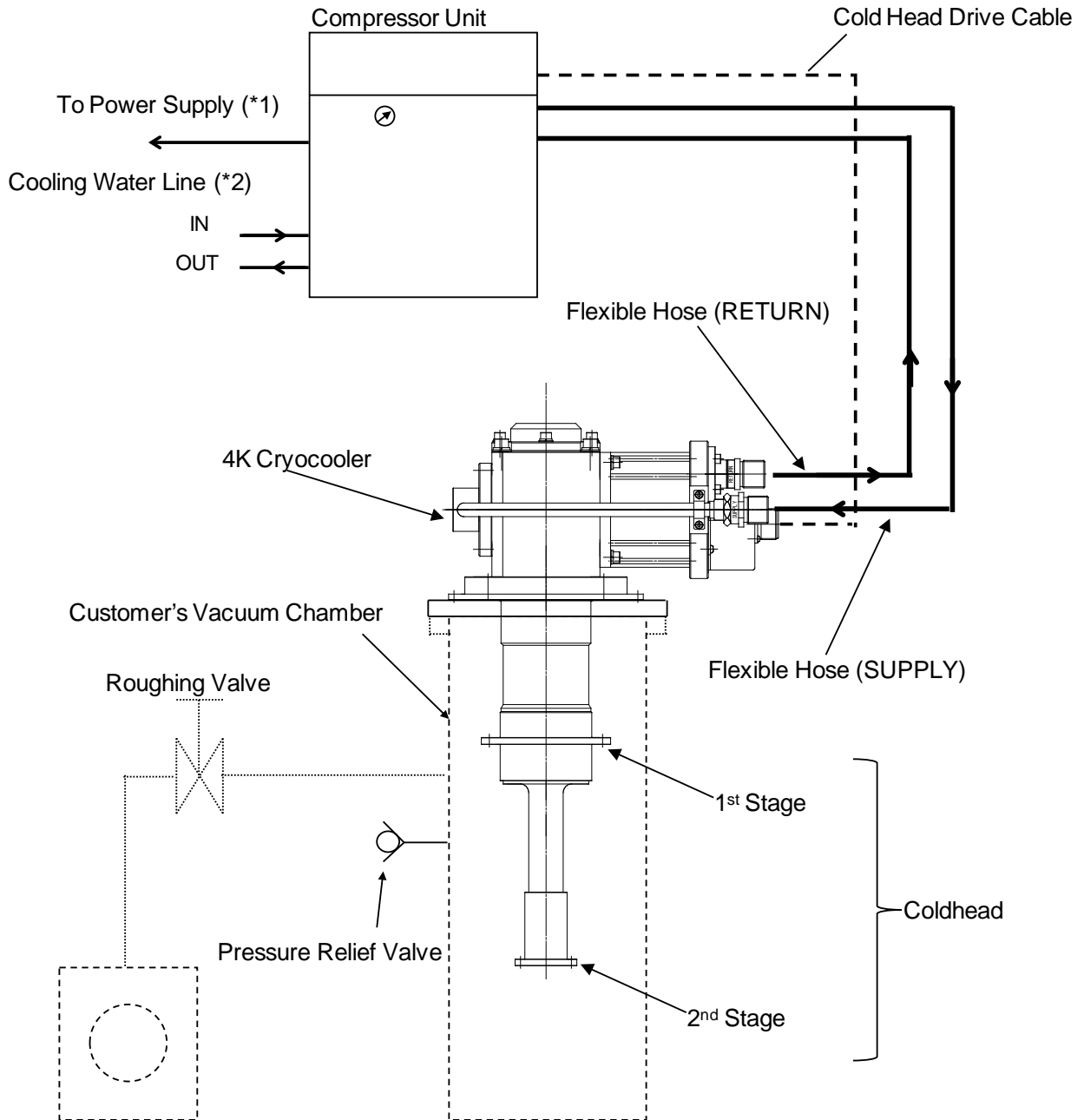
The Cryocooler system containing a 4K Cryocooler can perform prolonged continuous cooling operations in the cryogenic range. The 4K Cryocooler system (see Figure 1-1) consists of a 4K Cryocooler, compressor unit, flexible hoses, and various cables and uses helium gas as a refrigerant.

The 4K Cryocooler system is designed to be used in many areas that require cryogenic temperature. Using this system as a source of cryogenic cooling will make a significant improvement to the restriction on the design which breaks out with a system where a cryogen such as liquid nitrogen is used. Furthermore, the 4K Cryocooler can be installed in any direction (*1), which expands the possibility of system design because no cryogen is used.

The 4K Cryocooler system is used for cooling superconducting coil, cooling cryostat for optical measurement, high sensitivity measurement using superconducting sensor etc., and its range of application is further expanding.

(*1) The performance of the Cryocooler may change depending on the installation direction.

Note that the specification value of the refrigeration capacity of this 4K Cryocooler system is the value obtained when the cold head faces down (see Table 1-2).



(*1) Refer to "Compressor Unit Instruction Manual" for specifications of power supply.

(*2) Refer to "Compressor Unit Instruction Manual" for cooling water requirements.

No cooling water line in the air-cooling type compressor unit.

Figure 1-1 Typical Diagram of 4K Cryocooler System

1.2. Specifications

Table 1-1 4K Cryocooler System Standard Composition

| 4K Cryocooler | Compressor unit (*1) | Power source | Cooling system |
|----------------------------|----------------------|--|----------------|
| UHE10F UHE12F UHE15F | C30F2 | AC200V 3 ϕ ,50Hz AC200V 3 ϕ ,60Hz AC208V 3 ϕ ,60Hz AC220V 3 ϕ ,60Hz | Water-cooled |
| | C30F4 | AC380V 3 ϕ ,50Hz AC400V 3 ϕ ,50Hz AC415V 3 ϕ ,50Hz AC480V 3 ϕ ,60Hz | |
| | C30F2A | AC200V 3 ϕ ,50/60Hz | Air-cooled |

(*1) Refer to compressor instruction manual for details.

Table 1-2 4K Cryocooler Standard Capacity

| 4K cryocooler | Power frequency | Refrigeration Capacity (*1) | | Cooldown time to 4.2K(*2) | 2nd stage Ultimate temperature(*2) |
|---------------|-----------------|-----------------------------|-----------------|---------------------------|------------------------------------|
| | | 1st stage | 2nd stage | | |
| UHE10F | 50/60 Hz | 40/50 W 43 K | 1.0 W 4.2 K | 60 min | 2.7 K |
| UHE12F(*3) | 50/60 Hz | 53/60 W 43 K | 1.25 W 4.2 K | 60min | 2.7 K |
| UHE15F | 50/60 Hz | 35/45 W 50 K | 1.5 W 4.2 K | 60 min | 2.7 K |

- (*1) Shows Refrigeration capacity when the second stage of the coldhead is attached face down. The refrigeration capacity may slightly change depending on the cold head mounting direction. The figures shown here are achieved when heat load is applied to the first stage and second stage respectively at the same time.
- (2) The figures are achieved when running with no-load. Cooldown time may differ depending on the heat capacity of the object to be cooled. The ultimate temperature is affected by the incoming heat from ambient.
- (3) The refrigeration capacity of UHE12F shown in the above table is achieved with the flexible hose of 20A x 20m. The refrigeration capacity of UHE10F and UHE15F shown above is achieved when using 20A x 10m flexible hose.

Table 1-3 4K Cryocooler Composition Standard Specifications

| Cryocooler | UHE10F | UHE12F | UHE15F |
|---|---|--------|--------|
| Refrigeration cycle | G-M cycle | | |
| Helium gas supply and return connectors | 1/2B self-sealing coupling | | |
| Dimensions | Refer to Appendix F | | |
| Helium gas pressure | 1.60MPa at 20 °C | | |
| Weight | 18kg | | 19kg |
| Ambient conditions | | | |
| Operating ambient temperature | 10 - 35°C | | |
| Relative humidity | 20 - 90% (no condensation) | | |
| Allowable magnetic field | ≤500G | | |
| Altitude | <1000m | | |
| Atmosphere | Free from metal powder, dust, combustion gases, corrosive gases | | |
| Rated voltage | 200VAC, 3φ(50Hz/60Hz) | | |
| Electric current | 0.48A MAX | | |
| Dielectric strength | 1500VAC 1 minute | | |
| Insulation resistance | 500VDC 100MΩ以上 | | |
| Overtoltage category | II | | |


1.3. Vacuum Chamber Specifications

When a 4K Cryocooler is used in the cryogenic range, it must be installed to the vacuum chamber to prevent heat load due to thermal conduction and condensation. (To use a Cryocooler in the 1st stage temperature range of 60K or less, the vacuum chamber must have a vacuum of 1×10^{-2} Pa or better.)

Vacuum chamber which is made of stainless or nickel-plated iron. Specular finished-inner surface is recommended. Be sure that there is no leakage.

Vacuum chamber should feature a pressure relief valve to vent gases trapped inside vacuum system in case that the inner pressure exceeds atmospheric pressure.

1.4. Regulations applicable (Cryocooler)

| Mark | Applicable Regulations | File No. Certificate |
|---|--|------------------------------|
|  | UL471 : 10 th Ed. | File No. SA44290 |
|  | <p>Machinery Directive(MD):2006/42/EC</p> <ul style="list-style-type: none"> • EN ISO 12100: 2010 • EN 60204-1:2006+A1:2009 <p>Electro Magnetic Compatibility Directive (EMC):</p> <p>2014/30/EC</p> <ul style="list-style-type: none"> • EN 61000-6-4:2007+A1:2011 • EN 61000-6-2:2005 • EN 61000-3-2:2014 • EN 61000-3-3:2013 • EN 60601-1-2:2015 • EN 55011:2009+A1:2010 <p>RoHS Directive:2011/65/EU</p> <ul style="list-style-type: none"> • EN 50581:2012 | Self-certified CE marking |

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2. INSPECTION

| | | |
|------|---|-----|
| 2.1. | Shipping List..... | 2-1 |
| 2.2. | First Inspection of 4K Cryocooler | 2-2 |

2.1. Shipping List

When a product(s) delivered, make sure that there is no damage or shortage of delivered items by checking the external view of the package and the shipping list attached.

Please see Table 2-1 if you purchased a 4K Cryocooler system, and Table 2-2 for 4K Cryocooler alone.

Please read the enclosed cover letter for the details.

Table 2-1 Shipping List for 4K Cryocooler System

| Package | Package quantity | Item | Quantity |
|---------|------------------|---|----------|
| (1) | 1 | 4K cryocooler | 1 |
| (2) | 1 | Compressor unit | 1 |
| (3) | 1 | Accessory of compressor unit ^(*) | 1 |
| | | This instruction manual | 1 |
| | | Instruction manual of compressor unit | 1 |

^(*) Input power cable, Cold head drive cable, remote connector, spanner kit, flexible hose, etc. Contents of accessories depend on the model of your compressor unit. Read the compressor unit instruction manual for the details.

Table 2-2 Shipping List for 4K Cryocooler

| Package | Package quantity | Item | Quantity |
|---------|------------------|-------------------------|----------|
| (1) | 1 | 4K cryocooler | 1 |
| | | This instruction manual | 1 |

2.2. First Inspection of 4K Cryocooler

Unpack the package of the 4K Cryocooler confirm there is neither damage nor a dent in externals, connector, and cold head of the 4K Cryocooler unit, and is moreover no missing parts.

If you find any missing parts or damages of the product, please contact our Service Engineering Division or the nearest Customer Support Center.

3. INSTALLATION

- 3.1. Auxiliary Equipments Required3-1
- 3.2. Mounting the 4K Cryocooler to the Vacuum Chamber.....3-3
- 3.3. Connecting Roughing Pump3-4
- 3.4. Connecting Cooling Water Pipe3-4
- 3.5. Connecting 4K Cryocooler to Compressor Unit (Connecting Flexible Hose) 3-4
- 3.6. Connecting Remote Wiring3-5
- 3.7. Connecting Electrical Cables3-5

3.1. Auxiliary Equipments Required

For operating 4K Cryocooler system, the following auxiliary equipments are required.

- ◆ Vacuum Chamber: We recommend that a stainless-steel (or nickel plated iron) vacuum chamber with inner surface mirror polished to be supplied by customer. To use a 4K Cryocooler in a temperature range of 60K or below at the 1st stage and of 4.2K or below at the 2nd stage, the vacuum chamber must be able to maintain vacuum of 1×10^{-2} Pa or better.

When the stages are warmed up to room temperature, the inner pressure of the vacuum chamber may exceed atmospheric pressure. It is requested to attach a pressure relief valve that operates when the inner pressure is 10-20kPaG. The dimensions of the vacuum chamber flange to attach UHE10F, UHE12F and UHE15F are shown in Figure 3-1 for O-rings.

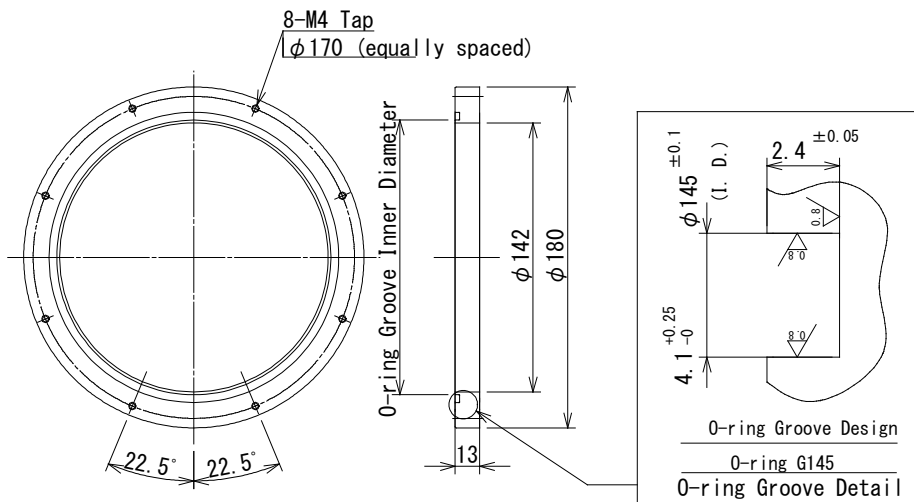


Figure 3-1 Recommended Mounting Flange for UHE10F,UHE12F and UHE15F

- ◆ Roughing pump : For rough pump the vacuum chamber.
To minimize heat transfer via gas, the roughing pump should be able to achieve 1Pa or below.
- ◆ Roughing valve : Isolates the vacuum chamber from the roughing pump.
- ◆ Vacuum gauge for rough pumping
: Use this gauge to monitor the pressure during rough pumping.
The gauge should be able to measure from atmospheric pressure to 1Pa.
- ◆ High-vacuum pump : Use this pump when necessary, such as when a large volume of outgas is emitted. A Pump with no oil-backflow, such as a turbomolecular pump is recommended.
- ◆ High-vacuum valve: Required for switching to a high-vacuum pump.
- ◆ High vacuum gauge:
: To monitor the vacuum chamber pressure while the 4K Cryocooler system is in operation The gauge should be able to measure 10^{-1} to 10^{-6} Pa. An ionization gauge is recommended.
- ◆ Temperature sensor, Temperature indicator:
For monitoring the temperature of the 4K Cryocooler. Make sure that the sensor or indicator meet the specifications.

3.2. Mounting the 4K Cryocooler to the Vacuum Chamber

- ◇ The 4K Cryocooler can be installed in any orientation. Downward orientation is recommended to achieve the maximum cooling performance.
- ◇ When installing the 4K Cryocooler, clear the space for performing maintenance work. Figure 3-4 shows necessary space.

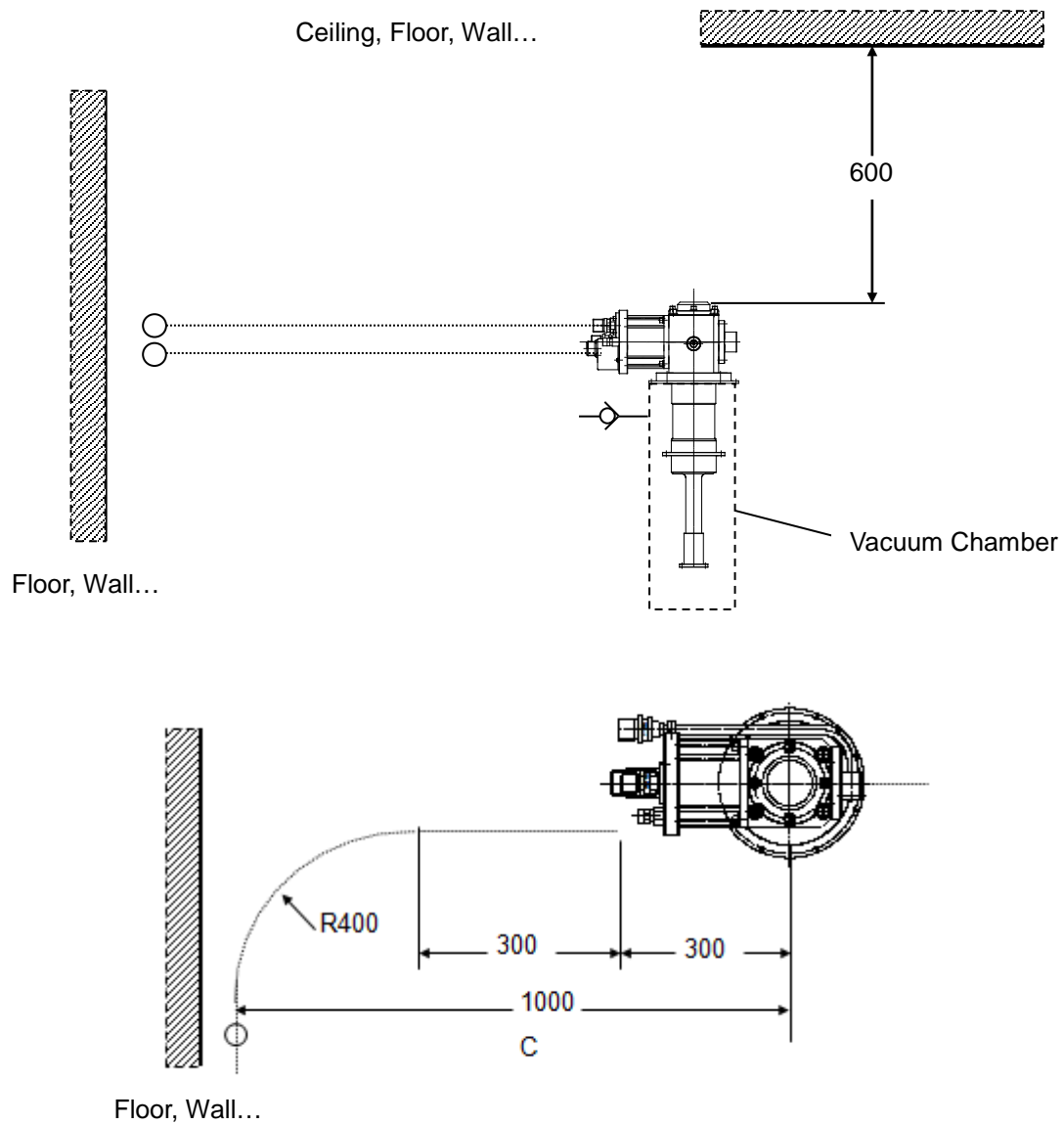


Figure 3-2 Maintenance Space for UHE10F, UHE12F and UHE15F

3.3. Connecting Roughing Pump

1. Connect roughing pump system to the vacuum.
2. Install a pirani gauge between vacuum chamber and roughing pump. It is recommended to install it as close as possible to the vacuum chamber.
3. Addition of a fore-line trap in the roughing line is recommended in order to prevent the vacuum chamber from back stream of oil when rough pumping to 40Pa or less by oil-sealed rotary pump. Regenerate the fore-line trap if necessary.

3.4. Connecting Cooling Water Pipe



CAUTION

Regarding cooling water of the compressor unit, observe the water quality criteria which is shown in the compressor unit instruction manual.

1. Connect cooling water pipe to the compressor unit. The connector thread size for both “COOLING WATER IN” and “COOLING WATER OUT” is Rc 3/8 female pipe thread.
2. Be careful not to mistake the inlet for the outlet.
3. Run the cooling water with the actual flow conditions, and make sure that there is no water leakage.

Refer to the compressor unit instruction manual for more information on the connecting method or the requirements for water pressure and flow rate.

3.5. Connecting 4K Cryocooler to Compressor Unit (Connecting Flexible Hose)



CAUTION

- Read the handling notes in appendix B about the connection of the flexible hoses.
- When connecting flexible hoses, always use two single open end spanners with width across flat 26mm and 30mm.
- Do not forcibly bend flexible hoses. They may be damaged and cause helium leakage.
- Do not connect or disconnect self-sealing coupling frequently. It may cause gas leakage. If there is a leakage, you may have to replace it with a new one according to the situation of the occurrence of Leakage.



1. Remove all dust plugs and caps from supply and return flexible hoses, compressor unit and 4K Cryocooler. Clean flat rubber gaskets on the self-sealing couplings to be free from dust or metallic powder.
2. Connect the flexible hoses between the compressor unit and the Cryocooler as follows. Refer to the instructions in Figure 3-3 and Figure 3-4 and perform the connection work in correct order.
3. Check helium gas pressure on the compressor unit. If the pressure is higher than appropriate, release helium gas by opening the gas charge valve slowly. If the pressure is lower than proper value, charge helium gas with purity of 99.999%.
 - ◇ Refer to the “Helium gas pressure” in the Table 1-3 in Section 1. INTRODUCTION for the appropriate helium charge pressure.
 - ◇ When connecting flexible hoses to the 4K cryocooler, make sure to connect to the RETURN connector first.

3.6. Connecting Remote Wiring

For remote operation, remote wiring is necessary.

Refer to the compressor unit instruction manual for the specifications for the circuits or switches.

3.7. Connecting Electrical Cables

| | |
|--|--|
|  |  WARNING |
| <ul style="list-style-type: none">• Do not connect the compressor unit power cable until all other connections have been made between the components and the 4K Cryocooler system. | |

1. Connect the Cold head drive cable from the compressor unit to the 4K Cryocooler.
2. Connect the ground.
3. Connect the input drive cable from the compressor unit to its power source.
4. Refer to the compressor unit instruction manual for how to start up the compressor unit.

- Connect RETURN and SUPPLY flexible hoses to the correct connectors.

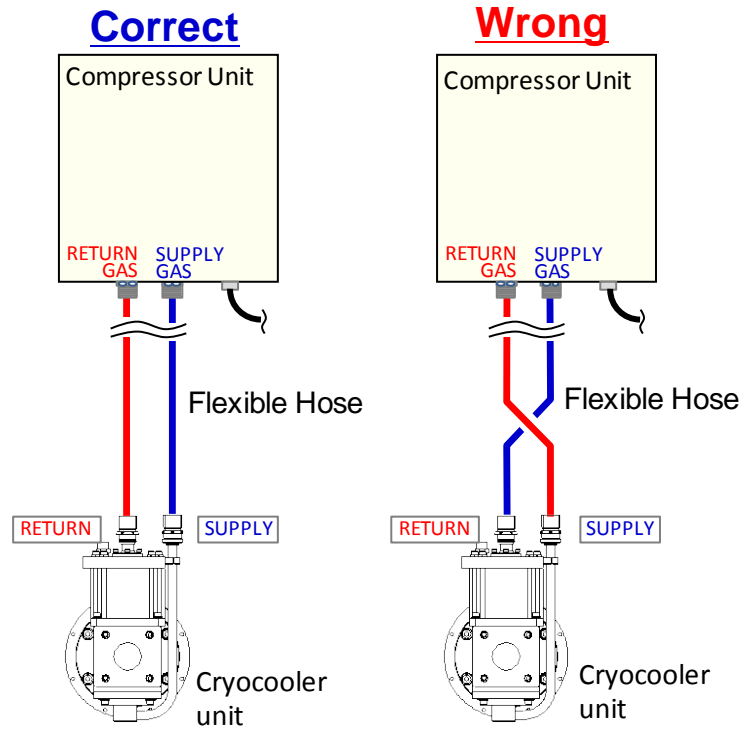


Figure 3-3 Connecting helium flexible hoses correctly

- Connect flexible hoses in the correct order.

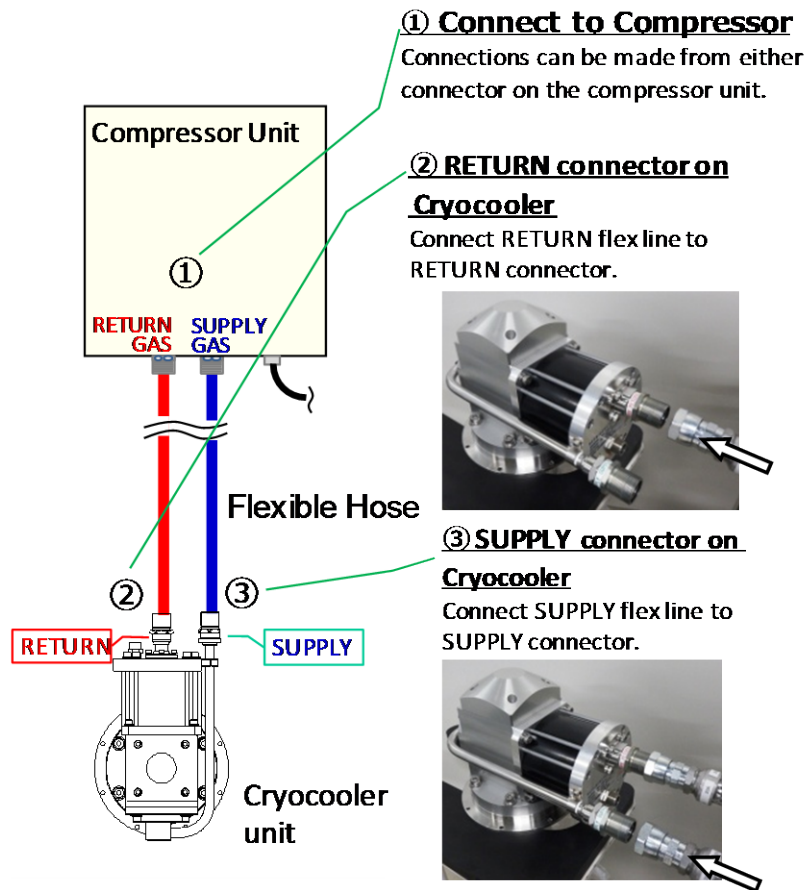


Figure 3-4 Flexible hoses connection order

- Use two spanners to connect the flexible hoses to the connectors.

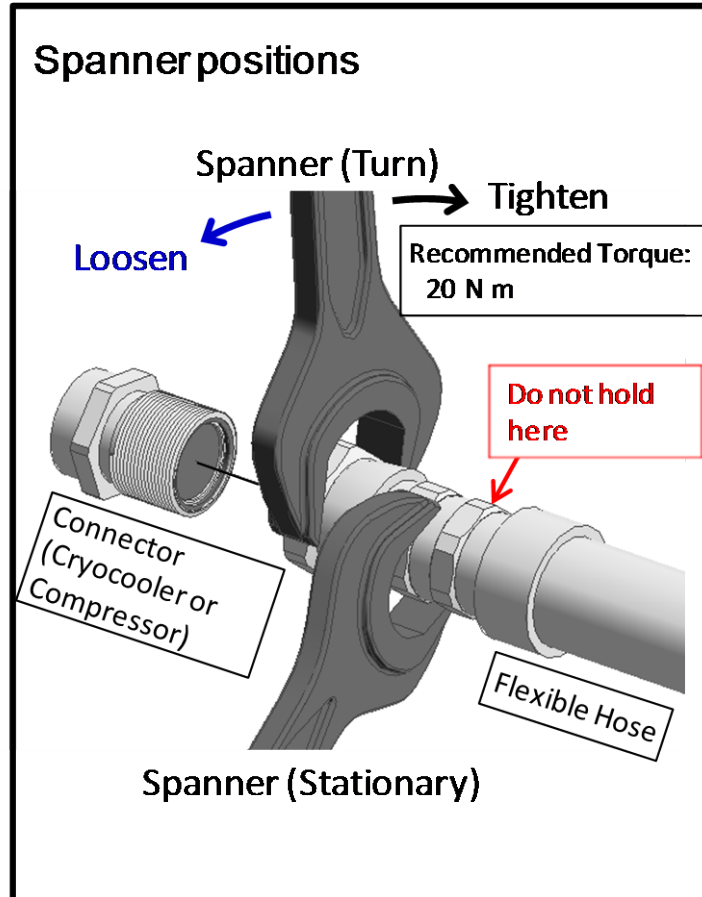


Figure 3-5 Using two spanners to connect / disconnect flexible hoses

4. OPERATION

| | | |
|------|---------------------------------------|-----|
| 4.1. | Prior to Startup..... | 4-1 |
| 4.2. | Mounting Samples (load) | 4-1 |
| 4.3. | Rough Pumping..... | 4-1 |
| 4.4. | Startup and Cooldown | 4-2 |
| 4.5. | Normal Operation | 4-2 |
| 4.6. | Shutdown Procedures | 4-3 |
| 4.7. | Handling of Hazardous Materials | 4-4 |

4.1. Prior to Startup

Before starting operation, check the followings:

1. The flexible hoses and cables are properly connected.
2. The gauges are mounted on each intended ports.
3. The roughing valves are closed.
4. The helium gas pressure gauge on the compressor unit shows appropriate value.

It is recommended to conduct daily check and keep an operating log to notice the first sign of a trouble as fast as possible. This will help you to get prompt technical assistance from us. The recommended operating log is attached to Appendix A.

4.2. Mounting Samples (load)

Mount a sample to be cooled (hereinafter “load”) to 1st or 2nd stage of the cold head. Be sure to use indium sheet as it improves the thermal conduction between the cold stage and the load.

4.3. Rough Pumping

1. Start up the roughing pump.
2. Open the roughing valve and then rough pump the vacuum chamber to 1Pa or below.
3. After the roughing pump completed, close the roughing valves and turn off the roughing pump.

(When a large volume of outgas is emitted from the vacuum chamber, start up the 4K Cryocooler while evacuating the vacuum chamber by the high-vacuum pump.)

4.4. Startup and Cooldown

1. Start up the compressor unit. The Cryocooler automatically starts operation. Collect data during the cooling operation every 10 minutes, and record it on the operation data sheet (Table A-2).

2. Wait until the temperatures of the 1st and 2nd stages of the 4K Cryocooler are stabilized. The temperatures should be roughly 40K or lower on the 1st stage and 4.2K or lower on the 2nd stage.

(Note) The cooling time and the achieved temperature of each stage differ depending on the environment of usage.

For the cooldown time of the 4K Cryocooler, refer to Table 1-1.



CAUTION

If the cryocooler is cooled down at poor vacuum level, the vacuum chamber may dew. It may cause short-circuit if an electric circuit is placed under the vacuum chamber. Be careful about the operating condition of equipment, and surrounding safety.

† For Your Information †

- In order to minimize the cooldown time, avoid heat load (heaters, for example) to the testing sample during refrigerator operation.
- Cooldown failure or longer cooldown time may take place when:
 - ① Testing sample is too large.
 - ② Incoming thermal load from radiation heat is too heavy.
 - ③ Pressure inside vacuum chamber is too high.

4.5. Normal Operation

The 4K Cryocooler can be operated without operator attendance. Record the operating logs during normal operation on a regular basis.

In regard to the operating pressure of the compressor unit, refer to the corresponding compressor instruction manual.



4.6. Shutdown Procedures






1. Shutdown the compressor. The 4K Cryocooler will stop automatically. Evacuate gases condensed in the vacuum chamber.
2. The vacuum chamber is warmed up to complete evacuation of condensed gases, and the 4K Cryocooler will be suspended operation.
3. If you continue to conduct inspection, replacement, or repair of the cryocooler, turn off the power breaker and stop circulating the cooling water before starting the work.

If there is no thermal load to the Cryocooler, it may take a long time to warm up the unit to the room temperature. It takes at least 12 hours under vacuum thermal-insulating condition to bring the low-temperature section of the Cryocooler up to room temperature after the Cryocooler is shutdown, though it depends on the thermal capacity of load.

<In order to reduce warm-up time>

Introduce clean and dry gas such as nitrogen with dew point temperature of -40°C or below or argon until atmospheric pressure.

| | | |
|---|---|----------------|
|  |  | WARNING |
| <p>When gas is introduced into the vacuum chamber to shorten the warm-up time, the condensed gases in the vacuum chamber evaporate with warm-up, and the inside pressure may exceed atmospheric pressure. After bringing the vacuum chamber to atmospheric pressure, open the roughing valve to release the evaporated gases.</p> | | |

| | | | | | |
|--|---|---|---|--|----------------|
|  |  |  |  |  | WARNING |
| <p>When toxic, corrosive, flammable, and explosive gases are pumped with the Cryocooler, never use the warm-up method of exposing the vacuum chamber to the air after bringing it to atmospheric pressure. Exhaust the captured gas to the pre-installed dedicated duct or dedicated exhaust facility diluting it with inert gas, such as nitrogen that its dew point temperature is -40°C or below or argon. Toxic or corrosive gases must be appropriately detoxified or made inert before they are exhausted outdoors.</p> | | | | | |



CAUTION

Maximum allowable temperature of the cryocooler is 70°C. If you use a heater, make sure to control the heater temperature so that the temperature of the cold stages (1st stage and 2nd stage) of the refrigerator does not exceed 70°C. If it exceeds 70°C, inside of the refrigerator may be damaged by the heat and a refrigerator replacement may be needed.

Please take appropriate measures to prevent the temperature of the cold stages unexpectedly become hot when baking a vacuum chamber or heating it by a heater.

4.7. Handling of Hazardous Materials



WARNING

- ◆ Do not pump large amount of toxic, corrosive, flammable and explosive gases. Especially, be careful not to exceed atmospheric pressure with those gases. Please refer to Safety Instructions for these hazardous gases.
- ◆ When evacuating toxic or corrosive gases, obtain proper instructions from a safety supervisor.
- ◆ Clearly identify toxic, corrosive, dangerous gases, or liquids on containers used to store or ship equipment after such exposure.
- ◆ Handle hazardous materials with care in accordance with applicable laws and regulations.

5. Disconnection and Storage

| | | |
|------|-----------------------------------|-----|
| 5.1. | Disconnecting Flexible Hose | 5-1 |
| 5.2. | Storage | 5-2 |

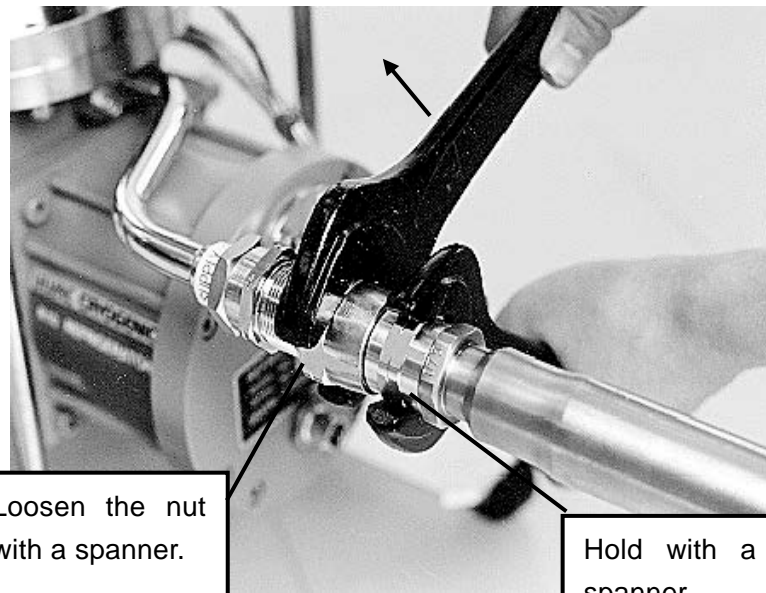
5.1. Disconnecting Flexible Hose



CAUTION



When disconnecting flexible hoses, be sure to use two single open end spanners with width across flat 26mm and 30mm.

1. Shut down the compressor unit.
2. Disconnect the flexible hoses after the first and second stages of the cryocooler return to room temperature.



Loosen the union nut using two spanners and disconnect the flexible hose by hand.

Figure 5-1 Disconnecting Flexible Hose

| | |
|--|--|
|  |  WARNING |
| <p>If the flexible hose is disconnected immediately after shutdown, low-temperature helium gas accumulated in the low-temperature part of the Cryocooler expands along with the temperature rise, resulting in pressure increase inside the Cryocooler. This may activate the pressure relief valve and cause helium leak. When the flexible hoses need to be disconnected for reasons as maintenance, make sure that the Cryocooler returns to room temperature before disconnecting. It takes at least 12 hours under vacuum thermal-insulated state to bring the low-temperature section of the Cryocooler up to room temperature after shutdown of the Cryocooler system, though it may vary depending on the weight of the object to be cooled.</p> | |

5.2. Storage

- When the 4K Cryocooler is stored in the state attached to your vacuum chamber; the vacuum chamber should be kept in a vacuum (of 100Pa or less) or under the atmospheric pressure replaced with dry nitrogen.
- When the 4K Cryocooler is stored removed from your vacuum system;
 1. Disconnect the flexible hoses. after the Cryocooler has reached room temperature completely.
 2. Disconnect the cryocooler from the vacuum chamber after the Cryocooler has reached room temperature.
 3. Put the protective cap on the helium gas connector of the Cryocooler. Use caution not to damage the 1st or 2nd stages and sealing surface.
 4. The cryocooler should be kept away from direct sun light, high temperature, humidity, dust, vibration, radiation, wind or rain.
- When storing the 4K Cryocooler over a long period;

Connect the refrigerator cable and operate the Cryocooler about 10 minutes biannually. This work is effective in maintaining the grease lubrication of the bearings used inside the Cryocooler.

When the Cryocooler has been left without operating for one year or more, perform helium circuit decontamination before resuming operation.
- When transporting the 4K Cryocooler
Return the Cryocooler to the state when delivered for the first time and avoid excessive shock.

6. MAINTENANCE

| | | |
|------|--|-----|
| 6.1. | Scheduled and Unscheduled Maintenance..... | 6-1 |
| 6.2. | Charging Helium Gas | 6-2 |

6.1. Scheduled and Unscheduled Maintenance

- ◇ Scheduled Maintenance:
 - Replacement of maintenance parts in the 4K Cryocooler
 - Replacement of the compressor adsorber
- ◇ Unscheduled Maintenance:
 - Adding helium gas
 - Decontaminating the helium gas line

Following equipments and helium gas are necessary for maintenance.

| | Item | Volume | Item code |
|---|---|-------------|--|
| 1 | Helium charging adapter kit (Regulator, Charging hose 2.4M, Charging adapter) | 1 | A700B5101000 |
| 2 | <Items independently available> Regulator (for helium gas) Charging hose 2.4M Charging adapter | 1 1 1 | A700A5101700 A700A5101800 A700B5101100 |
| 3 | Helium gas (with purity of 99.999% or above) | — | — |

Table 6-1 Maintenance Intervals

S: Scheduled maintenance **U:** Unscheduled maintenance or part replacement at fault

| Item | Parts | Interval | |
|-----------------|-------------------------|---|---|
| 4K Cryocooler | | | |
| S | Bearings replacement | Resin bearing Valve bearing Motor bearing | The maintenance intervals may vary depending on the frequency of operation. |
| S | Seal kit replacement | 1 st stage seal Cup seal | |
| S | Other | Bushing | |
| U | Other parts replacement | Other parts | At fault |
| Compressor unit | | | |
| S | Adsorber replacement | Adsorber | Refer to the compressor unit instruction manual. |

<NOTE> Maximum allowable temperature of the refrigerator unit is 70°C. If you use a heater for regeneration, control the heater temperature to prevent the cold stages from exceeding 70°C. If the cold head is repeatedly heated over 50°C during regeneration, more frequent maintenance is required since the displacer may deteriorate earlier.

6.2. Charging Helium Gas

Equipments for charging helium gas such as a regulator or charging hose that can be used at above 2.0MPaG are required.



CAUTION

If the helium pressure gauge of the compressor unit shows 0 MPaG, contamination caused by air or moisture may occur in the system. In such a case, contact our Service Engineering Division or customer support center.

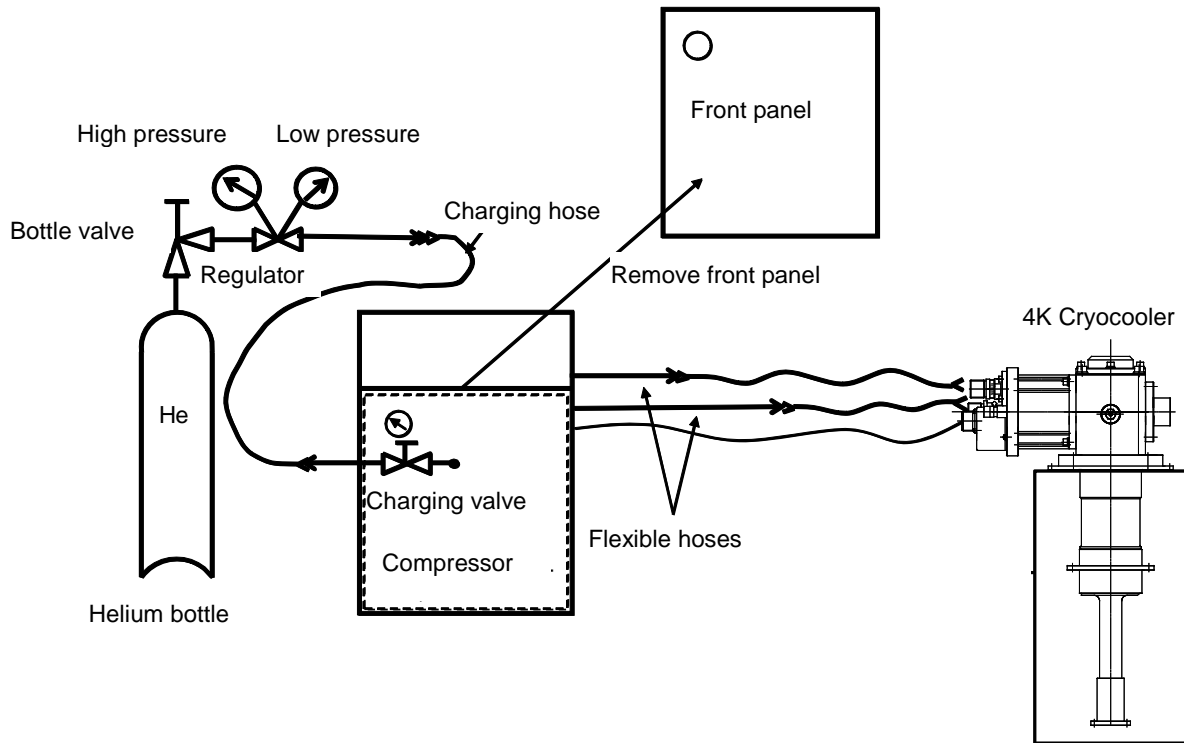


Figure 6-1 Charging helium gas

When helium gas pressure decreases, it is necessary to add helium (Figure 6-1). Identify the cause of the pressure decline before adding helium. If there is a leakage, take an adequate measure before charging. Improperly connected self-sealing coupling might be one of the causes of the leakage.

- It is recommended to use the regulator which shows the range of 4-6 MPaG as inlet pressure.
- The gas charge fitting is 1/4B male flare.
- **Use helium gas with purity of 99.999% or above.**

The procedure to charge helium gas is as follows:

1. When mounting the regulator on a new helium bottle, perform the following procedures in order to purge the air and fill helium gas in the gas line between the regulator and the bottle valve.
 - a) Slightly open the regulator. Normally the regulator opens by turning the handle clockwise.
 - b) Slowly open the bottle valve, and purge the air in the gas line for several seconds.
 - c) Close the regulator.

**CAUTION**

If you open the bottle valve ignoring the above procedure 1, the air between the regulator and the bottle valve diffuses into the helium bottle and contaminates helium gas.

2. Remove the front panel of the compressor unit.
3. Connect the helium charging hose as follows:
 - a) Connect the charging hose to the regulator.
 - b) Loosely connect the charging hose to the charge inlet on the compressor unit.
 - c) Open the regulator until the outlet pressure reaches 0.1 to 0.2 MPaG. Allow helium gas to flow out from the charging hose for about half a minute. Meanwhile, open the charge valve slightly in order to drive out the air that exists between the charge valve and the charge inlet.
 - d) Tighten the flair nut at the end of charging hose and close the charge valve. With the above steps, helium gas is charged in the line between the regulator and the charge valve.
4. Adjust the inlet pressure of the regulator at 1.8 MPaG.
5. Open the charge control valve slowly and follow the steps below according to the state of the compressor.
 - a) If the compressor unit is running normally, add helium gas until it reaches the operating pressure described in the compressor instruction manual.
 - b) If the compressor unit is suspended, add helium gas until it reaches the static pressure described in the Table 1-3 in this book.

**CAUTION**

When adding helium gas after the compressor unit is shutdown, make sure that the cryocooler has returned to room temperature before performing the work.

**CAUTION**

If helium gas has been charged more than appropriate pressure of 1.9MPaG or more, the pressure relief valve on the refrigerator may work. Charge helium gas slowly so that the pressure relief valve does not operate. The pressure relief valve in the compressor unit is set at 2.5MPaG.

6. Close the charge valve after charging helium gas.
7. Close the regulator and remove the charging hose from the charge fitting.

Appendix A


Troubleshooting

Regarding various potential failures, the Table A-1 explains its cause and corrective actions respectively. When the trouble cannot be solved, please contact our Service Engineering Division or the nearest customer support center.

| | |
|---|--|
|  |  WARNING |
| Disconnect all the power supply before performing trouble shooting. | |

Table A-1 Fault Diagnosis

| Problem | Possible Cause | Corrective Action |
|---|--|---|
| 1. Cooldown time is longer than usual, or cooldown is not sufficient. | 1) Helium Supply/Return line is not properly connected. Self-sealing coupling is not all the way seated in. | Properly connect the flexible hoses referring to Sec. 3.5. Check that all self-sealing couplings are connected properly. |
| | 2) Pressure in the vacuum chamber is too high. | Make sure that there is no leakage. The Cryocooler may fail to cool down due to thermal load of the gas caused by a leakage. |
| | 3) Helium filling pressure in the compressor unit is deficient. | Add helium gas with purity of 99.999% or more to the appropriate pressure. Refer to Sec.6.2. |
| | 4) Heat load to the Cryocooler is too high. | Take measures to reduce the heat load. |
| | 5) Helium gas is heavily contaminated. | Please contact us. |
| | 6) Failure of the Cryocooler or the compressor unit. | Please contact us. |

| Problem | Possible Cause | Corrective Action |
|---|---|--|
| <p>2. Neither the compressor unit nor the Cryocooler start.</p> | <p>Consult the instruction manual of compressor unit for details.</p> | |
| <p>3. The compressor unit operates but the cryocooler does not start.</p> | <p>1) A Cold head drive cable is not connected to the Cryocooler.</p> | <p>Turn off the compressor unit and connect the Cold head drive cable to the Cryocooler.</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p style="text-align: center;"> CAUTION</p> <p>Do not connect the Cold head drive cable to the Cryocooler without turning off the compressor unit. The Cryocooler motor may be damaged if this caution is not followed.</p> </div> |
| | <p>2) The drive motor of the Cryocooler has mechanical damage.</p> <p>① Motor shaft failure or bearing defects</p> <p>② Drive motor circuit failure</p> | <p>Check whether there is sound that shows a motion of a motor by turning on and off the Cryocooler.</p> <p>When no sound or irregular beat comes from the motor, contact our Service Engineering Division or the nearest CS center.</p> <p>Measure resistance and insulation resistance between the drive motor connector pins (Impressed voltage: 500V) and inform us the measured values with the serial number of the Cryocooler.</p> |

| Problem | Possible Cause | Corrective Action |
|--|--|--|
| 4. Cryocooler drive motor is making irregular or intermittent motion. | 1) Helium gas is heavily contaminated. | Please contact us. |
| | 2) Input voltage to the motor is low. | Check the input voltage to the Cryocooler. |

Appendix B

FLEXIBLE HOSE

1. 20A flexible hose specifications

- Gas : Helium Gas (Purity of 99.999% or above)
- Pressure : Maximum 2.45MPaG
- Temperature : 0 to 70°C
- Material : SUS304
- Length : 10 - 20 meters
- Minimum Bending Radius : 250mm
- Recommended Torque for Connecting : 20N·m

Fasten until the self-sealing coupling is tight enough.

- Connection : 1/2B self-sealing coupling

2. Precautions for Handling



CAUTION

- When carrying the flexible hose, hold the braid support of the hose. If it is bent forcibly at an acute angle, it may be damaged.
- Avoid twisting the flexible hose especially when making final connection.
- Keep away from water and salt to prevent corrosion. Do not place heavy objects on the flexible hoses in order to prevent being deformed or collapsed.

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Appendix C

PRINCIPLE OF REFRIGERATOR OPERATION

Helium gas is used as heat-medium gas of a refrigeration cycle in Cryocooler system, because it does not liquefy even 10K.

First, after the helium gas is compressed into high pressure and being continuously cooled by water-cooling or air cooling to room temperature within the compressor unit, it will be introduced into the refrigerator when the valve A opens. Then the helium gas is cooled by heat exchange between the regenerator and led to an expansion chamber with a rise of a displacer. Next, because the valve B opens at the same time the valve A closes, the high-pressure helium gas in the expansion chamber is exhaled toward the low pressure part of the compressor unit with the differential pressure. During this process, the pressure and temperature of the helium gas in the expansion chamber decreases (called Simon expansion). The cooled low-pressure helium gas is discharged completely from the expansion chamber by the descent of the displacer. As the helium gas passes through the regenerator again, it will be warmed up to room temperature and return to the compressor. At this moment, however, the regenerator is cooled down conversely. In this way, a refrigeration cycle returns to the first state. By repeating this refrigeration cycle, cryogenic temperature is obtained.

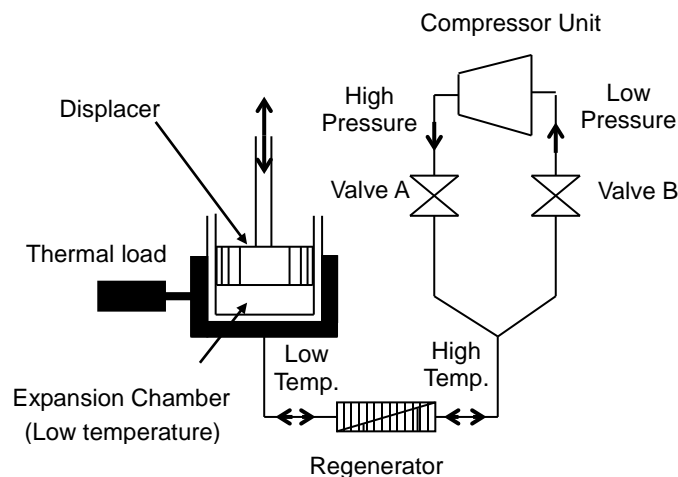


Figure C-1 Principle of Refrigeration

G-M Cycle

Gifford and McMahon developed the concept of G-M cycle in the late 1950's. In the driving method of G-M cycle, there are a way which drives mechanically and a way which drives using the differential-pressure of the operational gas. Since the GM

cycle is efficient, it can make drive speed late. Moreover, the load concerning the seal currently used for an inside is also light. Therefore, it is a highly efficient and reliable refrigeration cycle. In this manual, the refrigeration cycle with the mechanical driving system adopted by ULVAC CRYOGENICS INC is explained.

Figure C-2 shows the principle of G-M cycle & P-V chart (P: pressure, V: volume in the expansion chamber).

- A The displacer is first positioned at the bottom of the cylinder.
 ↓ The low-pressure valve is closed and the high- pressure valve is opened.
 ↓
 a The compressed helium is introduced into the warm end and the cold end (the expansion chamber) of the cylinder.
 ↓
 B Pressure inside the cylinder increases.
 ↓
 b When moving a displacer up, the cold end (expansion room) is filled up with the helium gas of room temperature, being cooled by the regenerator.
 ↓
 C The volume of the cold end (the expansion chamber) is now maximum.
 ↓ At this time the high- pressure valve is closed and low-pressure exhaust valve opened.
 ↓
 c The compressed helium in the cold end (the expansion chamber) is expelled through the regenerator causing a temperature decrease by Simon expansion.
 ↓
 D The cold end obtains the lowest pressure.
 ↓
 d The displacer is moved to the initial lower position and the low-temperature helium is transferred to the compressor. The temperature of the gas returns to room temperature by heat exchange between the regenerator.
 ↓

A One cycle of the helium gas circulation is completed.

The P-V diagram of idealized G-M cycle shows a quadrangle.

The ideal refrigeration ability “ Q_{ideal} ” is as follows when indicating the period of one cycle as “ t ” minutes:

$$Q_{ideal} = W / t$$

In the actual refrigerator, the structure with two stages is adopted in order to gain cryogenic temperature of 15K or less as shown in Figure C-3. In order to simplify structure, the regenerator is built into the inside of the displacer, and it is unifying. Moreover, since difference pressure is not applied to seals on the 1st stage and 2nd stage, the structure where the load to the seal is light has been adopted. Therefore, a long-lived, high reliability is acquired.

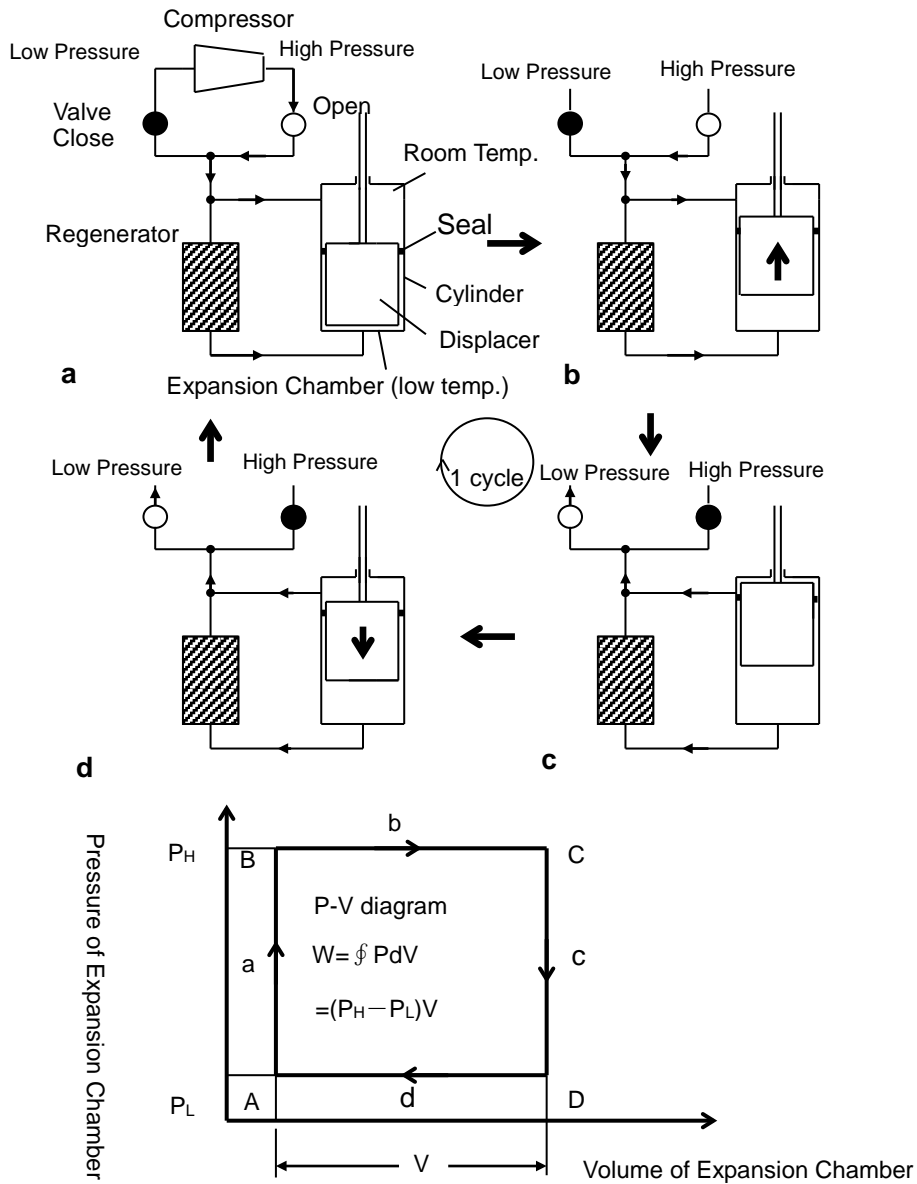


Figure C-2 Principle of G-M Cycle Operation

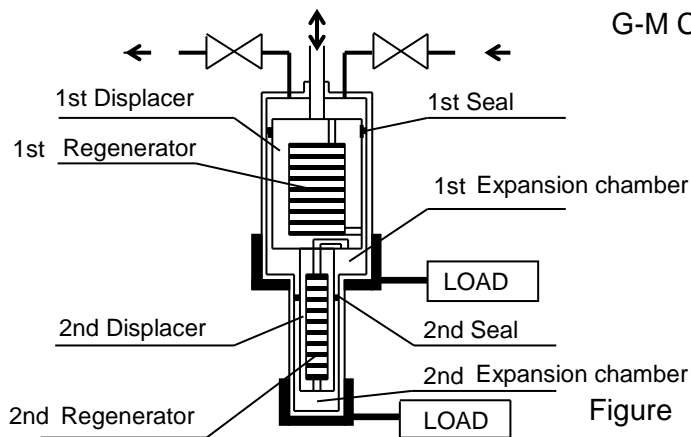
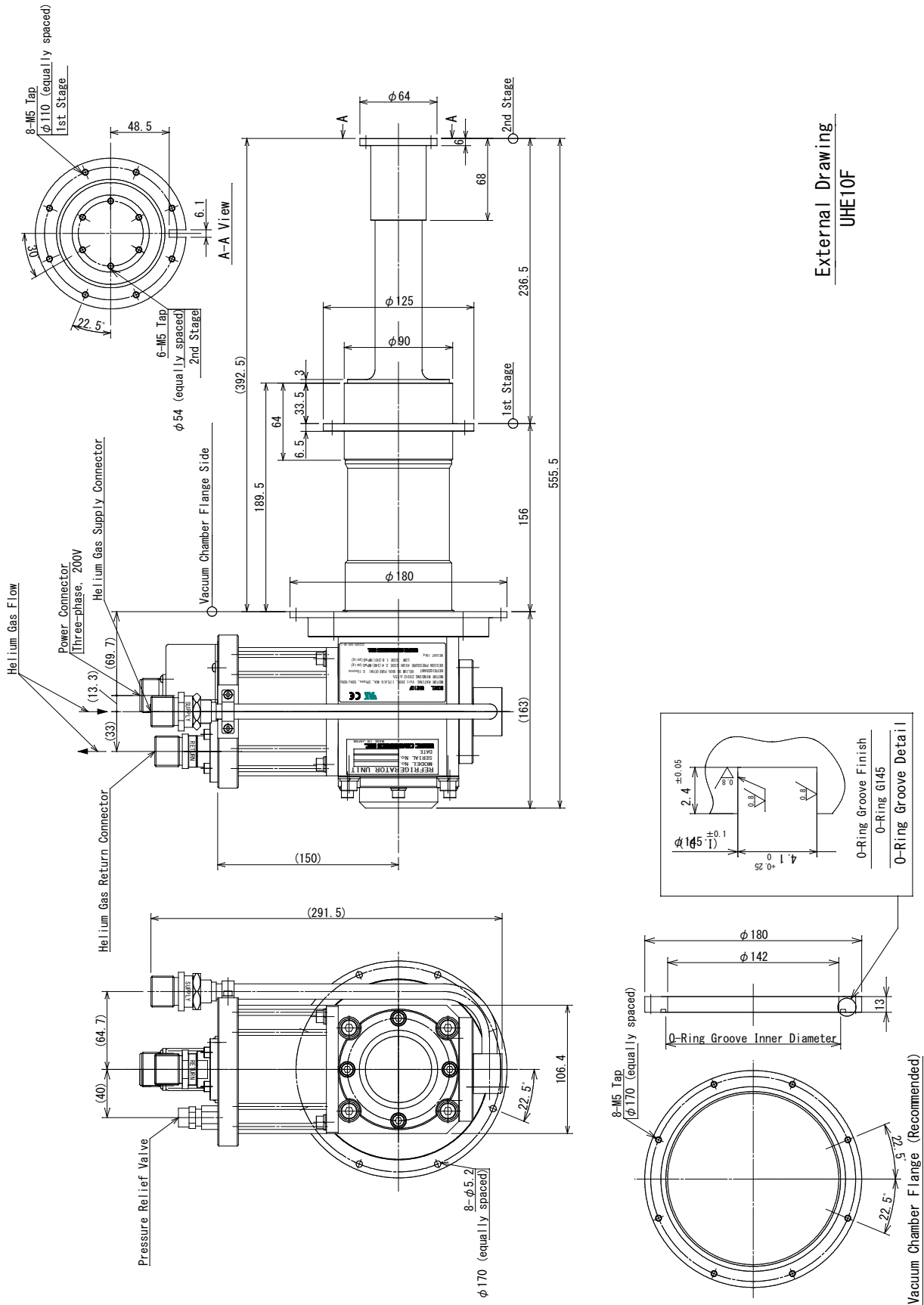


Figure C-3 Two-stage Refrigerator

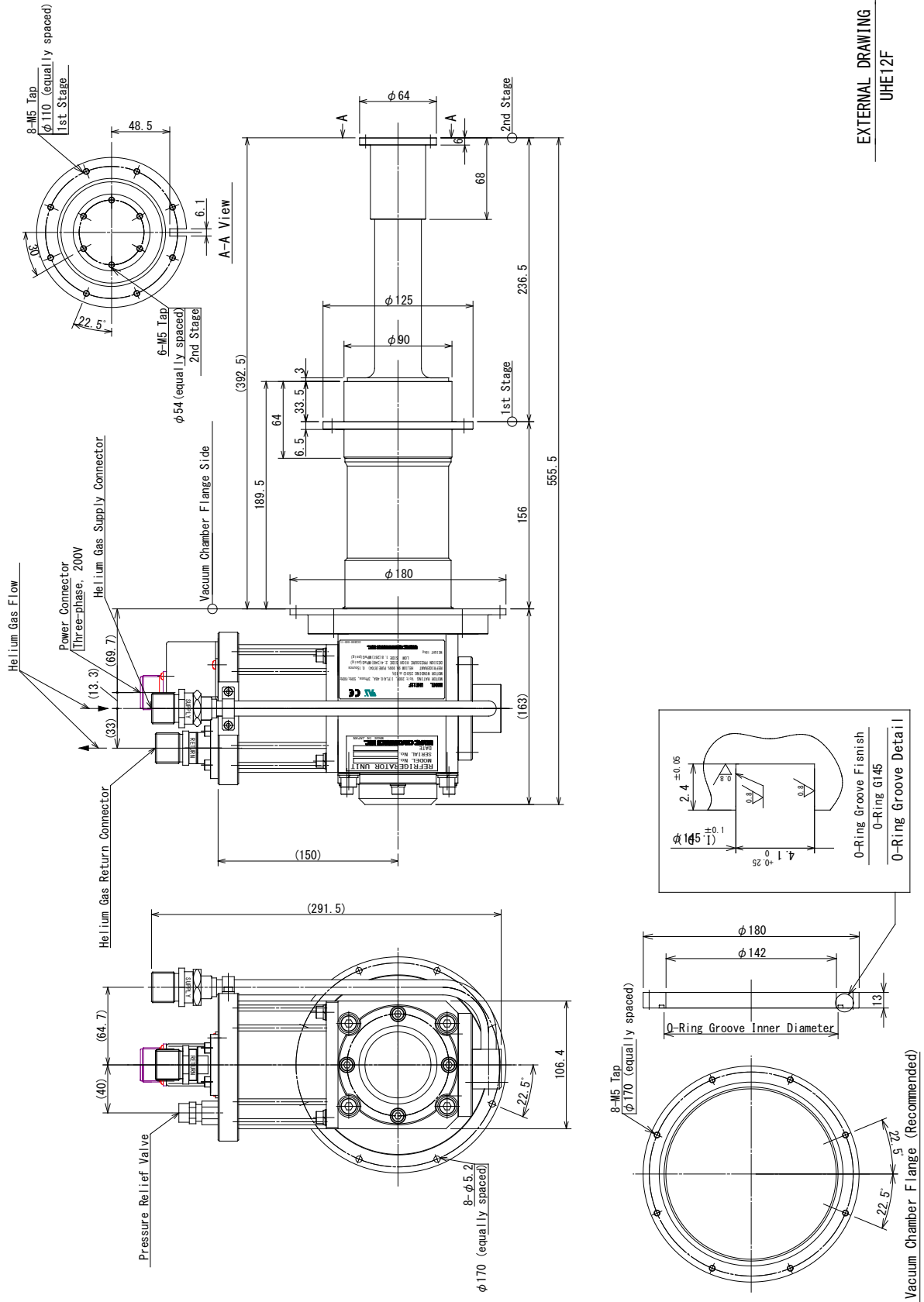
Appendix D

DIMENSIONAL DRAWING

| | |
|---------------------------------|-----|
| 4K Cryocooler Unit UHE10F | D-2 |
| 4K Cryocooler Unit UHE12F | D-3 |
| 4K Cryocooler Unit UHE15F | D-4 |



External Drawing
UHE10F



EXTERNAL DRAWING
UHE12F

Appendix E

Self-certification

Self-certification of CE marking of the Refrigerator Unit is posted on the next page.

Declaration of Conformity

We, ULVAC CRYOGENICS INCORPORATED
1222-1 Yabata, Chigasaki, Kanagawa, 253-0085, Japan

declare in our sole responsibility that the following product conforms to all the relevant provisions.

Product Name : Refrigerator Unit
 Model Name : **UHE10F,UHE12F,UHE15F,RM103F, RM203F, RM503F, RM803F**
RMS103F, RMS503F, RMS803F

Council Directives : Machinery Directive (MD) : 2006/42/EC
 Electro Magnetic Compatibility Directive (EMC) : 2014/30/EU
 RoHS Directive : 2011/65/EU

| | | |
|---------------------------------|------------------------|--|
| Applicable Harmonized Standards | : Machinery Directive, | EN ISO 12100 :2010 EN60204-1 :2006+A1 :2009 |
| | EMC Directive, | EN 61000-6-4:2007+A1:2011 EN 61000-6-2:2005 EN 61000-3-2:2014 EN 61000-3-3:2013 EN 60601-1-2:2015 EN 55011:2009+A1:2010 |
| | RoHS Directive, | EN 50581:2012 |

We keep the following Technical Documentation on file for review.

Technical Documentation File No. TC18-39-861

Authorized Representative in EU : Mutsuki Odawara
 Parkring11, 85748, Garching, (Munch), Germany

Place : Kanagawa, Japan

Date : May 8 , 2019



Signature

Takeshi Haginouchi / President

SERVICE NETWORK

- For technical support, servicing or additional contact information, visit us at www.ulvac-cryo.com.

ULVAC CRYOGENICS INC.

www.ulvac-cryo.com

1222-1 Yabata, Chigasaki, Kanagawa 253-0085, Japan

<Sales>

Tel: +81-467-85-8884

<Service Engineering Division>

Tel: +81-467-85-9366

Fax: +81-467-83-4838

ULVAC CRYOGENICS KOREA INC.

www.ulvac-cryo.co.kr

107, Hyeongoksandan-ro, Cheongbuk-Myeon, Pyeongtaek-si,
Gyeonggi-Do, Korea, 17812

Tel: +82-31-683-2926

Fax: +82-31-683-2956

ULVAC CRYOGENICS (NINGBO) INC.

www.ulvac-cryo.com

No.888 Tonghui Road, Jiangbei District, Ningbo, China, 315020

Tel: +86-574-879-03322

Fax: +86-574-879-10707

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Revision History

| Date | Revision No. | Contents |
|------------|--------------|---|
| 2018-11-21 | 2018.11 | First edition |
| 2019-01-08 | 2019JA01 | Appendix D has been modified. |
| 2019-02-27 | 2019FY02 | Descriptions on UHE12F have been added. |
| 2019-05-31 | 2019MY03 | Appendix E "Self-certification" has been added. |
| | | Name of a component has been modified. |

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