Trillium US Inc.
Cryogenic Water Pump
User's Manual

Rev A / March 2016

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1 Revision History

Date	Revision	ECR #	Description of Change
December 2013	1.0		Initial Release
November 2015	A	2887	Rebranding and format changes
Document Part Number: 97-00057-000			

2 Preface

2.1 About Trillium US Inc.

Trillium US Inc., an Oregon based company, specializes in the manufacture and repair of cryogenic vacuum pumps, cryocoolers (refrigerators) and helium compressors for semiconductor, optical coating, linear accelerators, medical equipment, and R&D applications.

You can find just what you need from our range of products and support services:

- New Equipment - cryopumps, such as the cryogenic water pump described in this manual, compressors, cryocoolers, and cryopump controllers.
- Comprehensive range of accessories for the installation of whole systems and a complete range of spare parts to repair cryopumps and compressors.

2.2 Other Services from Trillium US Inc.

Trillium US Inc. offers comprehensive refurbishment services for its own equipment as well as for that of most of our competitors. Our products and services are available through our global network of agents and dealers.

- Repair and refurbishment services - We offer our own quality products, as well as most other manufactures models, often with off-the-shelf availability.
- Exchanges - We offer our own quality products, as well as most makes of cryopumps and helium compressors, which are refurbished and fully warranted.
- Technical Support - Our support engineers will help determine if your cryopump system is operating correctly so that you can get your system back to optimum efficiency as soon as possible.
    - To contact Trillium US Inc. Technical Support:
    - E-mail: support@trilliumus.com
    - Telephone: 1-512-441-9258 or Toll Free: 1-800-404-1055
- Installation - On-site installation services are available to guarantee performance and save you time.
- Training - We offer on-site training to help you and your staff to know more about your cryopump and compressor systems. Our training will give you confidence and the ability to maintain a highest possible uptime for your system.

2.3 About this Manual

The purpose of this manual is to provide our customers using a cryogenic water pump with the information needed to safely and efficiently operate the compressor when operating as part of a cryogenic refrigeration system. Such a system is often comprised of the following equipment:

- Cryopump compressor unit such as the Model 600 compressor from Trillium US Inc.
- Coldhead(s) or cryopump(s)
- Connecting helium lines

This manual describes the design, operation and maintenance of the cryogenic water pump unit.

2.4 Compatibility

The cryogenic water pump is designed for use with Trillium US Inc. helium compressors (M125, M400, M600, M700 or equivalent).

3 Safety Warnings

3.1 Standards for the Use of Warnings and Cautions

Warnings are noted when there is a possibility of injury or death to persons operating the equipment or performing specific tasks or procedures noted in this manual. Cautions are noted when there is a possibility of damage to equipment if the caution is ignored.

3.2 Warnings Applicable to All Aspects of Cryogenic Water Pump Operation

Warning: **If a cryogenic water pump has been used to pump any toxic or dangerous materials, this information and associated paperwork must be listed on all shipping containers and on associated paperwork before the equipment is returned to Trillium US Inc. for any repairs.**

Warning: **When pumping any toxic, corrosive, or flammable gases, a vent pipe must be connected to the cryopump relief valve and vented to a safe location.**

Warning: **Do not install a hot filament vacuum gauge on the cryopump side of the hi-vac gate valve as this could be a source of ignition.**

Warning: **Helium gas can cause rapid asphyxiation and death if released in a confined area.**

Warning: **Use a pressure reducing regulator when with-drawing Helium gases from a high pressure cylinder**

Warning: **Detaching the helium flex lines with the compressor load at low temperature can cause the pressure rise in the system beyond the permissible level therefore creating a safety hazard.**

3.3 Operator Instructions

Follow standard cryogenic water pump operating procedures as described in this manual. If after reading this manual, you still have questions regarding the safe operation of the equipment, please contact Trillium US Inc. Technical Support using the contact information found in Section **2**.

4 Introduction

4.1 General Information about the Cryogenic Water Pump

Trillium US Inc. provides both custom and industry standard cryogenic solutions at highly competitive prices. Cryogenic vacuum pumps provide clean, oil-free high vacuum with high pumping speeds are the pump of choice for sputtering, electron beam evaporation, accelerator beam lines and many aerospace and coating applications.

Cryogenic water pumps are available in various standard inlet flange configurations -ANSI, ISO, CF and complete UHV, with temperature sensors either in diode or hydrogen-vapor-bulb (HVB) configurations.

4.1.1 Cryogenic Water Pump Features

The Cryogenic water pumps, as seen in
Figure 4 and **Figure 5**, are typically used in the following applications:

- Sputtering tools
- Ion implanters
- R & D bell-jar systems

- Surface analysis
- Accelerators
- Beam lines
- Any vacuum system or process where water vapor could cause degradation in system vacuum level and/or product qualities

4.1.2 Overview of Cryogenic Water Pump Operation

The pump-down time to achieve proper base vacuum level in a vacuum chamber is a critical cost element in a production environment. This is especially true for a large vacuum chamber which will require significant amount of pumping time to reach its desired base vacuum before production can begin. At 1.0×10^{-3} torr or better vacuum level, about 97% of the residual particles in the chamber are water vapors. Using cryogenic water pumps would therefore significantly reduce the overall vacuum pump down time and improve the productivity of the process equipment. It is also a cost-effective way of upgrading existing vacuum chambers that are equipped with turbo-molecular pumps (TMPs) or diffusion pumps (DPs).

Cryogenic water pumps can generally be configured in three different ways to maximize their effects. Each configuration has its own distinct advantages and in the case of upgrading a vacuum chamber, they may be selected based on characteristics of the chamber and its existing TMP/DP pumping system designs. The following are brief descriptions of these three configurations.

1. **In-Situ Configuration**: In this configuration, the cryo-panel or the so-called sail of a cryogenic water pump is located inside the vacuum chamber, while the coldhead and its drive motor are mounted on a vacuum chamber port. **Figure 1** represents two variants of such a configuration.
    a. The main advantage of this configuration is that the sail of the pump can be custom designed to fit the geometry inside the chamber, with largest achievable cryo-pumping surface area (hence highest achievable water pumping speed). However, this configuration does need sufficient clearance within the chamber and access to the inside of the chamber for maintenance, etc.
    b. When using this configuration to upgrade a chamber that has installed TMP or DP pumping system, it has no impact on the pumping speeds of other process gases if the pump is mounted on its own port.
2. **In-Line Configuration:** When a chamber has no spare port to mount a cryogenic water pump independently, the in-line configuration can be used to take advantage of the benefit of a cryogenic water pump without significant change to the existing chamber equipment design and setup. In this configuration, a cryogenic water pump is inserted in between the existing TMP or DP and the mounting port, as shown in **Figure 2**. The cylindrical cryo-panel of the pump is situated inside the pump vessel that connects the inlet of the TMP or DP to the vacuum chamber port, and does not protrude into the chamber itself.
    a. The addition of the cryogenic water pump in front of the existing TMP or DP will somewhat impact the pumping speed of the later. The change can be described as:

$$1/S_{eff} = 1/S_{ini} = 1/C_{wp}$$

    With S_{ini} being the TMP or DP pumping speed of a particular gas at the mounting port without the cryogenic water pump, and C_{wp} being the water pump conductance of the same gas. S_{eff} is then the effective TMP or DP pumping speed of this particular gas with the in-line cryogenic water pump installed. Generally, this could result in reduction of the TMP or DP pumping speed.
3. **Appendage Configuration: Figure 3** illustrates an appendage configuration of a cryogenic water pump. For a vacuum chamber that has extra ports available, this configuration will allow adding significant water vapor pumping capability to the chamber without interfering with the existing vacuum equipment setup and performance.
    a. This configuration does not affect the pumping speed of the existing TMPs or DPs.

Figure 1 – Cryogenic Water Pump Mounted In-Situ on a Vacuum Chamber

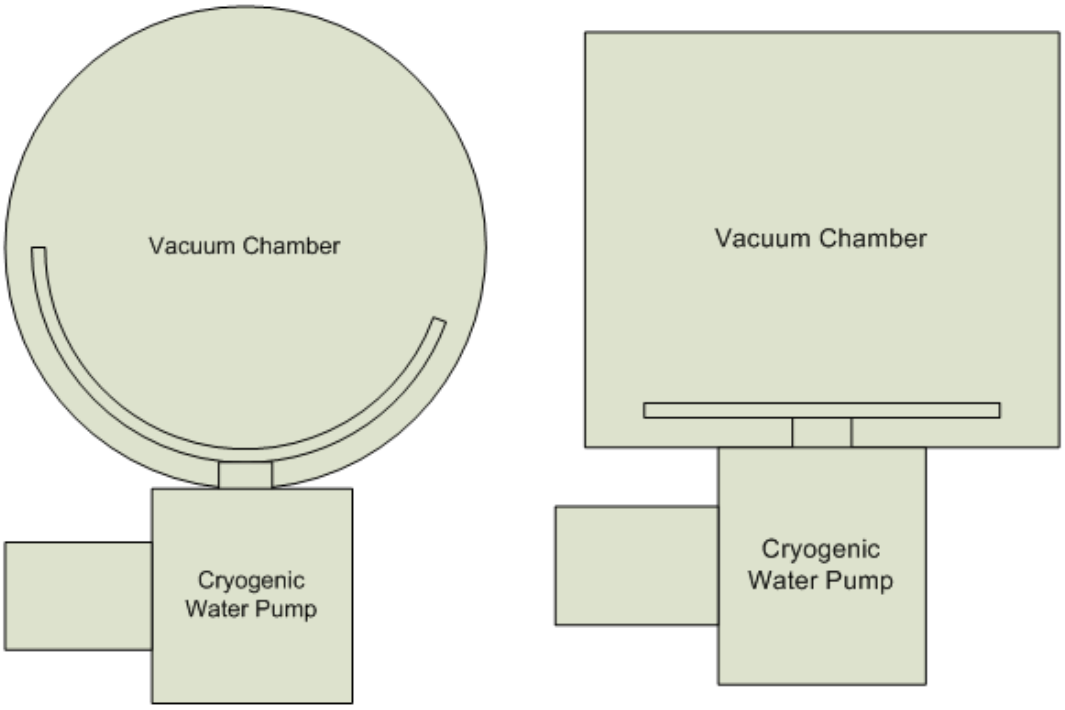


Figure 2 – Cryogenic Water Pump In-Line with Turbo/Diffusion Pump

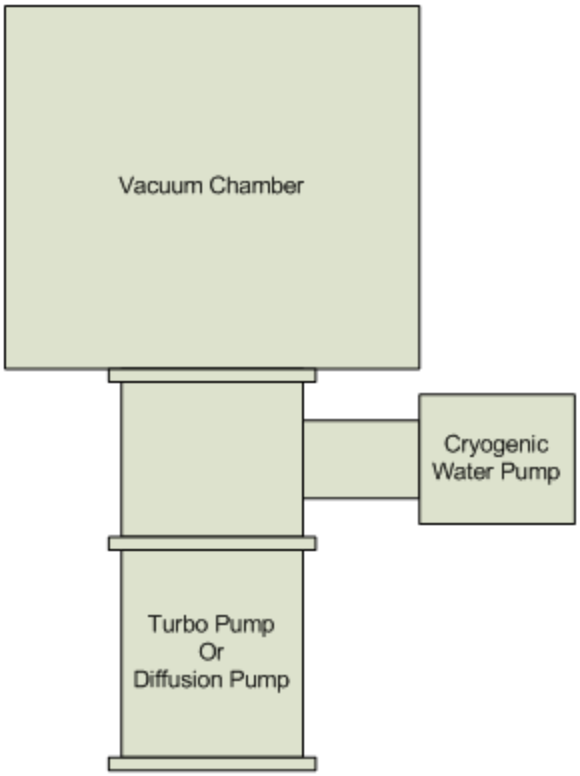
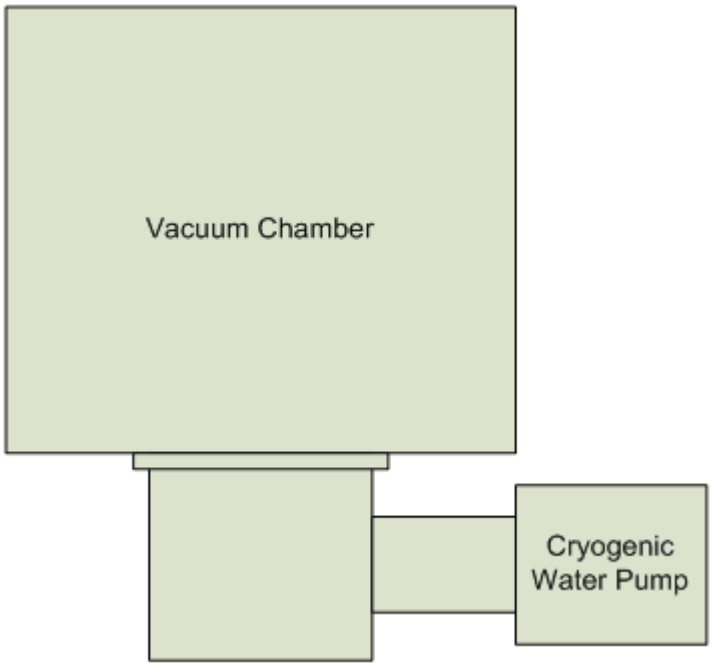


Figure 3 – Cryogenic Water Pump Appendage Configuration



Trillium US Inc. designs and manufactures cryogenic water pumps of all three configurations, at sizes of 4", 6", 8", 10" and 16", and with different types of flanges (CF, ISO, ANSI, etc.). Trillium US Inc. can also design and manufacture custom configuration of cryogenic water pumps. **Table 4-1** lists the water pumping speed and other info of the ASC cryogenic water pump product line.

4.2 Specifications

The cryogenic water pump specifications are listed in **Table 4-1.** **Figure 4** thru **Figure** 5 show cryogenic water pump dimensions of several configurations.

Table 4-1: Cryogenic Water Pump Characteristics

Pump Size	**4"**	**6"**	**8"**	**10"**	**16"**
Water Vapor Pumping Speed (liter/sec)	1,100	2,500	4,000	7,000	16,000
Conductance* (N_2, in-line configuration)	450	1,000	1,800	2,800	7,800

*For in-line configuration only.

Note: Cryogenic water pumps can operate safely in any mounting orientation.

Figure 4 – 6" In-Line Cryogenic Water Pump with Rotatable CF Inlet Flanges
Standard and UHV Versions with a Custom RGA Port

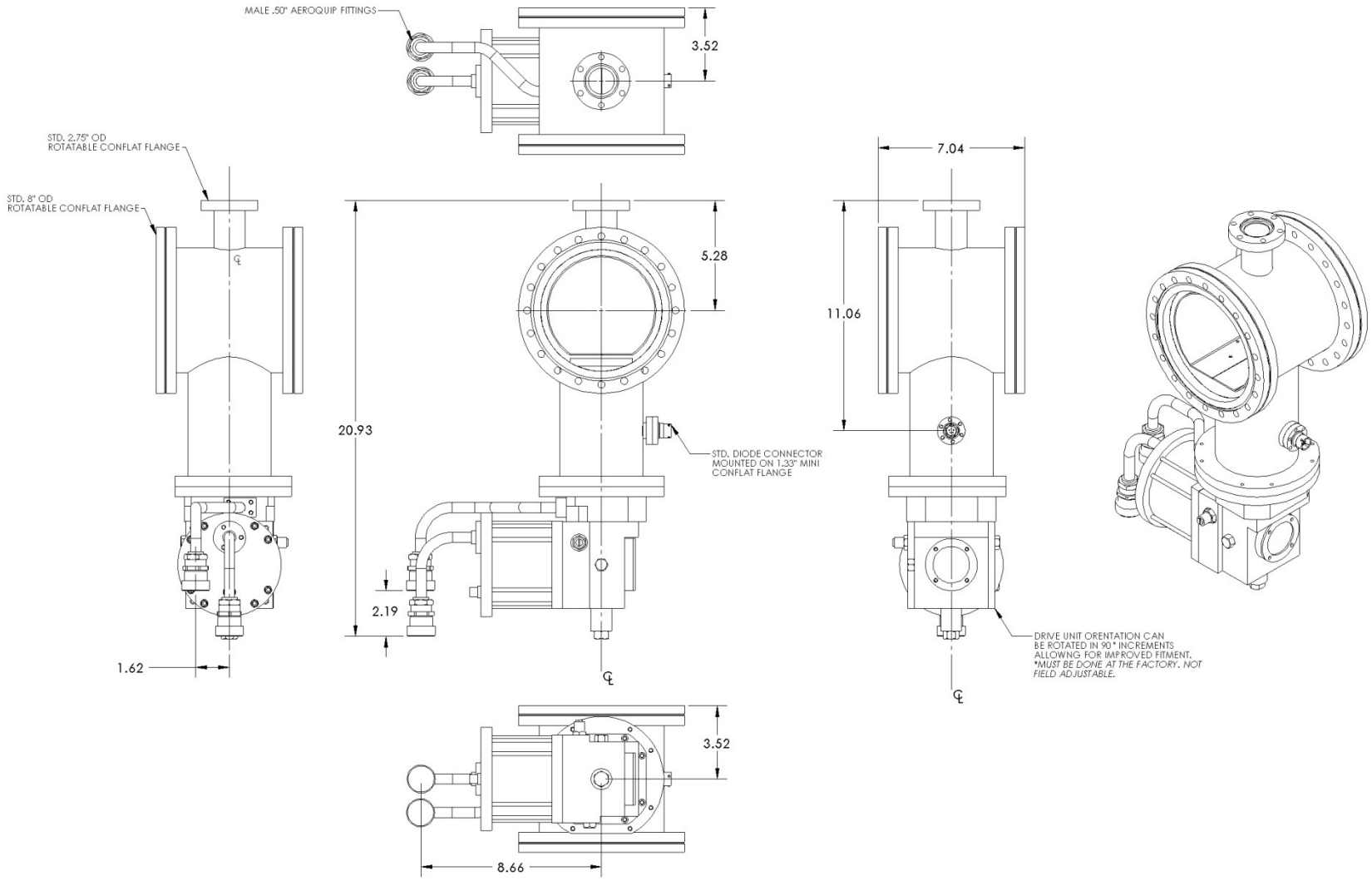


Figure 5 – 8” In-Line Cryogenic Water Pump with Rotatable CF Inlet Flanges
Standard and UHV Versions with a Custom RGA Port

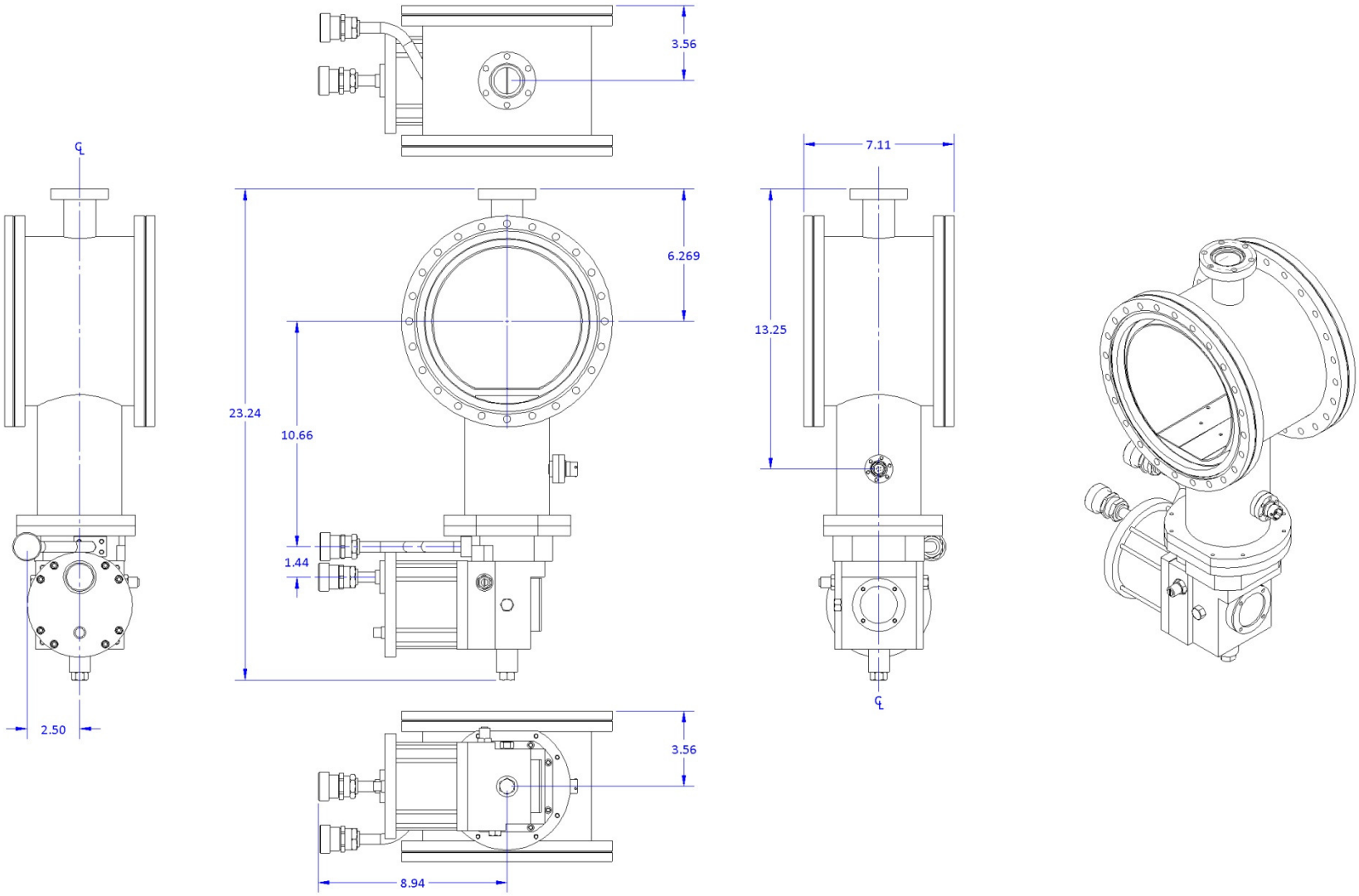


Figure 6 – 4" In-Line Cryogenic Water Pump with Rotatable CF Inlet Flanges
Standard and UHV Versions

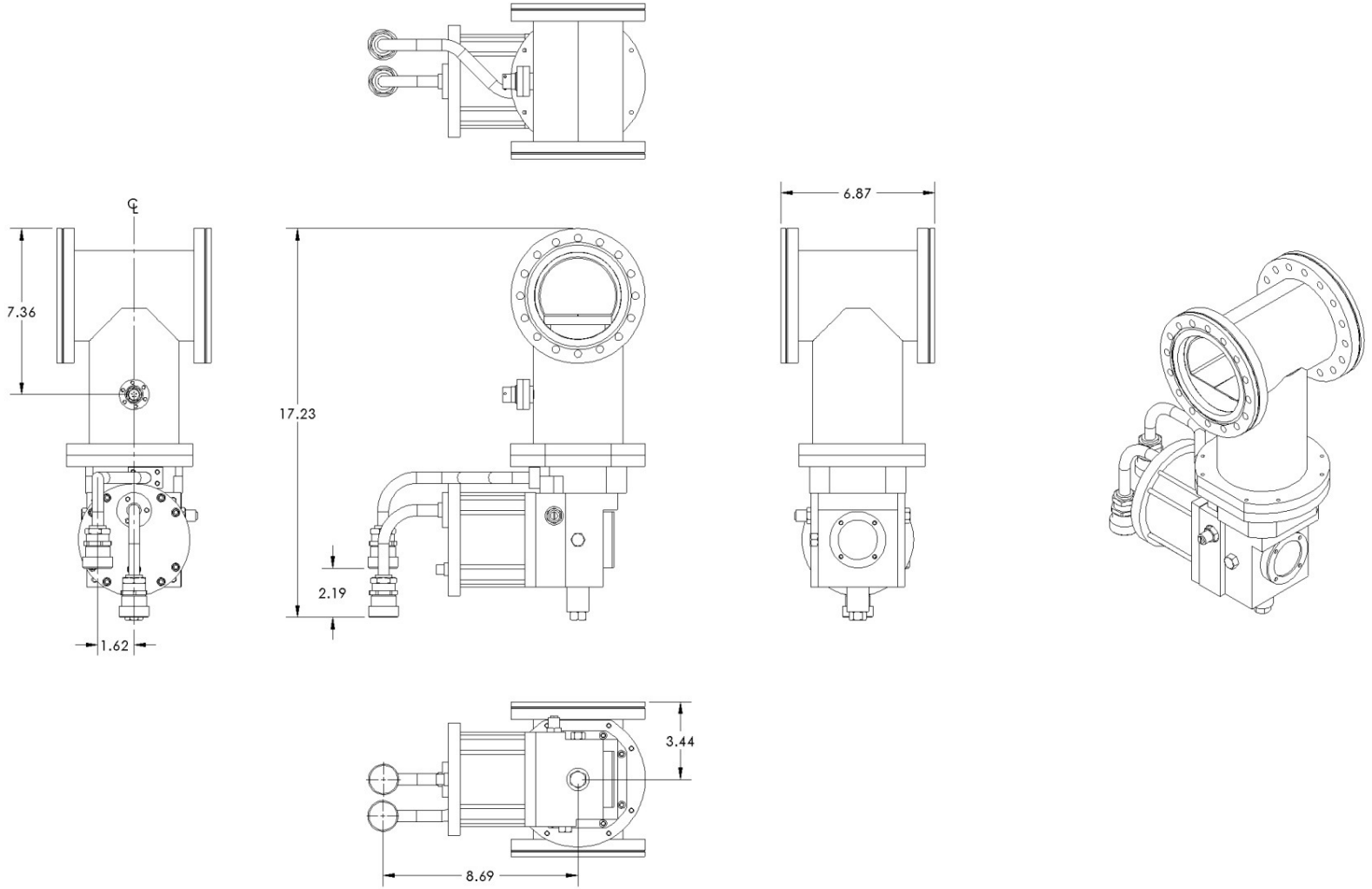


Figure 7 – 16” In-Line Cryogenic Water Pump with ISO Inlet Flanges

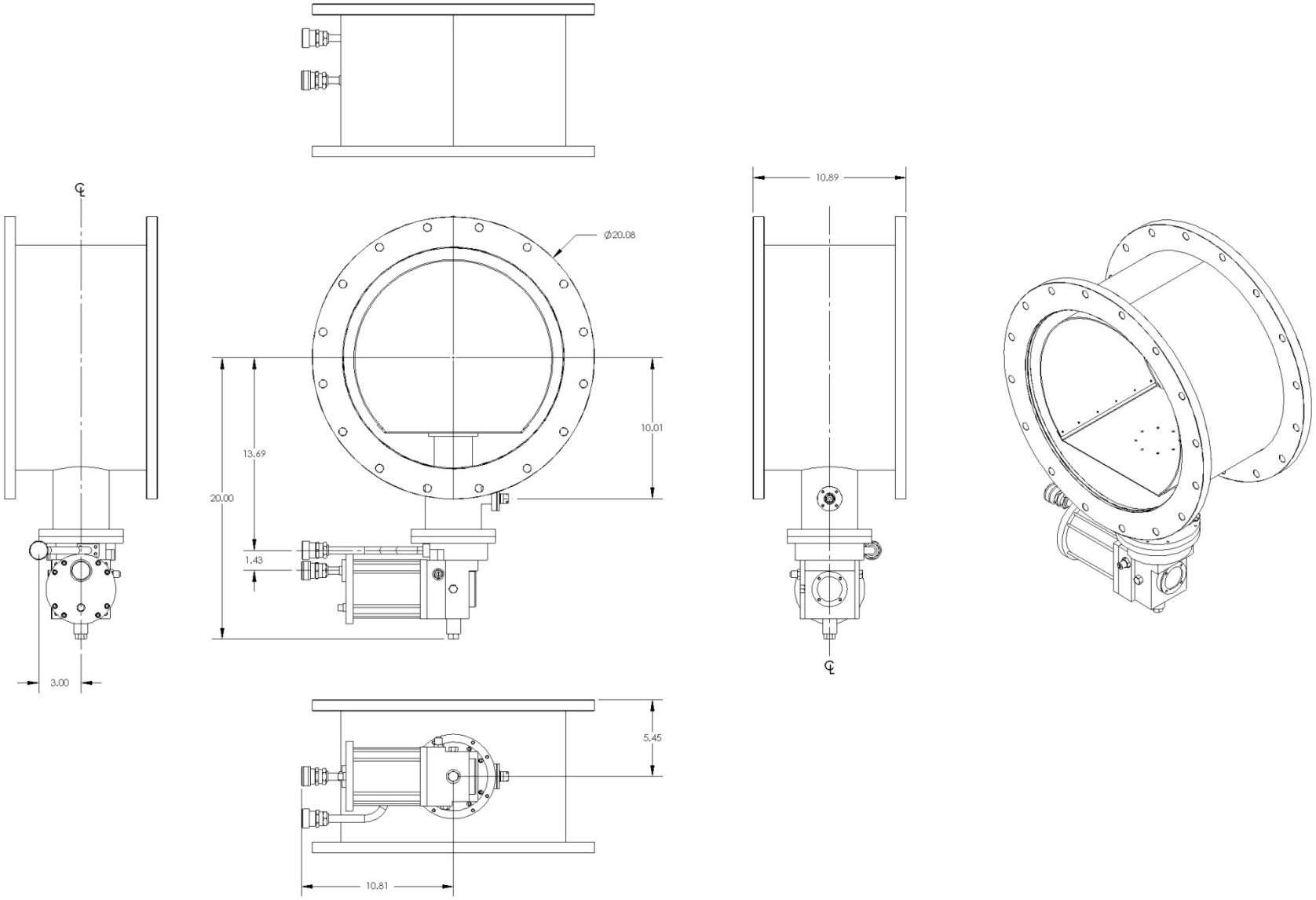


Figure 8 – 6" (ISO160) In-Situ Cryogenic Water Pump with ISO Inlet Flanges (MK-50 Equivalent)

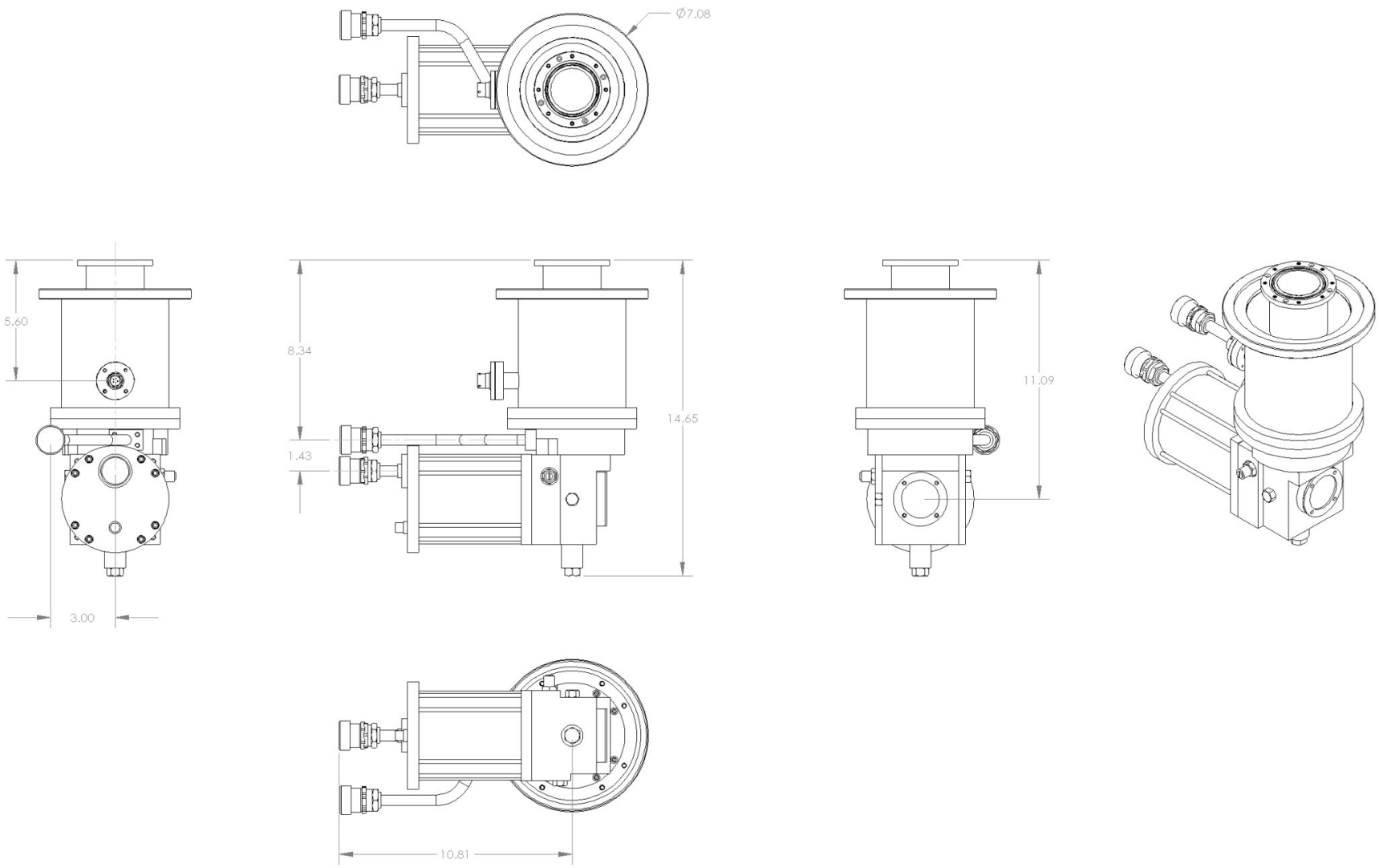
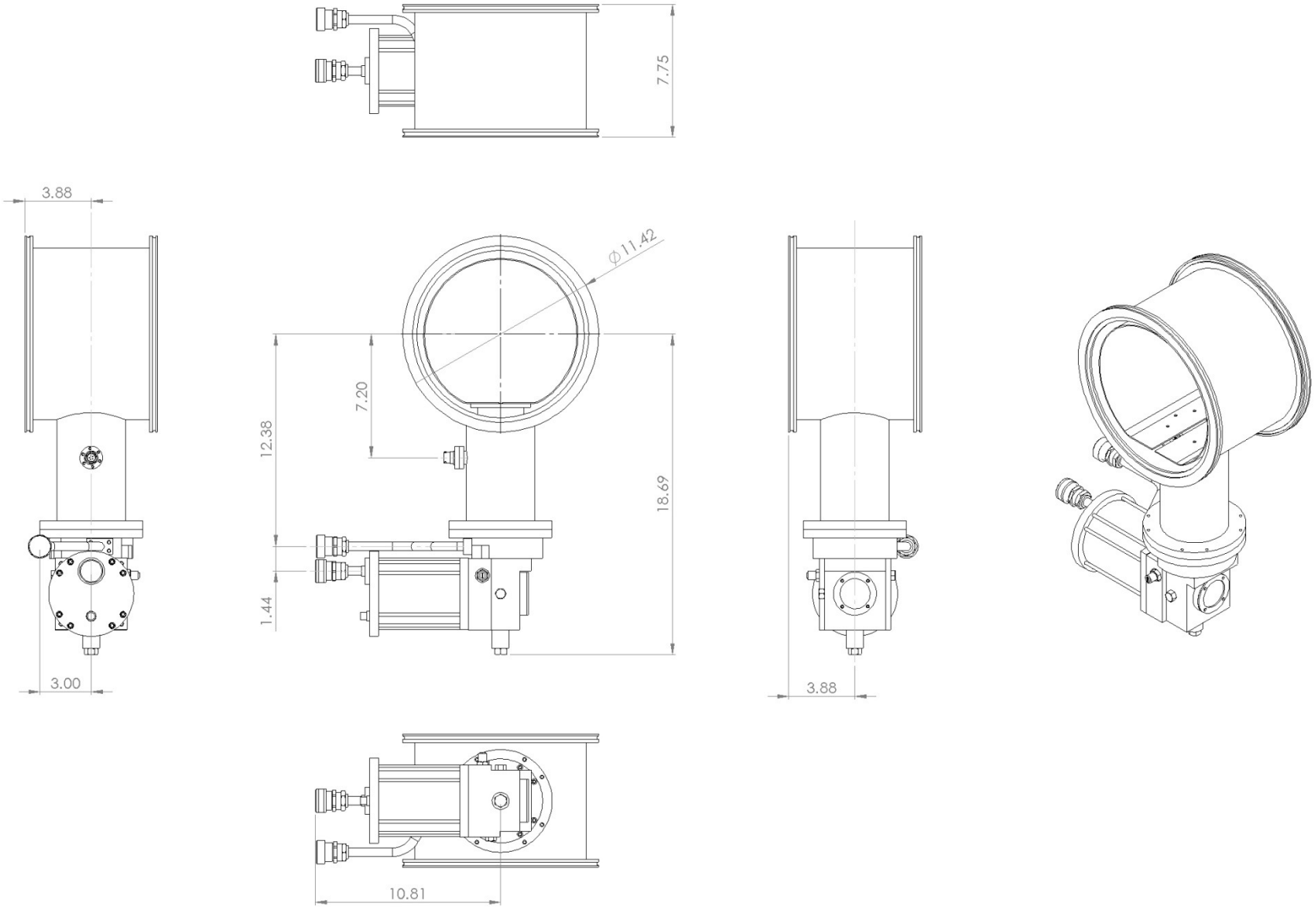


Figure 9 – 10” In-Line Cryogenic Water Pump with ISO Inlet Flanges



4.3 Ordering Information

Table 4-2 contains the ordering information for the cryogenic water pumps. Customers can also order the optional accessories and replacement parts listed in **Table 4-3**

Table 4-2: Cryogenic Water Pump Ordering Information

Pump Type	Pump Inlet Flange Size	Inlet Flange Type	Part Number
In-Line	4”	CF (Rotatable) x 2	92-00700-000
In-Line	6”	CF (Rotatable) x 2	92-00100-000
In-Line	6”	CF (Rotatable) x 2; Full UHV	92-00300-000
In-Line	8”	CF (Rotatable) x 2	92-00200-000
In-Line	8”	CF (Rotatable) x 2; Full UHV	92-00400-000
Appendage	6” (ISO160)*	ISO	92-00008-000
In-Line	10”	CF (Rotatable) & ISO	92-00600-000
In-Line	10”	ISO –LFB x 2	92-00600-001
In-Line	10”	ISO x 2	92-00600-002
In-Line	16”	ISO x 2	92-00800-000

*CTI MK-50 Water Pump Equivalent

Table 4-3: Optional Accessories and Replacement Parts

Accessories/Replacement Parts	Part Number
E1000 Remote Temperature Controller (Controller Only)	81-00040-000
Kit, E1000 Remote Temperature Controller (10ft Compressor Input Cable)	99-00079-000
Kit, E1000 Remote Temperature Controller (15ft Compressor Input Cable)	99-00079-015
Kit, E1000 Remote Temperature Controller (20ft Compressor Input Cable)	99-00079-020
Cable, Diode, Dual Pump, 10ft	81-00038-010
Cable, Diode, Dual Pump, 20ft	81-00038-020
Cable, Diode, Dual Pump, 25ft	81-00038-025
Coldhead Drive Unit Power Cable (10 ft.)	10144-10
Helium Line, 0.5"ID, 10ft *	10418-10
Single Pump Installation Kit	10251

*Custom length available.

5 Installation

5.1 Safety Warnings

Review the safety warnings in Section 3 before beginning any installation activities.

5.2 Inspect Equipment Before Installing

Remove the cryopump from the box and inspect for any damage during shipping. Notify the shipping company and Trillium US Inc. immediately if any damage was found.

5.3 Tool Needed for Installation

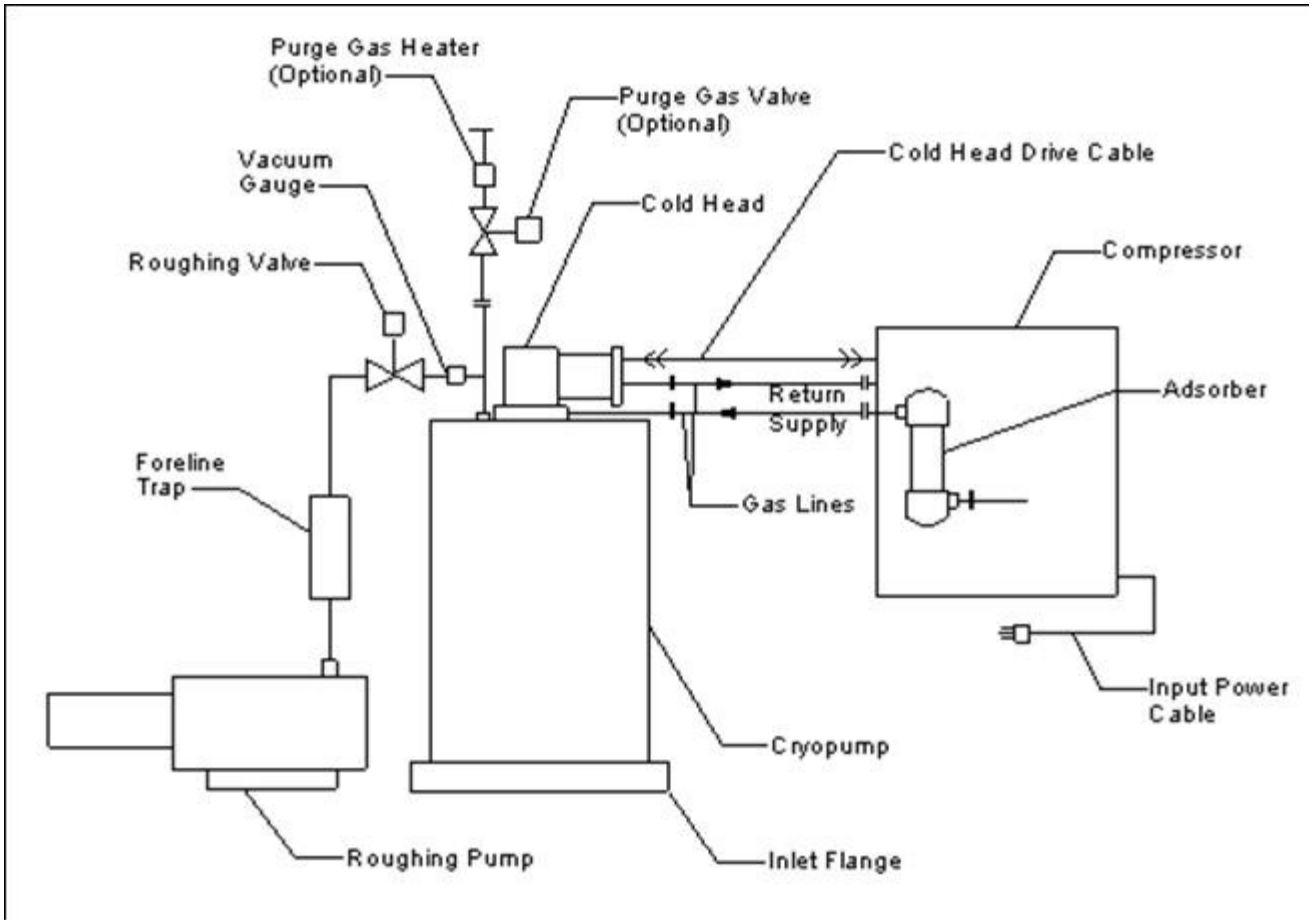
The Installation Kit for the cryogenic water pump is offered as an optional accessory that can be ordered from Trillium US Inc. Refer to **Table 4-3** for the part number.

5.4 Installing the Cryogenic Water Pump

Figure 10 shows a typical installation diagram when making connections. Follow these steps to install the cryogenic water pump:

1. Clean all sealing surfaces, apply a thin film of vacuum grease to inlet flange gasket or o-ring and install it.
2. Mount the cryogenic water pump:
    a. For an appendage or in-line cryogenic water pump, mount and secure the pump to the chamber gate valve.
    b. For an in-line cryogenic water pump, mount the original TMP/DP/CP to the other flange of the pump.
    c. For an in-situ cryogenic water pump, mount and secure the pump to a chamber port (no gate valve).
3. For an in-situ cryogenic water pump, install the sail to the coldhead from the chamber side.
4. Remove dust plugs from any Aeroquip Self Sealing Couplings and inspect gasket seals.
5. Connect helium gas lines in the following order.
    a. Use a helium flex line to connect the “Return” ports on both the cryogenic water pump and the compressor.
    b. Use a helium flex line to connect the “Supply” ports on both the cryogenic water pump and the compressor.
6. Check gas pressure gauge per compressor specifications.
7. Connect cold-head drive cable from cryopump to compressor.
8. Connect diode cable to temperature monitor/controller if applicable.
9. Connect main power cable per compressor specifications.

Figure 10 – Connection Diagram



6 Operations and Controls

6.1 Cryogenic Water Pump Normal Operation

6.1.1 Cryogenic Water Pump Start-Up

1. For an in-line or appendage cryogenic water pump, make sure the chamber gate valve is closed
2. Turn on the mechanical roughing pump and rough to 1.0 x 10^{-3} torr or better pressure level within the pump vessel.
3. For an in-situ cryogenic water pump that has its sail located inside the vacuum chamber, make sure the chamber pressure reaches 1.0 x 10^{-3} torr or better.
4. Turn on the compressor that runs the cryogenic water pump and start the cool down process.
5. Close the rough valve and start the compressor that runs the cryopump.
6. When a cryogenic water pump is operating properly, it usually takes about 15~30 minutes to reach 104-108°K.
7. Make sure the pressure level within the pump vessel reaches at least the crossover of the vacuum chamber before opening the gate valve.

6.1.2 Cryogenic Water Pump Shut-Down

1. For an in-line or appendage cryogenic water pump that is separated from the main vacuum chamber through a gate valve, close the gate valve.
2. Turn off the compressor that runs the cryogenic water pump.
3. The pump will then be warmed up to ambient temperature.

7 Trouble Shooting Activities

7.1 Troubleshooting Activities

Table 7-1 describes some problems that users might encounter while operating the cryogenic water pump and provides solutions to those problems.

Table 7-1: Trouble Shooting Procedures

Problem	Possible Cause	Corrective Action
Temperature of cryogenic water pump does not reach required operating temperature	1. The sail is loose, thereby preventing good thermal contact with its cold station on the cold head. 2. Excessive thermal load 3. Decrease in water pump cold head performance	1. Warm the water pump to ambient temperature, and retighten the sail to about 15 to 20 in-pounds. 2. Reduce the thermal radiation load by (1) shielding the pump or (2) lowering the temperature of the radiating surface 3. If the helium pressure gauge reads well above or below the normal operating pressure, release or add helium gas as described in the compressor manual. Warm up and then re-cool down the water pump. If the temperature remains high, the problem may be within the

Problem	Possible Cause	Corrective Action
		cold head. Contact Trillium US Inc.
Pump fails to cool down to the required operating temperature or takes too long to reach temperature.	1. Incorrect helium supply pressure. 2. Vacuum leak in vacuum system or cryogenic water pump. 3. Compressor problem	1. Add or release helium gas as described in the compressor manual a. Check vacuum system for leaks. b. Check cryogenic water pump for leaks Contact Trillium US Inc.
Cryogenic water pump has intermittent noise during operation, a ratcheting or thumping sound.	1. Helium Contamination	1. Contact Trillum US Inc.

8 Maintenance

8.1 Maintenance Personnel Requirements

Only trained and qualified personnel should perform the maintenance procedures described in this chapter. Observe safety warnings as described in Section **3**. All other maintenance work must be performed by Trillium US Inc. personnel in the factory. Please contact Trillium US Inc. to make arrangement for such work. See contact information in Section **2**.

Caution: **Always use two wrenches when connecting or disconnecting the Aeroquip self-sealing couplings.**

8.2 Cleaning Equipment

Caution: **Do not use solvents to clean connectors. The fittings should never be greased or oiled; otherwise the helium gas circuit of the system could become contaminated.**

8.3 Returning Equipment

Before returning any equipment, contact Trillium US Inc. to receive special instructions and to obtain a return authorization number (RMA). See contact information in Section **2.**