

**EASYCOOL** 易酷®

PRIDE Leading New Cryogenics Technologies

# KDHRR80 Helium Liquefier Operating Manual

 **PRIDE** CSIC PRIDE (NANJING) CRYOGENIC TECHNOLOGY CO.,LTD.

# CATALOGUE

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# SAFETY REQUIREMENTS

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## GENERAL

The safety of the equipment of CSIC Pride (Nanjing) Cryogenic Technology Co., Ltd. (CPCT) is guaranteed when the installation, operation and service are performed in accordance with the technical manual. You can find the information about Service Center in the service section of this manual.

## SPECIAL NOTICES

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

## WARNINGS

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

## CAUTIONS

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

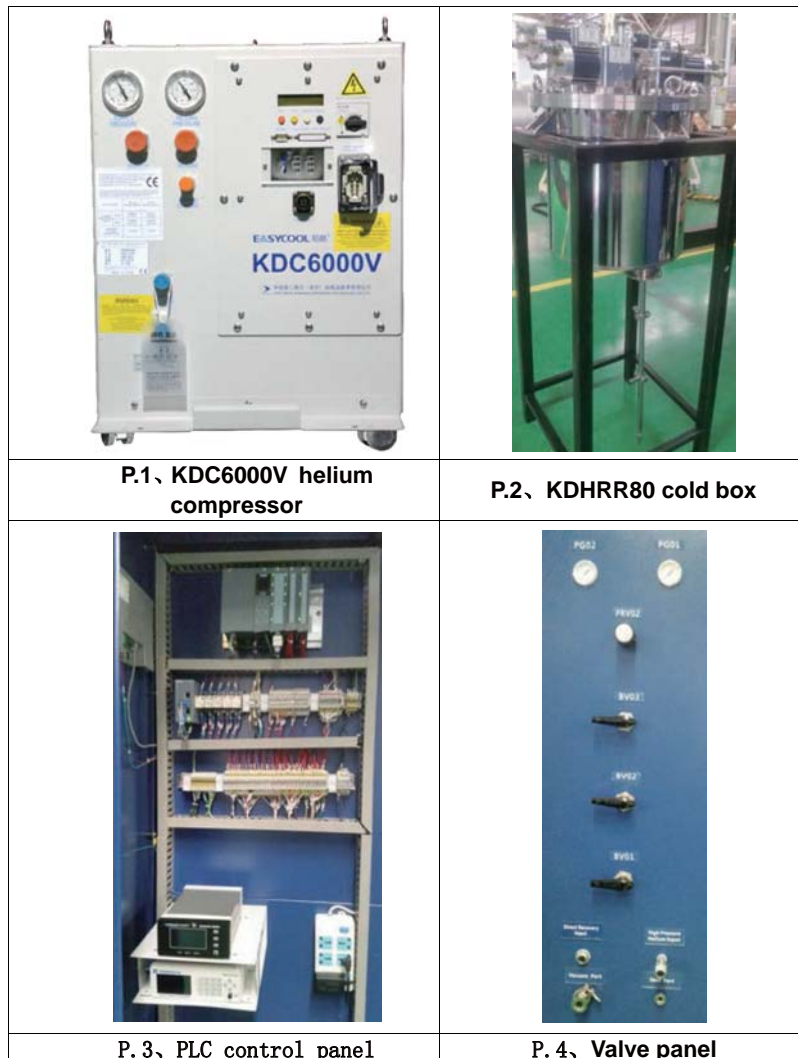
## NOTES

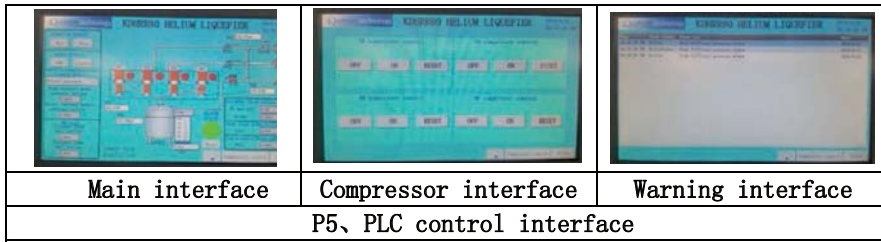
provide important, additional information to explain or suggest related problems or operations.

## SYSTEM PROFILE

KDHRR80 Helium Liquefier developed by Pride Cryogenics is a key component for Helium liquefaction, purification and liquefaction system. It has many features, such as easy control, reliable, low power consumption and so on. Because of these features, KDHRR80 Helium Liquefier has been widely used in the university laboratory where needs liquid helium around the world.

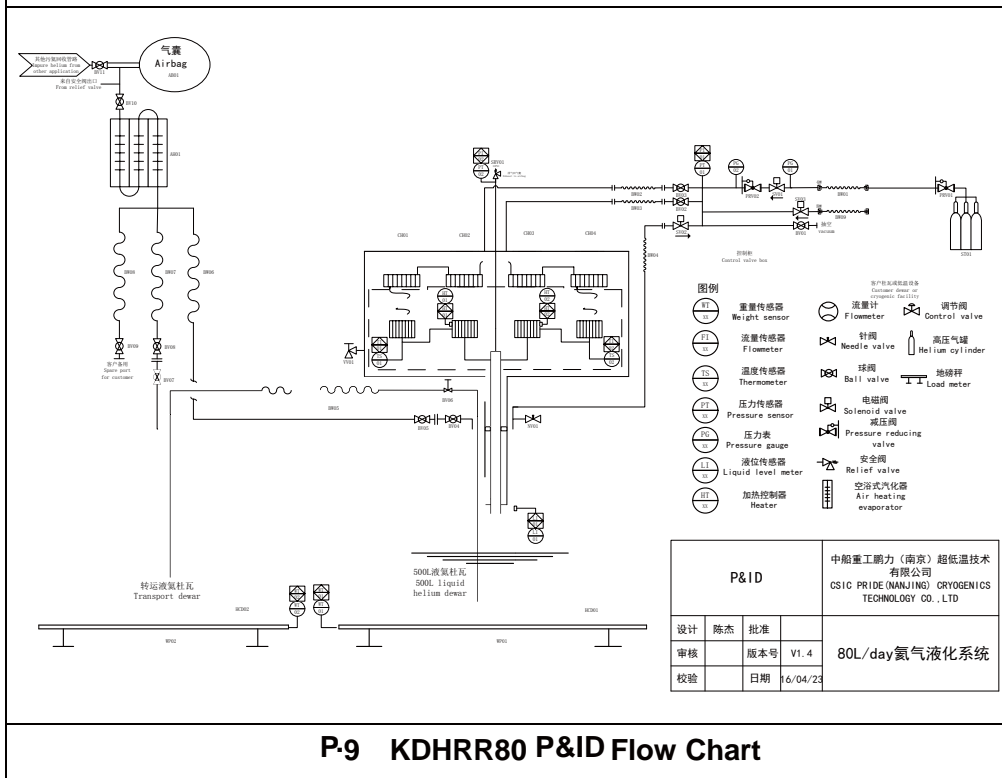
KDHRR80 Helium Liquefier mainly consists of helium compressor, cold box, PLC control panel, Valve panel, compressor cabinet and Liquefier cabinet. Photo 1 to Photo 8 are the photos which show our KDC6000V helium compressor, cold box, PLC control panel, Valve panel, PLC control interface, compressor cabinet and Liquefier cabinet and the whole unit separately. Picture 9 is the P&ID flow chart of the helium liquefier system.







P.8、The whole unit



P.9 KDHR80 P&ID Flow Chart

The introduction of the main components:

### 1. KDC6000V Helium compressor:

Its main function is to supply high pressure helium gas for KDE415 coldhead, and for more details please find KDC6000V Operating manual.

## 2. KDHR80 Cold box:

There are 4 sets of KDE415 coldheads built into the KDHR80 liquefier. To improve the liquefaction efficiency, we use the heat exchanger, condenser, infusion tube and multi-layer isolation system independently developed by ourselves.

## 3. PLC control panel:

The control panel includes Siemens PLC, touch screen and data acquisition equipment. The data acquisition equipment can acquire the temperature, pressure, liquid level of the liquefier and monitor the working status of the helium liquefier and helium compressor. Meanwhile, The PLC control panel performs solenoid valve control according to the acquisition data and then realize the fully automatic operation.

## 4. Valve panel:

All the valves such as Pressure reducing valve, solenoid valve and ball valve are bought from the foreign famous companies. Through these valves, high purity helium gas is introduced to the cold box and changed to be liquid, finally stored in the Dewar.

## 5. Compressor cabinet:

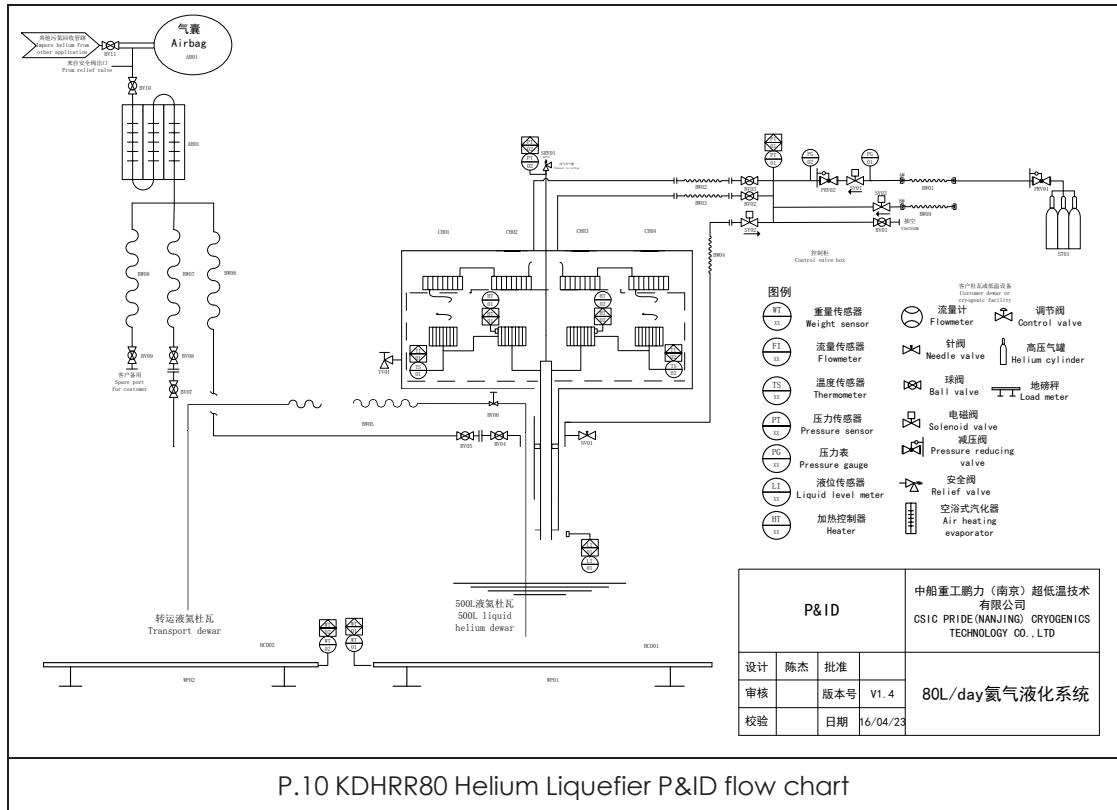
4 KDC6000V compressors are set into the cabinet, the spare gas lines are wrapped in the upper space of the cabinet.

## 6. Liquefier cabinet:

The PLC control panel, valve panel, cold box and liquid helium Dewar are all integrated in this cabinet. This cabinet is connected by the power line and helium flexible gas line between helium compressor and cold head.



# THE DESIGN PRINCIPLE AND DEMONSTRATION FOR THIS SYSTEM



P.10 KDHR80 Helium Liquefier P&ID flow chart

P.2 is the flow chart of KDHR80 Helium Liquefier. We use 4 KDE415 GM Cryocoolers to liquefy the high purity (> 99.999%) helium gas. These 4 Coldhead are series connected and separated to 2 sets, then this 2 sets are parallel connected to 1 unit. Helium gas is introduced to the cold box and separated to 2 airstreams, the first one will flow through the coldhead 1&2, and the other airstream will flow through coldhead 3&4. Take the first airstream for example, it will be pre-cooled by the first stage of 1&2, and then be cooled to 6.5K by the second stage of coldhead 1, finally be liquefied by the second stage of coldhead 2.

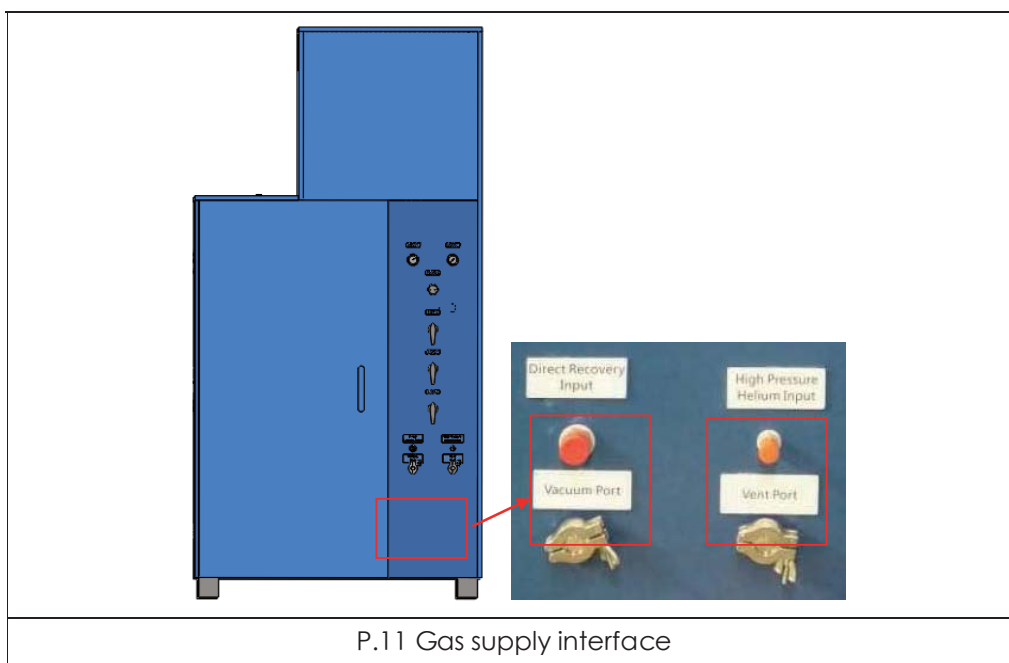
The temperature, pressure and liquid level of the whole system can be monitored by PLC, and the operating data can be acquired and stored by the remote monitoring and control software.

## THE COMPOSITION OF THE SYSTEM

KDHRR80 Helium liquefier consists of gas supply unit, control components, cold box unit, liquid helium storage unit, control unit and so on.

### Gas supply unit

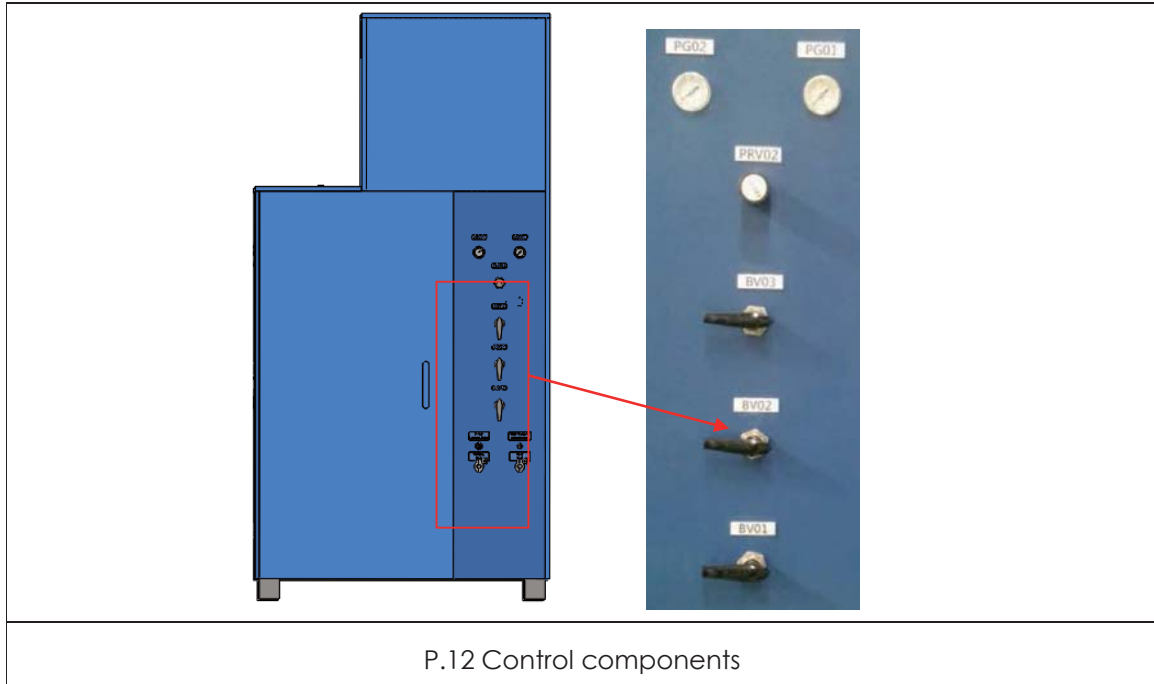
The purpose of gas supply unit is to supply high purity helium gas for the helium liquefier, the purity of the helium gas is  $> 99.999\%$ . The gas supply unit can provided by the customer or by us.



The high purity helium gas is from high purity helium gas cylinder or the boiling gas from liquid helium Dewar. When the gas from the cylinder flow through the 1st stage relief valve PRV01 (provided by customer), its pressure will decrease to around 30bar. Then the gas will be introduced to the KDHRR80 “High Pressure Helium Input” interface by flexible gas line, shown as P.3. Then the gas will flow through the second stage relief valve PRV02 and decrease to the liquefaction pressure, finally be introduce to the cold box. If the helium gas is from the liquid helium Dewar, it will be introduced to “Direct Recovery Input” interface directly, and finally go to the cold box for liquefaction.

## Control components

Control components include control valves, pressure sensors, relief valves, pressure gauges and so on, shown as P.4. It is used for the gas inlet pressure control, the first time evacuation of the cold box, system auto control etc.



## The cold box

The cold box is the key component of KDHRR80, the helium gas will be cooled down and liquefied in the cold box. The cold box includes 4 KDE415SA GM Cryocoolers, 4 first stage coldhead heat exchanger, 4 second stage coldhead heat exchanger, spiral tube, temperature sensor and pressure sensor and so on.



When the high purity helium gas introduced to cold box is cooled down and liquefied by the 1st stage and 2nd stage coldhead, under the function of gravitation, the liquid helium will drop into the storage Dewar through the infusion tube. We install temperature sensor and pressure sensor on the 2nd stage coldhead, according to the temperature data and pressure data, we can determine whether or not the cryocooler is working well and the pipe is blocked.

The cryocooler is our own KDE415 Cryocooler, for more details please find <KDE415 Cryocooler operating manual>.

Helium compressor is our own KDC6000V compressor, and for more details please find <KDC6000V Operating manual>.

## Liquid helium storage unit

Liquid helium storage unit includes liquid helium Dewar, liquid helium level meter and heater. The Dewar volume used in KDHRR80 is 500L, there are one liquid level meter set up in the Dewar, which can monitor the height of liquid helium.

## Control unit

The whole system is Auto controlled by PLC, which can real-time monitor the inner temperature, pressure and liquid level of the helium liquefier. PLC control panel is installed on the KDHRR80 cabinet, easy to operate.



## SYSTEM FEATURES

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1. Fully automatic control by PLC, no workers need to be on duty
2. Small square and easy to install in the lab
3. The cold source is our G-M Cryocooler, whose technology is mature and maintenance cost is low
4. The liquefier can be parallel connected by other similar system to increase the liquefaction rate.
5. It can work in 2 modes: 1、 no boiling mode; 2、 Liquefaction mode
6. We can supply the helium recovery system, purification system and liquefaction system according to the customers' requirements.

## SPECIFICATION AND PARAMETERS

The helium liquefier's specification and parameters are shown as table 1

Table 1. Specifications and Parameters

Liquefaction rate	$\geq 65\text{L/d@2psig}$ ; $\geq 70\text{L/d@4psig}$ ; $\geq 75\text{L/d@8psig}$
Compressor power supply	3 phase 380V (50Hz) or 3 phase 480V (60Hz)
Control unit power supply	Single phase 110~240V (50~60Hz)
Cooling water	Inlet temperature 5~25°C; Flow rate 24~36L/min; Pressure < 8bar
Helium purity requirement	> 99.999%
Cool down time (to full load liquefaction)	About 4 hours
Liquid helium infusion line	Material: SUS304, O.D 21.3 mm, Length 680mm (can be customized according to customer requirements)
Dimension	Refer to KDHRR80 dimension chart
The volume of Dewar	$\geq 500\text{L}$ (can be customized according to customer requirements)

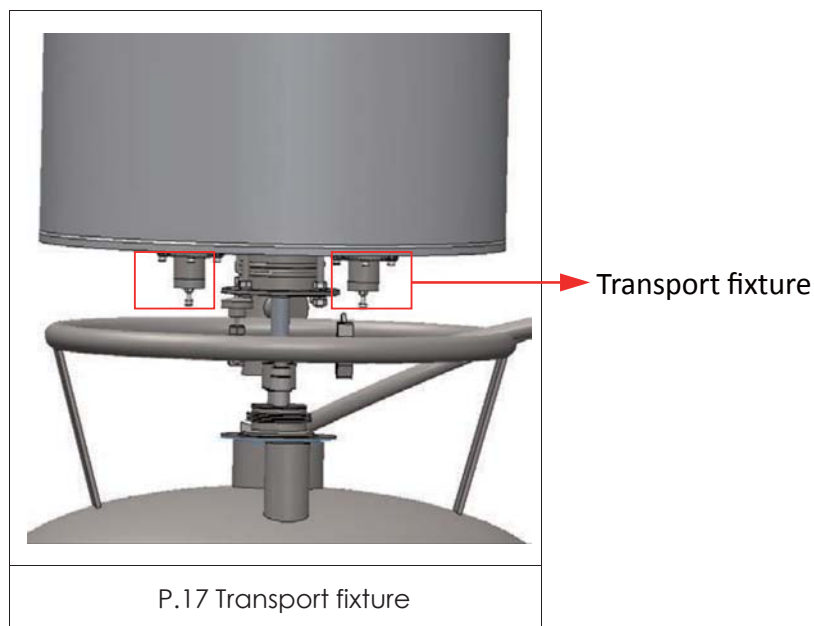
## OPERATION ILLUSTRATION

### Installation introduction

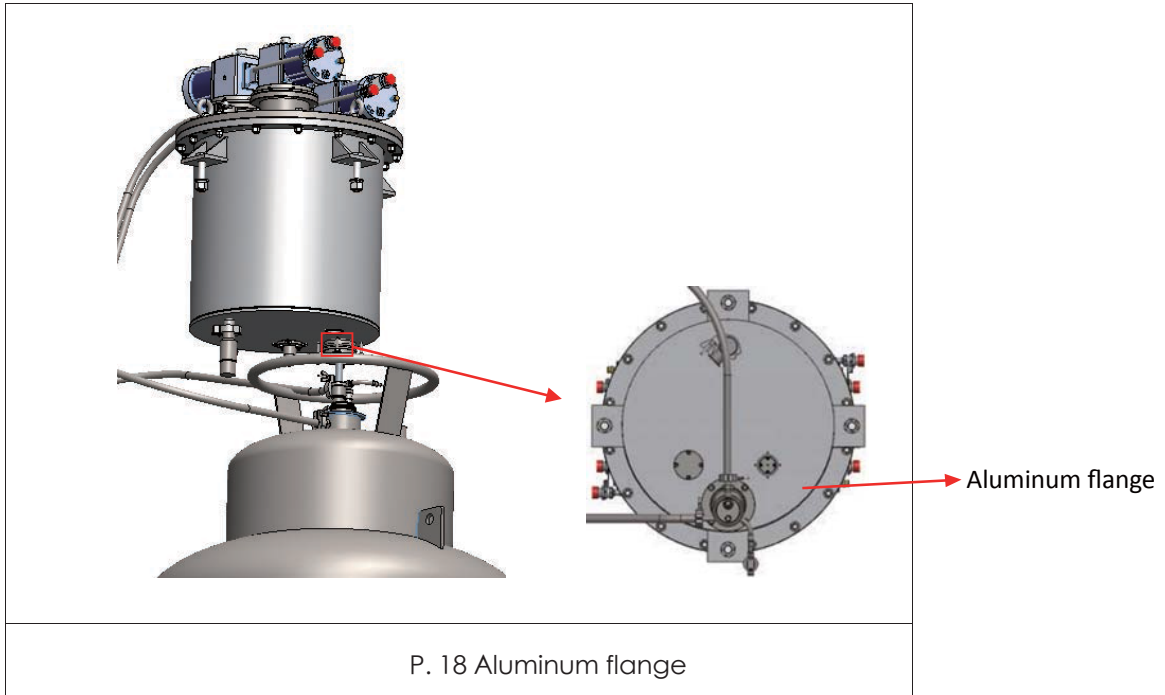
To avoid the errors caused during the loading, unloading and connection, please follow this installation introduction

- 1) When you receive the liquefier, please check its appearance to make sure no damage on it. Please take a photo for it to make it easy to ask for compensation from insurance company if necessary
- 2) Open the packing box and make sure on damage on the components. If there are damage, please take a photo for it and inform us immediately.
- 3) If the above 2 inspection is OK, please open the package carefully.
- 4) Finally remove the transport fixture combination

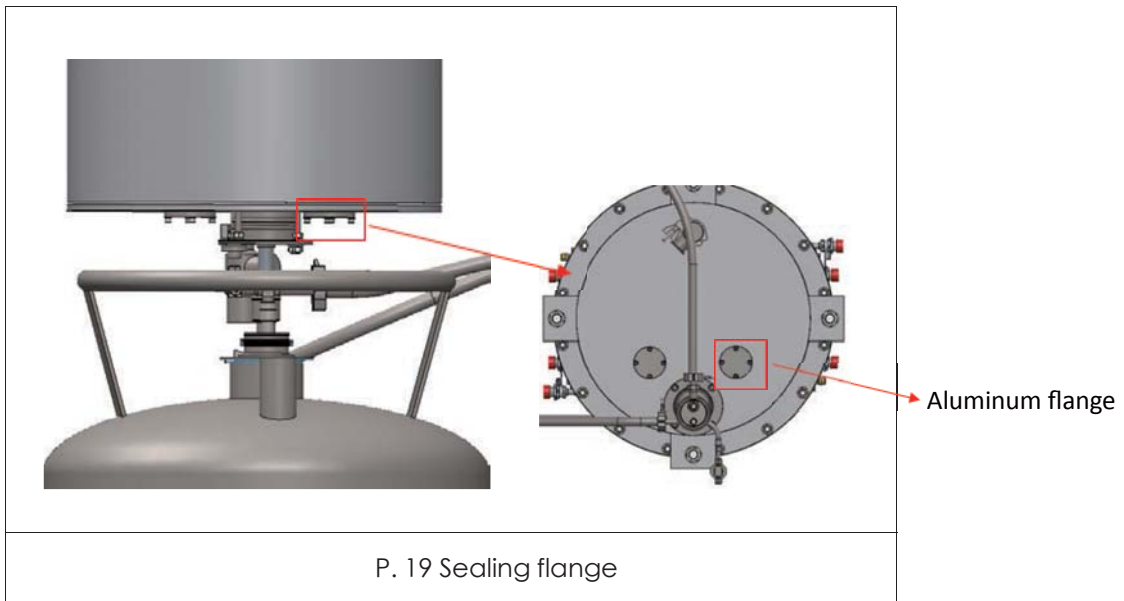
There are 2 transport fixtures locate at the bottom of the cold box, please use your hand to loosen the screw, and unscrew the fixture down along the vertical direction.










Then screw the aluminum flange on the aluminum flange, shown as P. 18, finally install sealing flange, and it is sealed by O-ring.



Operation steps shown below

Num.	Step illustration	Figures
1	Confirm the package and make sure no damage occurs	
2	Disassemble the relative screws	
3	Turn the fixture in a clockwise direction	

4	Prepare the aluminum blind plate	
5	Install the aluminum blind plate, totally 4 screws	
6	Install the stainless blind plate, totally 4 screws	

5) Evacuate the cold box

Connect the vacuum pump to the vacuum angle valve VV01, in room temperature, evacuate the cold box to 10-2 Pa. Close the vacuum angle valve VV01.

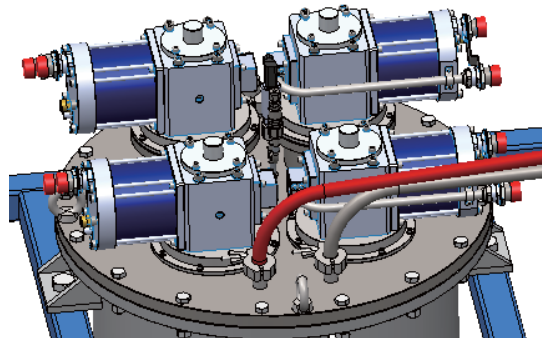
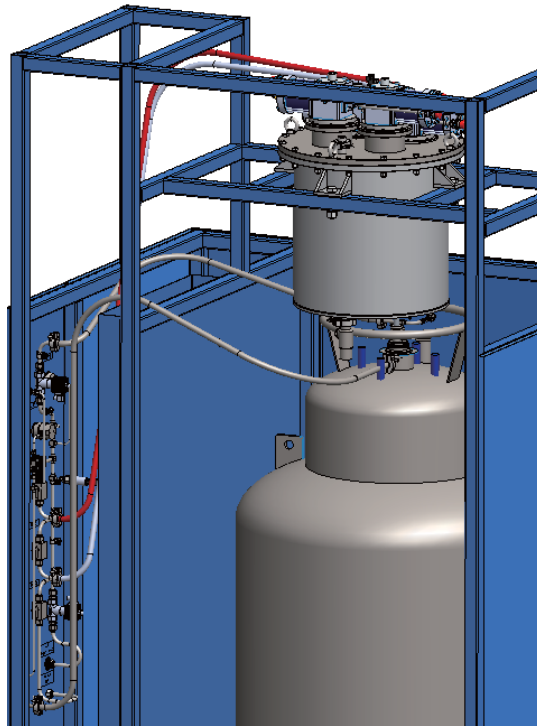
6) Pipeline connection

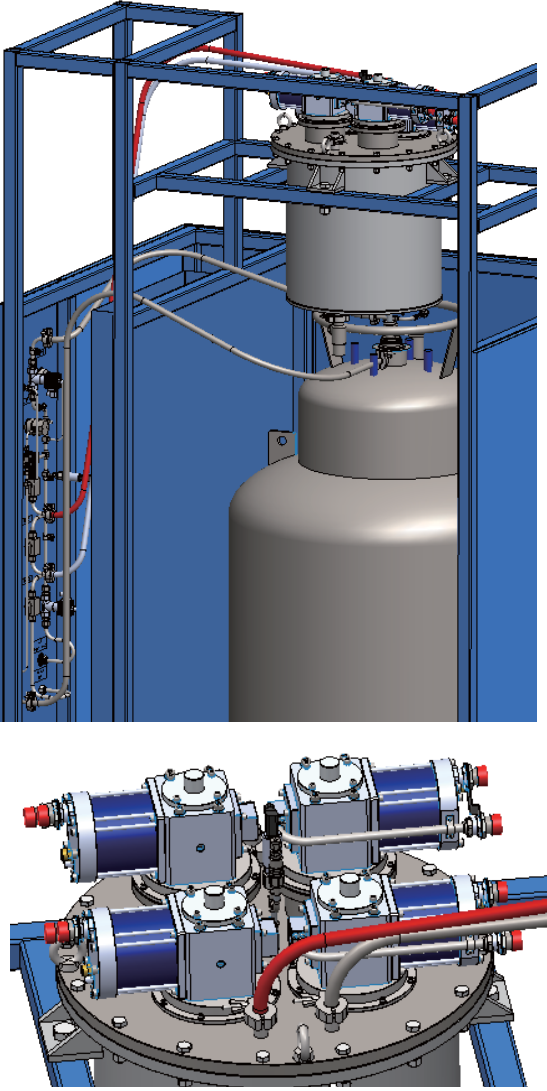
After the evacuation, put the 500L liquid helium Dewar and cold box into the liquefier shell, connect the pipes according to the <pipeline connection illustration>. Pipeline connection illustration is shown as below:

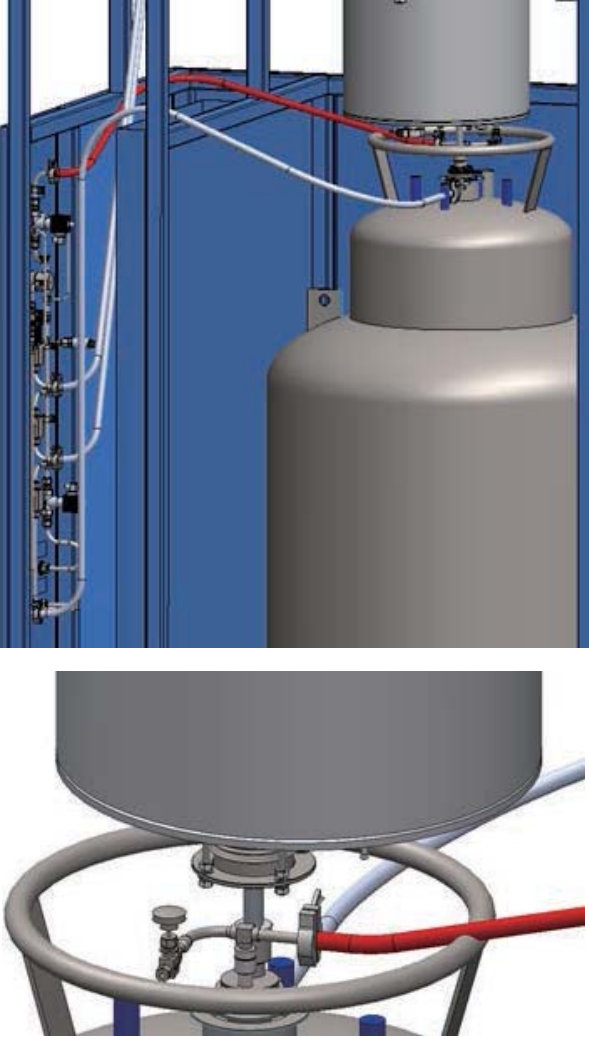
Num.	Step illustration	Figures
1	Prepare 4 vacuum flexible line (NUM: D0004666) Prepare 8 KF16 O-ring (NUM: D0002220) and 8 KF16 Clamps (NUM: D0002235)	

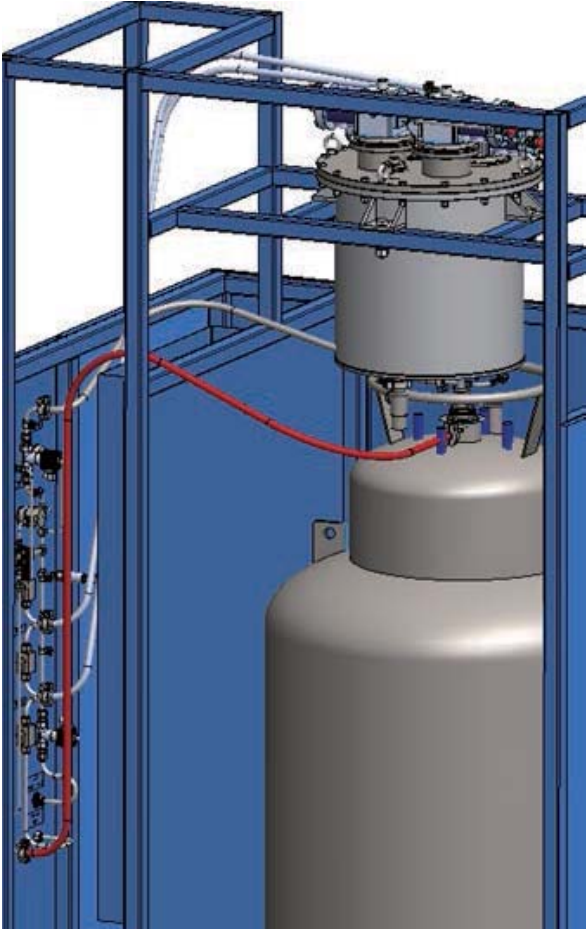
2

Connect one of the flexible lines according to the red line demonstrated in the diagram.



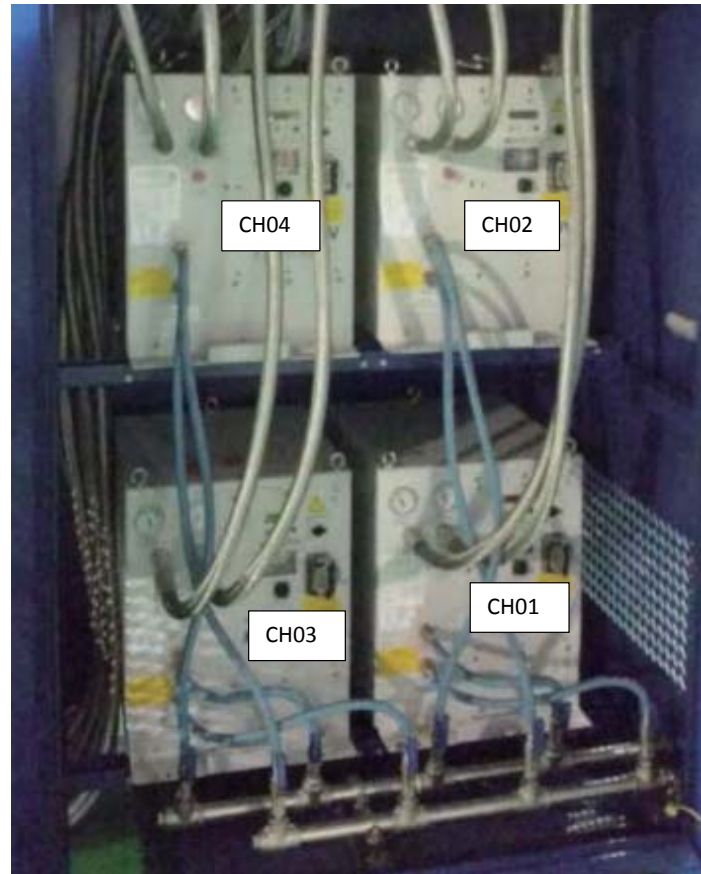
<p>3</p>	<p>Connect the second flexible line according to the red line demonstrated in the diagram.</p>	
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4	<p>Connect the third flexible line according to the red line demonstrated in the diagram.</p>	
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5	<p>Connect the forth flexible line according to the red line demonstrated in the diagram, This flexible line is connected by the exhaust port of Dewar and the exhaust port of valve pane. NOTE: Before the connection, you need transfer KF16 flange to NPT1/2 (NUM: D1001146) and screw it into the exhaust port of Dewar</p>	
6	<p>Make sure all the clamps are tightened. Then, the connection of inner low pressure gas lines have been finished</p>	

7

Check the number of all the cold heads, compressors, and flexible helium gas lines. Make sure the gas lines do not come off.








		
<p>8</p>	<p>Make According to the one-to-one match way, connect the coldheads and compressors by metal helium flexible gas line. Please connect the coldhead side first, then the excess gas line will be wrapped around the top of the cabinet, finally connect the helium gas line to the compressor. ( Note: supply and return lines and connectors cannot be wrong) . Connect the cooling water pipe according to the right photo, screw the clamp. Use plastic tie to fasten the places need be tight.</p>	
<p>9</p>	<p>Finally, make sure all the interface are connected well</p>	

7) Circuit connection

Please connect the circuits according to < circuit connection illustration>, shown as below:

Num.	Steps Demonstration	Figures
1	Inspect all the circuit to make sure no damages on them and no come off occurs	
2	Check the labels on the joints, and connect the joints one-to-one match	
3	Connect the joints of liquefier cold box sensors	
4	Connect the liquid level meter power supply and signal circuit	
5	Connect the 4 compressor power supply circuits and remote control lines	

6	Chose the suitable voltage for the compressors in the power supply option window, and then connect the power supply circuits.	
7	Connect the helium liquefier power supply circuits	
8	When all the circuits have been connected, open PLC, check the data presentation of the temperature sensors and pressure sensors is normal or not, and the solenoid valve is working well or not	

8) When the installation is done, prepare for the starting-up operation

### Run starting-up operation

The first time turn on the liquefier, please evacuate the system pipes and Dewar first.

1) Close the BV01, BV02, BU03, SV01, SV02, SV03, regulate the PRV02 to the smallest. Introduce the high purity helium gas to “high Pressure Helium Input” joint (the pressure of helium gas should be decompressed to 3MPa), open SV01, and regulate PRV02 until the pressure gauge PG02 and pressure sensor PT01 is 5psig (then do not touch the relief valve)

2) Connect the dry vacuum pump to “Vacuum Port” : Manual open BV01, BV02, BV03, SV02 and SV03, turn on the pump, evacuate the system pipes and Dewar to PT02 less than 0.1KPa, and keep evacuate the system for another 60 minutes.

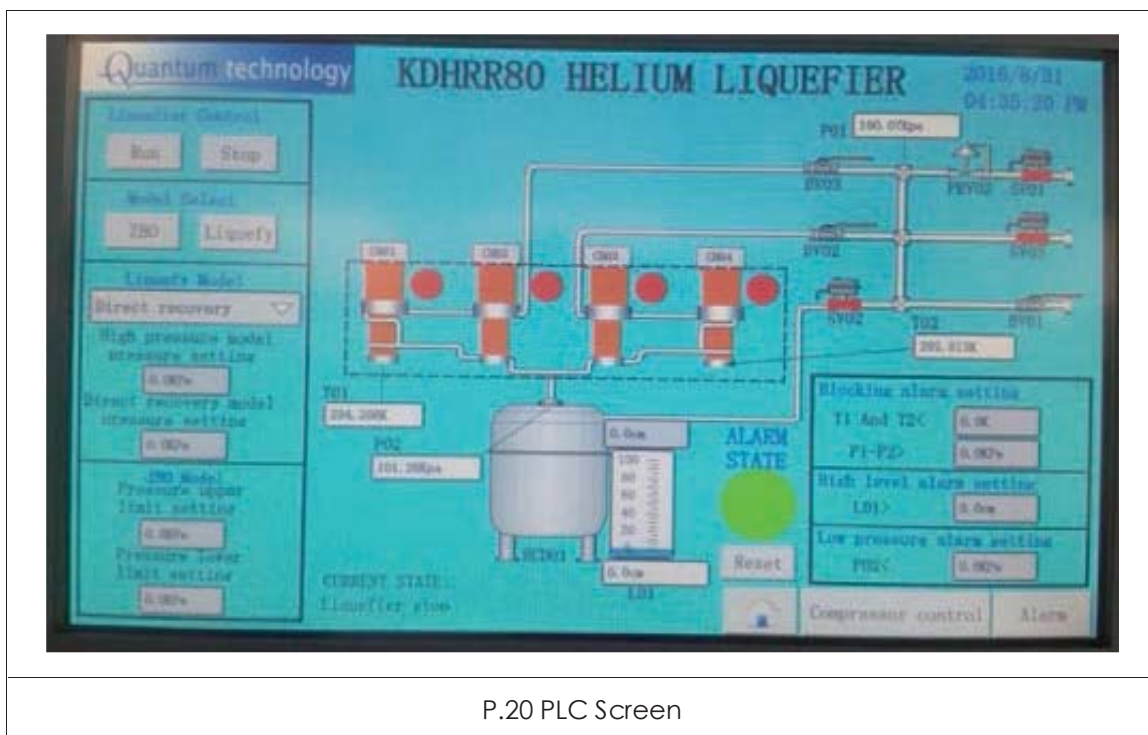
3) Close BV01, keep BV02, BV03, SV02, SV03 open, open SV01, and introduce high purity helium gas to the system pipes and Dewar until PT02 pressure sensor is 1psig for the first time. Then close SV01 and wait for 10 minutes, open BV01 slowly, evacuate the system pipes and Dewar to PT02 less than 0.1KPa for the second time, and keep evacuate the system for another 60 minutes.

4) Close BV01, keep BV02, BV03, SV02, SV03 open, open SV01, and introduce high purity helium gas to the system pipes and Dewar until PT02 pressure sensor is 1psig for the second time. Then close SV01 and wait for 10 minutes, open BV01 slowly, evacuate the system pipes and Dewar to PT02 less than 0.1KPa, and keep evacuate the system for another 60 minutes for the third time.

5) Close BV01, keep BV02, BV03, SV02, SV03 open, open SV01, and introduce high purity helium gas to the system pipes and Dewar until PT02 pressure sensor is 1psig for the third time. Then close SV01 and wait for 10 minutes, open BV01 slowly, evacuate the system pipes and Dewar to PT02 less than 0.1KPa, and keep evacuate the system for another 60 minutes for the fourth time.

6) Close BV01, keep BV02, BV03, SV02, SV03 open, open SV01, and introduce high purity helium gas to the system pipes and Dewar until PT02 pressure sensor is 1psig for the fourth time. Then close SV01 and wait for 10 minutes, open BV01 slowly, evacuate the system pipes and Dewar to PT02 less than 0.1KPa, and keep evacuate the system for another 60 minutes for the fifth time.

7) Close BV01, keep BV02, BV03, SV02, SV03 open, open SV01, and introduce high purity helium gas to the system pipes and Dewar until PT02 pressure sensor is 4~5psig. Close SV01, SV01, SV03.



The volume of Dewar is too big and the vacuum degree of its sandwich is not so good, so it is hard to cool it down to 4.2K directly. So before the first time you start the system, please inject 50L liquid helium to the 500L Dewar.

The operation way is: During the transport of liquid helium, inject liquid helium through the side liquid infusion port. Open BV06 (cryogenic valve on the infusion tube), exhaust the air from the infusion tube, during the exhaust process, please insert the output infusion tube to the transport Dewar, close BV06, and pressurize the transport Dewar, use your hand to open BV06, BV04(discharge valve of Dewar), BV05( If it has been installed). The helium gas produced during the infusion process can recharge to gas bag or discharge into the air. When the liquid level meter shows the 500L Dewar' s liquid level is above 50L, please close BV06 and stop injecting liquid helium. About 1 hour later, close BV04, BV05, prepare to start up the helium liquefier.

## Liquefier start-up

Set all PLC parameters ready, including liquefaction pressure, low limit of self-circulation pressure and high self-circulation pressure. According to the gas supply source to choose “high pressure mode” or “Direct recovery mode”, set the Alarm value of alarm frame ready.

Keep ball valve BV02, BV03 open and BV01 closed, click the “Run” button on the PLC Screen, the initial default state is “ZBO, zero boiling operation”. At this time, the 4 GM cryocoolers will start up at the same.

About 4 hours later, the cold head temperature will go to its lowest value, then the helium liquefier will go to “allow to liquefy mode”, click the “liquefy” button on the PLC Screen, the liquefier will automatically open solenoid valves to inlet the helium gas to be liquefied according to “high pressure mode” or “Direct recovery mode” which has been selected. When the liquid level of Dewar has come to its height limit or no need for helium liquefaction, choose the liquefier’s mode to be “ZBO, zero boiling operation”. At this time, the system will stop gas supply, the self-boiling helium gas from Dewar will go to liquefier to be liquefied through the bypass solenoid valves, the pressure of liquefier will keep between the low limit and high limit pressure of “ZBO, zero boiling operation” mode.

## Liquid helium transport

When you need transport the liquid helium, please insert the liquid infusion tube into the transport Dewar, open the exhaust valve BV07 (Discharge valve of Dewar), BV08 (If it has been installed). Manually open BV06, then the liquid helium in the 500L Dewar will be transported to transport Dewar through the infusion tube. If you find the pressure of 500L Dewar decreases quickly and you still need speed up the liquid helium infusion, please manually close Solenoid Valve SV03, open SV02 and SV01 (make sure that the high pressure cylinder has been connected to the high pressure gas inlet). At this time, the high pressure helium gas from cylinder will be introduced into 500L Dewar directly, the inner pressure will rise up and speed up the liquid infusion. When the pressure is too high, please close SV01 and SV02, stop high pressure gas supply. When the pressure of 500L Dewar decreases quickly again, you can reopen SV02 and SV01, the infusion pressure should below 5psig, otherwise the too quick liquid infusion will reduce the transport efficiency. When the liquid infusion comes to its end, please manually close BV06 and click “high pressure mode” or “Direct recovery mode” again according to your own requirements.

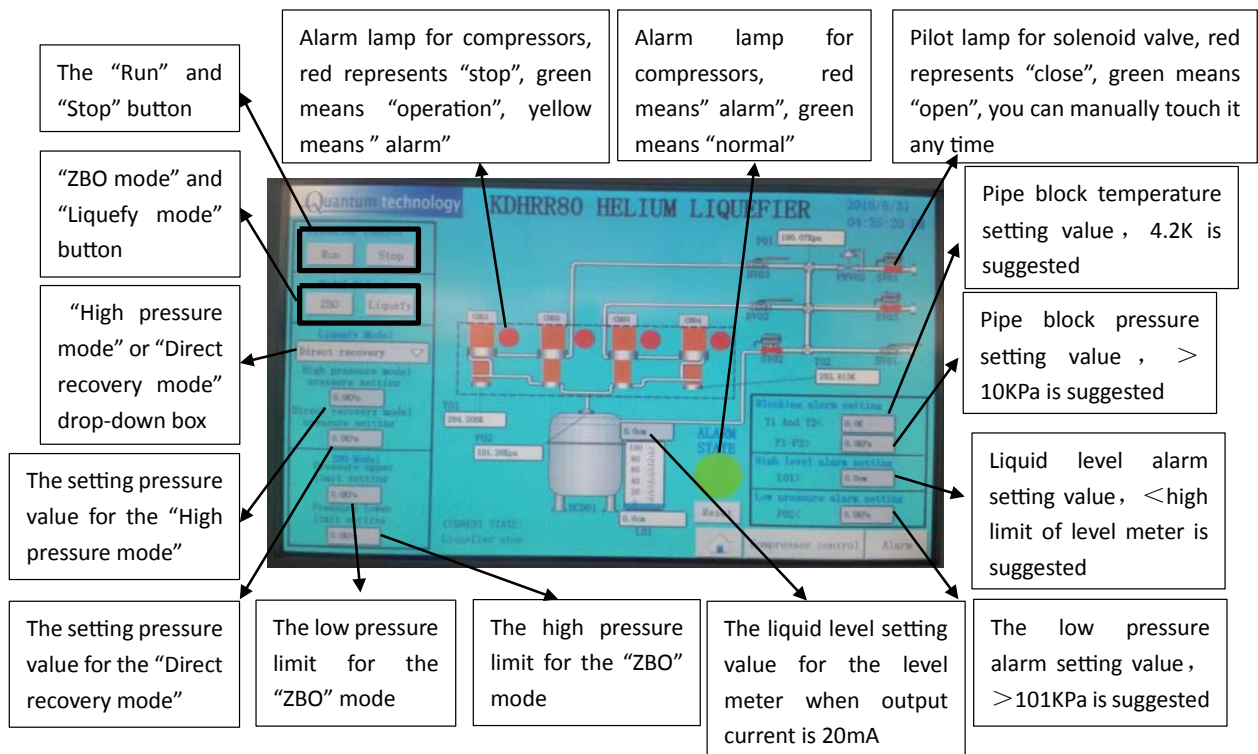
## Liquefier shutdown

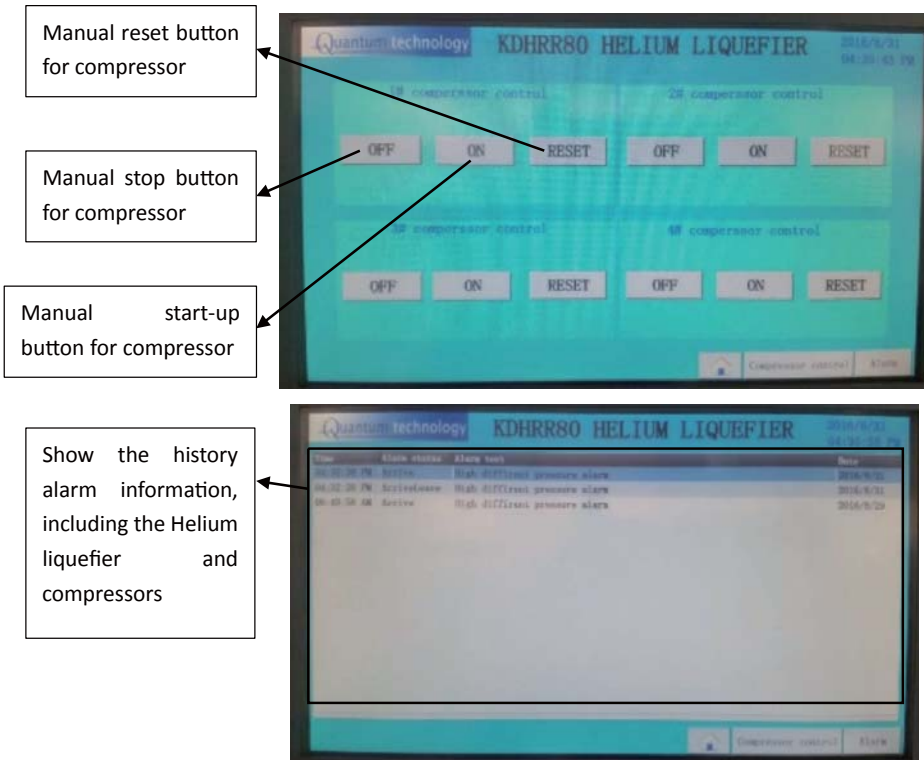
For short term shut down, you need not stop the Liquefier unit.

If the liquefier will not be used for a long term, please click the “Stop” button on the Screen to stop the liquefier unit. At this time, all the 4 compressors will shut down, the liquid helium in the Dewar will be self-boiling, and you can open the 1psig relief valve to release the Dewar inner pressure, keep the relief valve open and then the self-boiling gas will discharge into environment.

## Program illustration and parameters setting

The following parameters are the suggested value for the PLC





## PHYSICAL PORTS

The physical ports include helium inlet, vacuum port, exhaust port, cooling water inlet and outlet port and so on. When you want to turn on the system, please make sure that all the ports are connected well.

1. Direct gas recovery input--connected by self-sealing joint, the connector is 8#, male head (8M), brand is Aeroquip, through plate connection, and gas line is fixed on the metal plate surface;

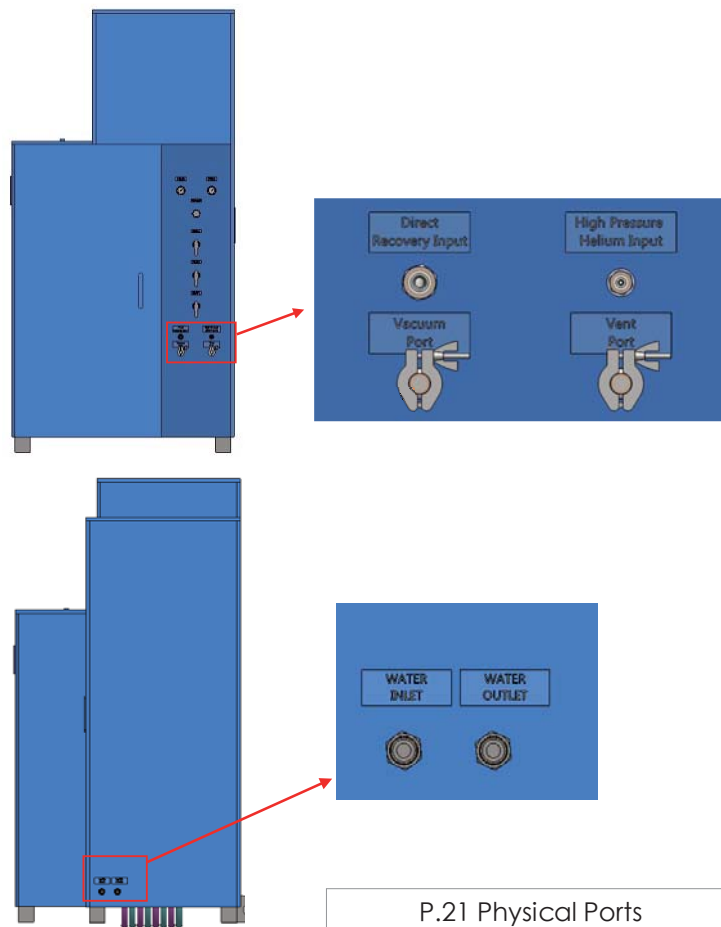
2. High pressure helium input-- connected by self-sealing joint, the connector is 4#, male head (4M), brand is Aeroquip, through plate connection, and gas line is fixed on the metal plate surface;

3. Vacuum port--connected by vacuum corrugated hose, the connector is KF16

4. Vent port-- connected by vacuum corrugated hose, the connector is KF16

5. Cooling water inlet—connected by Non-Metallic Water Pipe, the connector is 1inch Pagoda type.

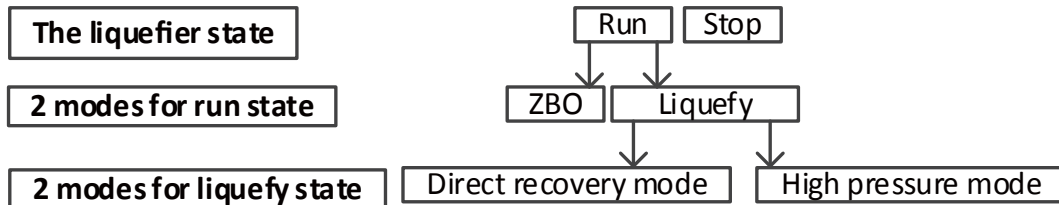
6. Cooling water outlet—connected by Non-Metallic Water Pipe, the connector is 1inch Pagoda type.





# THE CONTROL LOGIC OF PROGRAM

The control mode and logic of the KDHRR80 helium liquefier



The 2 states of the liquefier: Run / Stop

The 2 modes for run state: ZBO / Liquefy

The 2 modes for run state: Direct recovery model / High pressure model

## Stop:

Click the “stop” button, the 4 GM Cryocoolers will stop at the same time, close all the Solenoid valve

## Run:

Click the “run” button, the 4 GM Cryocoolers will start at the same time, default go to the Zero Boiling Operation (ZBO) mode.

## ZBO:

At this mode, please close SV01, SV03. If the value of P02 > the high pressure limit of ZBO mode, SV02 will automatically be open. If the value of P02 < the low pressure limit of ZBO mode, SV02 will automatically be closed.

## Direct recovery mode:

If  $P02 > (\text{“direct recovery model pressure setting”} + 0.5\text{KPa})$ , open SV02, open SV02, close SV01, SV03. Then stop introducing the helium gas, the pressure of P02 will decrease.

If  $P02 < (\text{“direct recovery model pressure setting”} + 0.5\text{KPa})$ , open SV02, open SV03, close SV01, SV02. Then start introducing the helium gas, the pressure of P02 will increase.

### High pressure mode:

If  $P02 > (\text{"high pressure mode pressure setting"} + 0.5\text{KPa})$ , open SV02, open SV02, close SV01, SV03. Then stop introducing the helium gas, the pressure of P02 will decrease.

If  $P02 < (\text{"high pressure mode pressure setting"} + 0.5\text{KPa})$ , open SV02, open SV03, close SV01, SV02. Then start introducing the helium gas, the pressure of P02 will increase.

### Other Alarms:

Whatever the operating mode is, if the temperature value of T1 and T2  $< \text{"Blocking alarm setting"}$  and the value of  $(P1-P2) > \text{"Blocking alarm setting"}$ , the system will alarm and go to ZBO mode, waiting for the professional to stop the liquefier and operate the temperature recovery.

If  $P02 < \text{"Low pressure alarm setting"}$ , the system will alarm and go to ZBO mode

If  $L01 > \text{"High level alarm setting"}$ , the system will alarm and go to ZBO mode

## GUIDES FOR FAULTS INSPECTION

The following table is about the common faults and its causes and solutions:

NO.	Phenomenon	Causes	Solutions
1	KDC6000V Compressors implement the alarm or shutdown protection	The inner faults of compressor or the cooling water problems	Refer to <KDC6000V compressor operation manual>
2	The GM cryocooler produce uncommon noise	The inner motion components get damaged or faults	Please call the factory for help
3	Condensation occurs on the surface of the cold box and infusion pipes	The vacuum degree of the cold box vacuum sandwich is not good or there are ambient air or inner helium gas leakage	Use the helium mass spectrometer leak detector to check the vacuum cover of the cold box and the inner helium pipes
4	The pressure deference between the cold box inlet and outlet is too big	The inner gas line is blocked or air, H <sub>2</sub> , gas water block the pipes	Stop the liquefier, when the temperature comes to 100K, reverse purge the pipes. If the block remains, please recovery the temperature to room temperature
5	The cold box temperature shows too low or too high	Thermometer or temperature monitor is damaged	Please call the factory for help
		The data acquisition line loose contacts	Check the data acquisition line to make sure it is tight
		If the gas line is blocked, it will cause the cold box temperature less than 4K	Stop the liquefier and reverse purge the pipes.

6	The inlet pressure or the inner pressure of the cold box temperature is too low or too high	Pressure sensor is damaged	Please call the factory for help
		The data acquisition line loose contacts	Check the data acquisition line to make sure it is tight
		If the gas line is blocked, it will cause the inlet pressure too high or the inner pressure too low	Stop the liquefier and reverse purge the pipes.
7	The liquefier is on liquefy mode, the pressure is below the liquefaction pressure but no gas is introduced in	The inlet solenoid valve is damaged	Please call the factory for help
		The power supply line of the inlet solenoid valve loose contacts	Check the power supply line to make sure it is good contacts
		The inlet pressure is higher than the solenoid valve's open upper limit	Inspect the inlet pressure, The pressure of high pressure cylinder should not be higher than 50barg, direct recovery inlet should not be higher than 2barg
8	Condensation occurs on the surface of the Dewar	The vacuum degree of the Dewar vacuum sandwich is not good or there are ambient air or inner helium gas leakage	Use the helium mass spectrometer leak detector to check Dewar and the inner pipes
9	In the ZBO or liquefy mode, the pressure or liquid level constantly drops	There are helium leaks in the system connectors	Use leak detection water or the helium mass spectrometer leak detector to check all the connectors

10	In the ZBO or liquefy mode, the pressure or liquid level constantly increases and is over the setting value	The Dewar heat leak is too big and causes the liquid helium's evaporation rate rise	Use the helium mass spectrometer leak detector to check Dewar and the inner pipes
		The capacity of liquefier drops	The cold head and compressor need maintenance
		The bypass valve is closed or damaged	Please call the factory for help

## NOTICE

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1. Please read this user manual carefully
2. Please read the KDC6000V user manual and KDE415 user manual carefully the first time you start the system
3. Please make sure that the cooling water unit works well and the cooling water meets the requirements
4. No changes on the control program
5. All the charts, technical proposals, 3D model pictures can be sent to other companies
6. If you have any other questions, please call our engineers

## MAINTENANCE

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### Equipment maintenance

When the KDHR80 helium liquefier is not on use, , please carry out leak detection and check all the pressure gauge' s reading, and prepare well for the dust control measures. If you find any problems, please contact the factory.

The maintenance period for GM cryocooler cold head is 1.5 years, and 3 years for compressors. The KDHR80' s other components need maintain independently. Please call for the factory in advance when the liquefier' s components end its maintenance period.

## SERVICE

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