EASYCOOL 易酷®

PRIDE Leading New Cryogenics Technologies

KDHRR60 Helium Liquefier

Operating Manual

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

CATALOGUE

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SAFETY

GENERAL

CSIC Pride (Nanjing) Cryogenic Technology Co., Ltd. (CPCT) equipment are designed according to the national safety standards. 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

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

⚠WARNINGS!

AVOID EXPOSURE.

People with Cardiac Pacemakers, Defibrillators or Ferromagnetic Implants shall avoid exposure to strong magnetic field. Long term effects of high magnetic fields have not be completely discovered. Shorten the personal exposure time in the magnetic field.

AVOID ASPHYXIATION.

Keep the operation environment properly ventilated.

AVOID ELECTRIC SHOCK.

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

AVOID INJURY.

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

Always wear eye protection when handling pressurized gas lines and other pressurized equipment. Never heat up the pressurized gas line or other pressurized components.

Disconnect gas lines only when the compressor is stopped. Disconnect the cold head while the gas returns to the room temperature. Material failure and uncontrolled pressure release might cause serious injury.

Please disconnect or connect a gas line coupling to avoid loosening the cold head or compressor coupling according to the KDC6000V compressor operating manual. Gas pressure can push the coupling with enough force to cause serious injury.

Extreme cold may cause frostbite. Do not touch any parts with frost while handling system components.

Do not splash cryogenic liquids on any areas of clothing or exposed skin, otherwise, skin tissue will get damaged. Always wear eye protection and gloves.

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

⚠ CAUTIONS !

PRESERVE YOUR WARRANTY.

Modification to equipment without the consent of the manufacturer will void the warranty. Helium gas with a purity of 99.999% is required. The unqualified high purity helium gas can damage the system and warranty is invalid in this condition.

PREVENT EQUIPMENT DAMAGE.

Only disciplined persons are permitted to install and remove the coldhead.

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

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AVOID AMALFUNCTION

Do not allow air to get into the helium gas cryogenic system. Moisture from the atmosphere can seriously degrade the performance of coldhead and produce an abnormal noise so that the system can't work normally.

AVOID GAS LEAKS.

Check the gasket seal on the male half of each Aeroquip coupling. Be sure that the gasket seal is in place and the sealing surfaces both on the male and female halves are clean before connecting. Replace the gasket seal if it is damaged or missing. Keep the gas line couplings aligned when making or breaking a coupling connection. Leaks might occur due to the weight of the gas line or due to a sharp bend near the connection.

INTRODUCTION

Helium Liquefier, Model KDHRR60

KDHRR60 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, KDHRR60 Helium Liquefier has been widely used in the university laboratory where needs liquid helium around the world.

KDHRR60 Helium Liquefier mainly consists of helium compressor, cold box, PLC control panel, Valve panel and system cabinet. FIG. 1 to FIG. 7 are the photos which show our KDC6000V helium compressor, KDHRR60 cold box, PLC control panel, Valve panel, PLC control interface, system cabinet and the whole system separately. FIG. 8 is the P&ID flow chart of the helium liquefier system.

FIG.1. KDC6000V helium compressor

FIG.2. KDHRR60 cold box

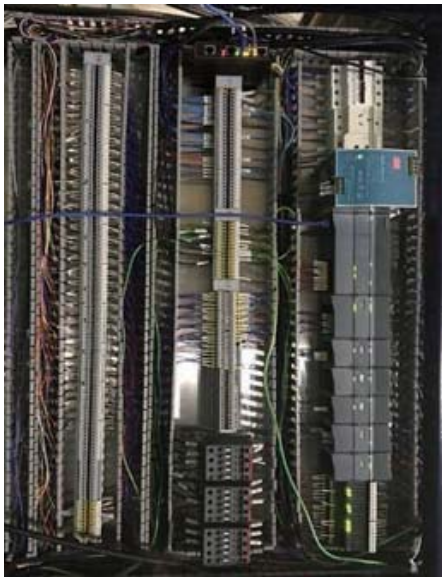
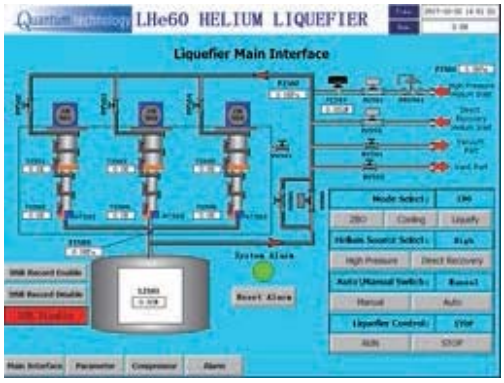


FIG.3. PLC control panel

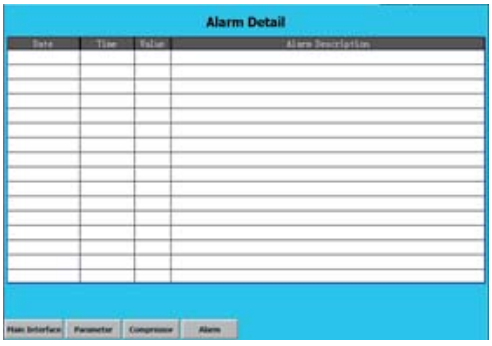
FIG.4. Valve panel



Main interface

Compressor and heater control interface

Parameter setting interface



Warning interface

FIG.5. PLC control interface

FIG.6. System cabinet

FIG.7. The whole liquefier system

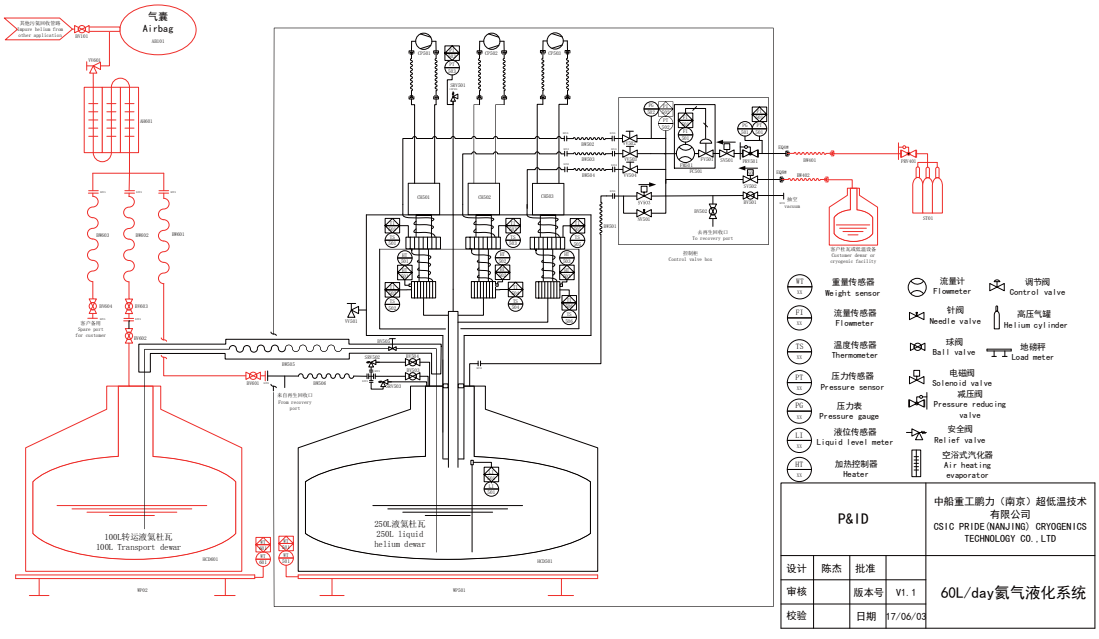


FIG.8. KDHRR20 P&ID Flow Chart

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. KDHRR60 Cold box: There are 3 sets of KDE415 coldheads built into the KDHRR60 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. System cabinet: Three KDC6000V compressors are set into the cabinet. The PLC control panel, vale panel, cold box and liquid helium Dewar are all integrated in this cabinet. Compressor, helium liquefier cold box, liquid helium Dewar and valve panel are interconnected by multiple helium Metal hoses.

PRINCIPLES OF OPERATION

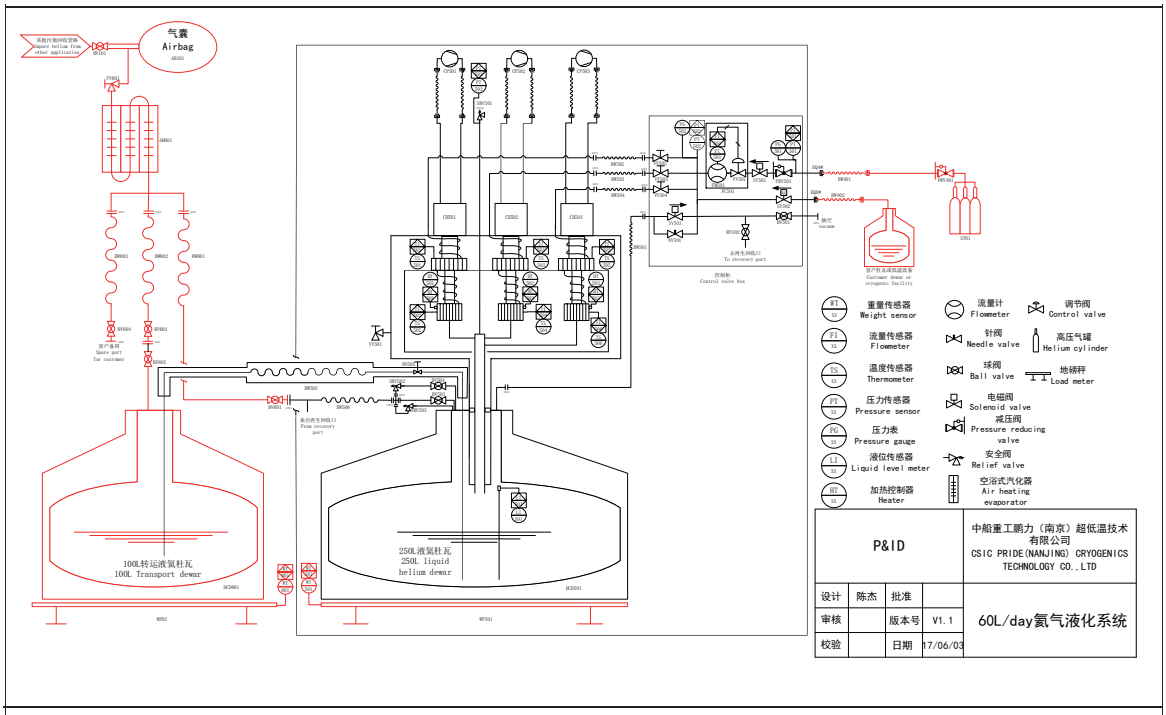


FIG.9. KDHRR60 Helium Liquefier P&ID flow chart

FIG.9 is the flow chart of KDHRR60 Helium Liquefier. We use three KDE415 GM Cryocoolers to liquefy the high purity(> 99.999%) helium gas. These three coldheads are parallel. Helium gas is introduced to the cold box and separated to 3 gas streams, the first one will flow through the coldhead CH501, the second stream will flow through coldhead CH502, the another one will flow through the coldhead CH503. Take the first stream for example, it will be precooled by the first stage of CH501, and then be cooled to 6.5K by the second cylinder of CH501, finally be liquefied by the second stage of CH501.

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.

DESCRIPTION

KDHRR60 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 our helium purifier.

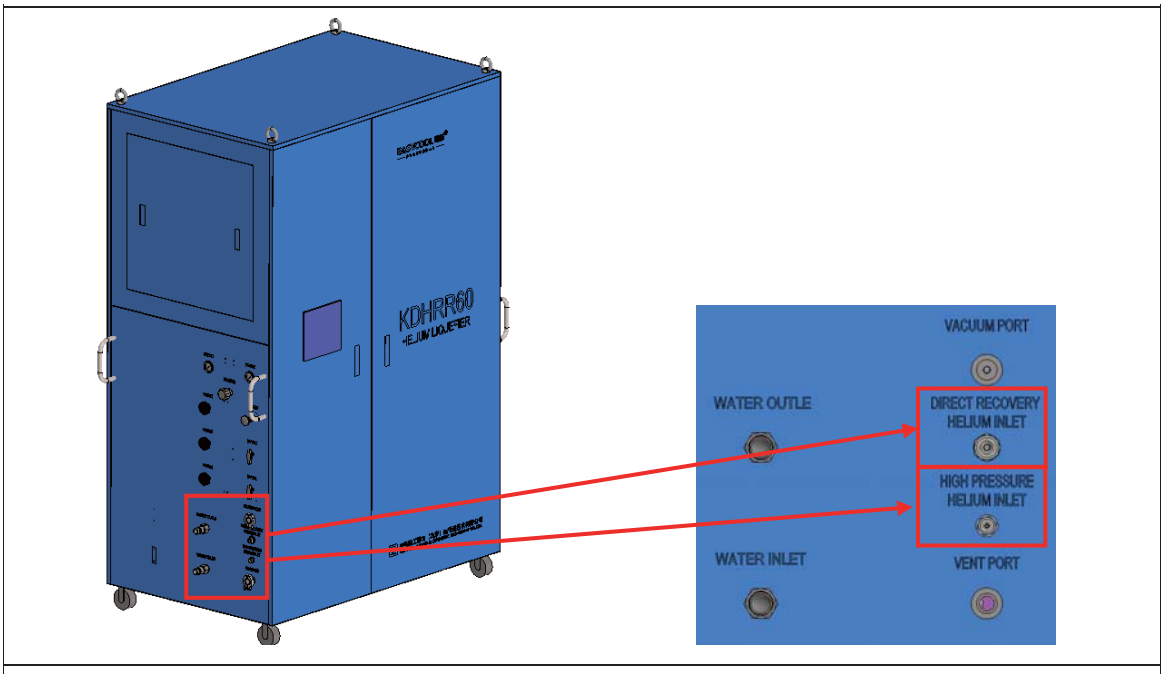


FIG.10. Gas supply interface

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 regulator PRV401 (provided by customer), its pressure will decrease to less than 40barg. Then the gas will be introduced into the KDHRR60 "HIGH PRESSURE HELIUM INLET" interface by flexible gas line, shown as FIG.10. Then the gas will flow through the second regulator PRV501 and decrease to around 1.5barg, finally be introduce to the cold box. If the helium gas is from the liquid helium Dewar, it will be introduced to "DIRECT RECOVERY HELIUM INLET" interface directly, and finally go to the cold box for liquefaction.

Control components

Control components include control valves, pressure sensors, regulators, pressure gauges and so on, shown as FIG.11. It is used for the gas inlet pressure control, the first time evacuation of the system, auto control of the system etc.

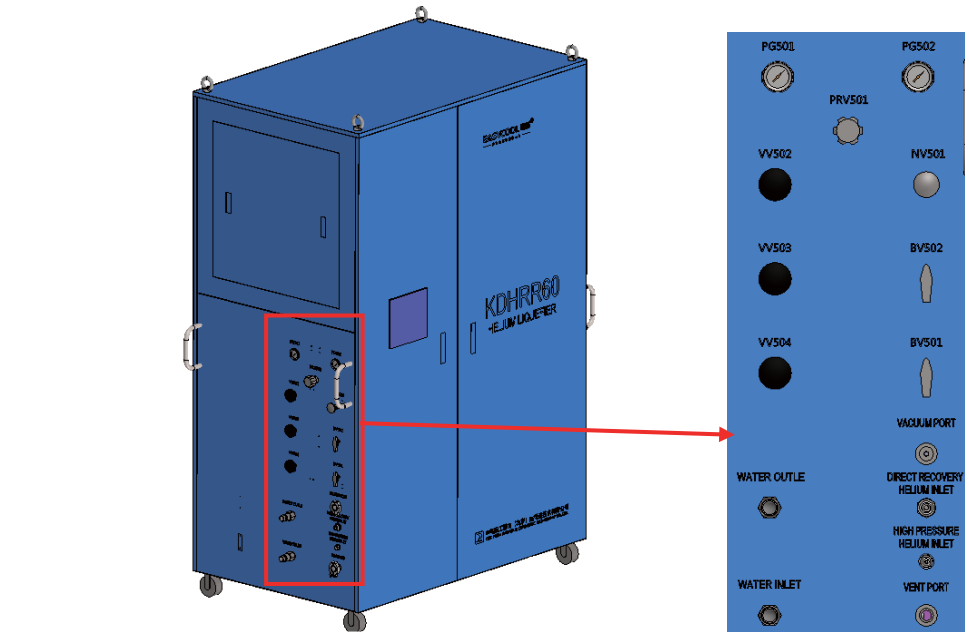


FIG.11. Control components

The cold box

The cold box is the key component of KDHRR60, the helium gas will be cooled down and liquefied in the cold box. The cold box includes three KDE415SA GM Cryocoolers, 3 first stage heat exchanger, 3 second stage heat exchanger, spiral tube, temperature sensor and pressure sensor and so on.

FIG.12. Cold box

FIG.13. KDE415 Cryocooler

FIG.14. KDC6000V Helium Compressor

When the high purity helium gas introduced to cold box is cooled down and liquefied by the 1st stage and 2nd stage of the cryocoolers, under the function of gravitation, the liquid helium will drop into the storage Dewar through the infusion tube. We install temperature sensor and heater on the 2nd stage, according to the temperature data, we can determine whether the cryocooler is working well and the pipe is blocked.

The cryocooler is KDE415 Cryocooler produced by ourselves, for more details please find <<KDE415 Cryocooler operating manual>>.

Helium compressor is KDC6000V compressor produced by ourselves, and for more details please find <<KDC6000V Helium Compressor operating manual>>.

Liquid helium storage unit

Liquid helium storage unit includes liquid helium Dewar and liquid helium level meter. The Dewar volume used in KDHRR60 is ⩾350L, there is a 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 temperature, pressure and liquid level of the helium liquefier. PLC control panel is installed on the KDHRR60 cabinet, easy to operate.

FIG.15. PLC Control Panel

FEATURES

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 GM 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 three modes: 1. Cooling mode; 2. Liquefy mode; 3. ZBO (zero boil off) mode.

6. We can supply the helium recovery system, purifier and liquefier according to the customer’ s requirements.

SPECIFICATIONS

The specifications and parameters of the helium liquefier are shown as table 1

Table 1. Specifications and Parameters

Liquefaction rate	⩾60L/d@5psig
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℃; Flow rate 18~27L/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: 550mm (can be customized)
Dimension	Refer to KDHRR60 dimension chart
The volume of Dewar	⩾350L (can be customized)

OPERATION

Installation introduction

To avoid installation errors during handling and connection, observe the following installation instructions:

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 no 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.

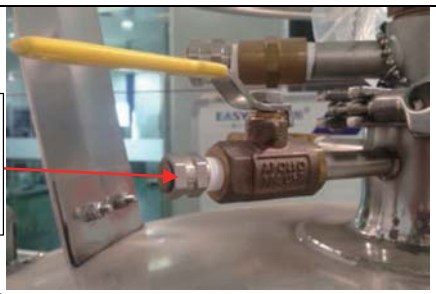
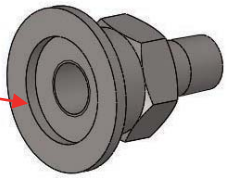
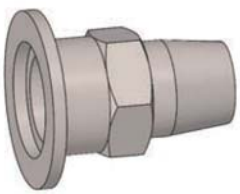
4) Vacuum the cold box

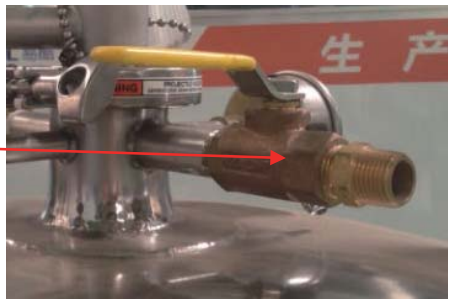
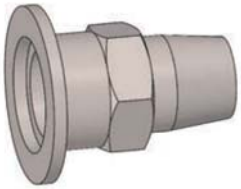
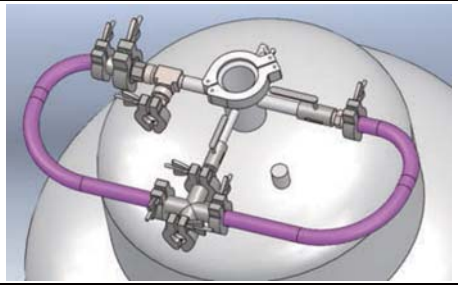
Connect the molecular pump to the vacuum angle valve VV501, at room temperature, vacuum the cold box to 10-2 Pa, then close the vacuum angle valve VV501.

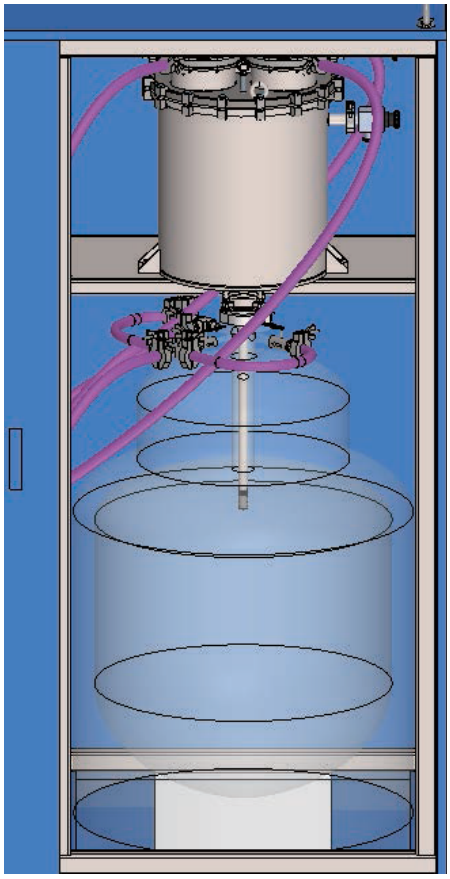
5) Pipeline connection

After the vacuum, put the 350L liquid helium Dewar and cold box into the shell, connect the pipes according to the <<pipeline connection illustration>>. Pipeline connection illustration is shown as below:

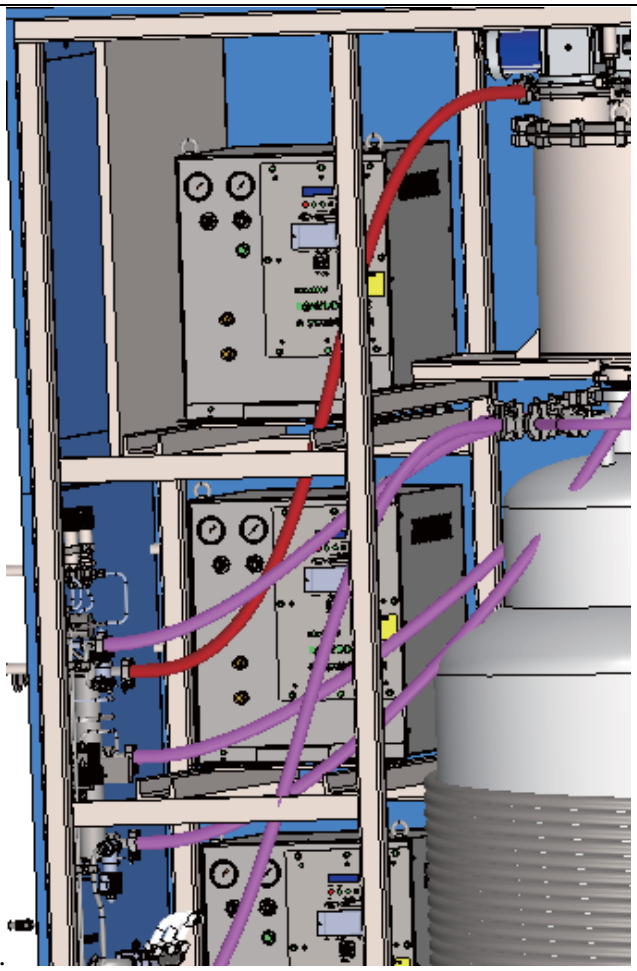
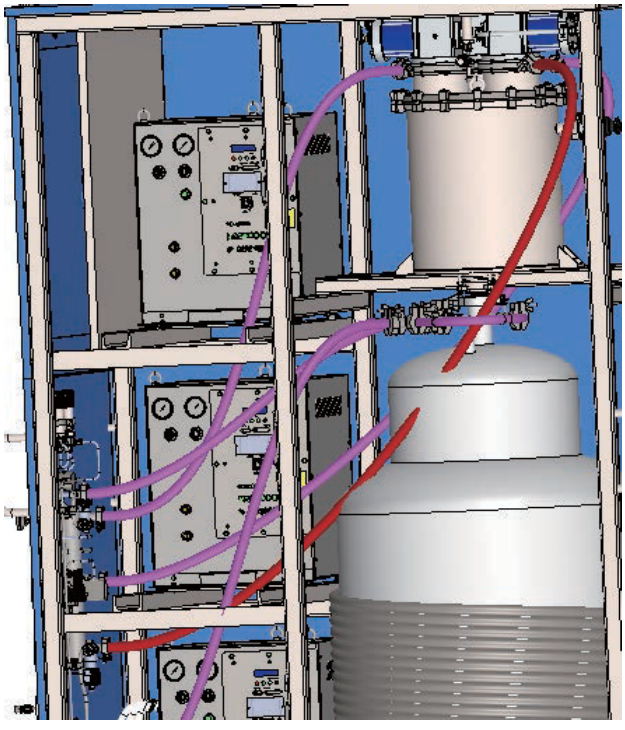
Num	Steps Demonstration	Figures
Transformation of Dewar Pipeline		

1	Removal of Dewar anti-collision ring	Remove the ring here 
2	Remove the 0.5 psig safety valve from the Dewar Install the adapter Install the disassembled safety valve	Remove the 0.5 psig safety valve here  Install the disassembled safety valve  Install the adapter
3	Remove the 10 psig safety valve from Dewar Install the tee connector Install the adapter 1 in the outlet 1 Install the adapter 2 in the outlet 2 Install the safety valve	Remove the 10 psig safety valve here  Outlet1 Outlet2  Install tee connector Install the disassembled safety valve here  Install the adapter 1  Install the adapter 2

4	Install the adapter 2 in the Dewar emptying valve outlet	Install the adapter 2 here   The adapter 2
5	Connect the three outlets of Dewar with the bellows	
Dewar pipeline transformation is completed		
The liquefier connect with the Dewar		
6	Remove the end of the liquefier infusion tube	
7	Lift the liquefier cold box as a whole	
8	Remove Dewar's casters	
9	Move Dewar into the shell	
10	Install the liquefier Dewar adapter flange at the bottom of the liquefier cold box	Liquefier Dewar adapter flange 

11	Insert the liquefier cold box infusion tube into Dewar (Note: Please measure the length of the infusion tube and the length of the neck inside the Dewar. Ensure that when the installation is completed, the end of the infusion tube is below the Dewar neck)	
12	Slightly move the Dewar and liquefier position to avoid serious deformation of the bellows on the adapter flange.	
13	According to the bolt hole position of the Dewar casters, drill the holes in the corresponding position on the bottom plate and fixed them with the bolts and nuts.	

14	Tighten all clamps and bolts	
Complete the liquefier and Dewar installation		
System pipe connection		
15	Lift the 3 sets of compressors and push into the rails	
16	Using six flexible metal hose to connect the compressor and the coldhead (note:supply and return can not take the wrong))	
17	Prepare five bellows and the corresponding clamp and O-ring	

18	Five bellows is connected according to the red pipe position	1.  2. 

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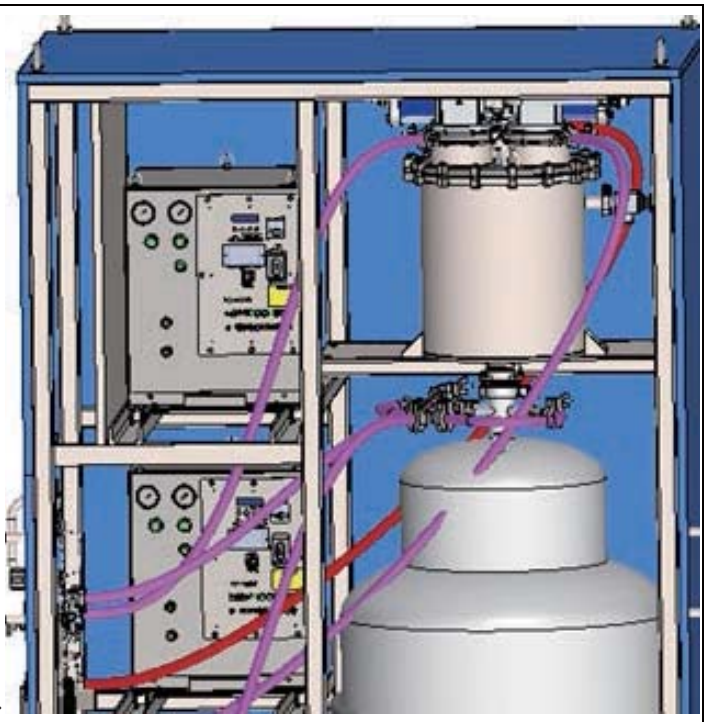

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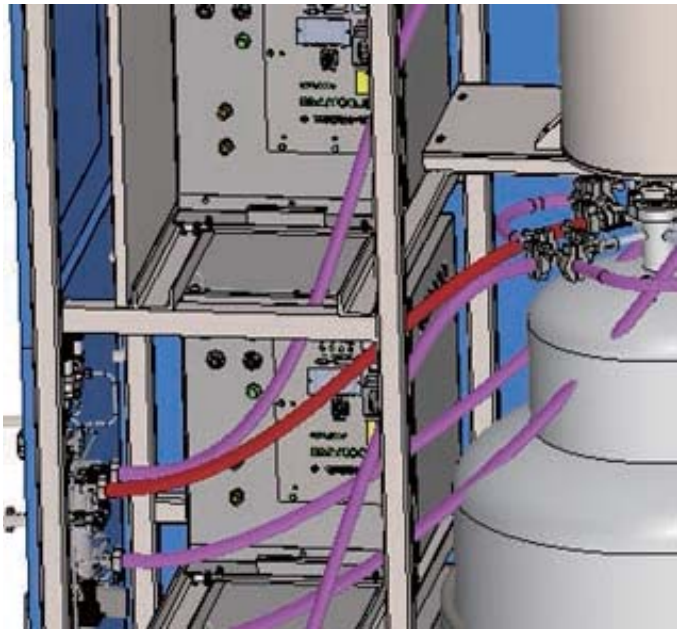
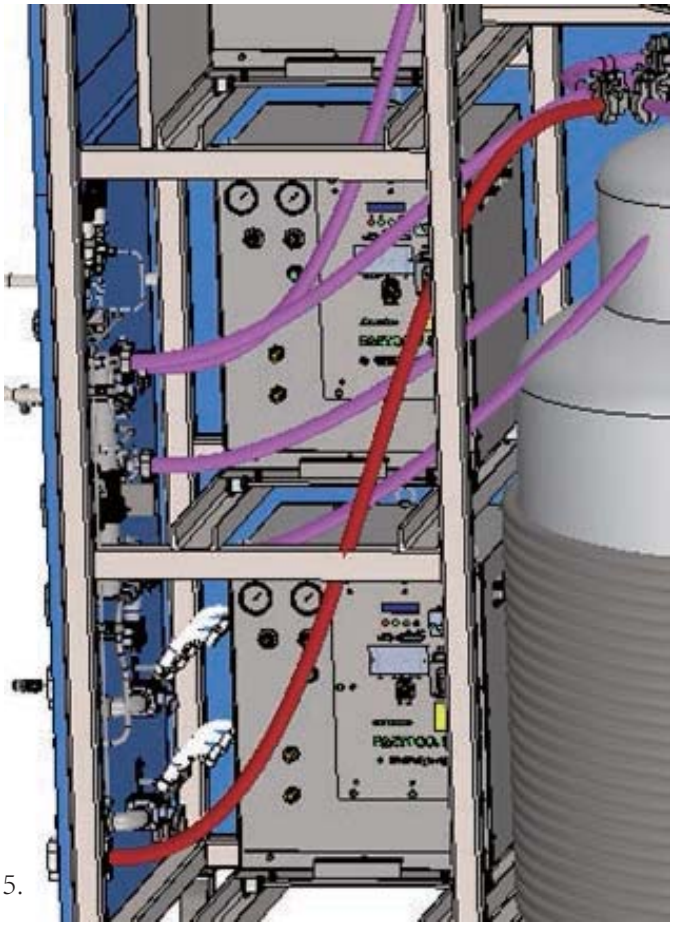


		5. 

19	Tighten all clamps and bolts	
System pipe connection is complete		
System water pipe connection		
20	Using the flexible water pipe to connect the compressor water inlet / outlet ports and the cabinet panel water inlet / outlet ports (Note: inlet and outlet do not get wrong)	
21	Use clamp to fasten and prevent water leakage	
The system water pipe connection is complete		
22	Finally, check that all ports are well connected	

6) Circuit connection

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

Num.	Steps Demonstration	Figures
1	Inspect all the circuit to make sure no damages on them and make sure the labels are not fall off	
2	Check the labels on the joints, and connect the joints one-to-one match	
3	Connect the joints of liquefier cold box sensors (pressure sensors and temperature sensors)	
4	Connect the liquid level meter power supply and signal circuit	
5	Connect the 3 compressor power supply circuits and remote control circuits	
6	Choose 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 , and the solenoid valve is working well	

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

Run starting-up operation

Before the first time run the liquefier, please vacuum the system pipes and Dewar first, and replace with the high pure helium.

1) Close the BV501, BV502, BV503, NV501, SV501, SV502, SV503, regulate the PRV501 to the smallest. Introduce the high purity helium gas to "HIGH PRESSURE HELIUM INLET" joint (the pressure of helium gas should be regulated to ≤3MPa), click the "manual" button on the touchscreen, open SV501, set "FC501 flow controller flow rate" parameters as 40slpm in the parameters setting interface, slowly regulate PRV501 until the pressure gauge PG502 and pressure sensor PT502 is 10psig (then do not touch the regulator), close SV501.

2) Connect the dry vacuum pump to "Vacuum Port": Manual open BV501、BV502、NV501、SV502、SV503, turn on the pump, evacuate the system pipes and Dewar until PT503 is less than 0.1KPa, and keep evacuate the system for another 60 minutes.

3) Close BV501, keep BV502、NV501、SV502、SV503 open, open SV501, and introduce high purity helium gas to the system pipes and Dewar until PT503 pressure sensor is 1psig for the first time. Then close SV501 and wait for 10 minutes, open BV501 slowly, evacuate the system pipes and Dewar until PT503 is less than 0.1KPa for the second time, and keep evacuate the system for another 60 minutes.

4) Close BV501, keep BV502、NV501、SV502、SV503 open, open SV501, and introduce high purity helium gas to the system pipes and Dewar until PT503 pressure sensor is 1psig for the second time. Then close SV501 and wait for 10 minutes, open BV501 slowly, evacuate the system pipes and Dewar until PT503 is less than 0.1KPa for the third time, and keep evacuate the system for another 60 minutes.

5) Close BV501, keep BV502、NV501、SV502、SV503 open, open SV501, and introduce high purity helium gas to the system pipes and Dewar until PT503 pressure sensor is 1psig for the third time. Then close SV501 and wait for 10 minutes, open BV501 slowly, evacuate the system pipes and Dewar until PT503 is less than 0.1KPa for the fourth time, and keep evacuate the system for another 60 minutes.

6) Close BV501, keep BV502、NV501、SV502、SV503 open, open SV501, and introduce high purity helium gas to the system pipes and Dewar until PT503 pressure sensor is 1psig for the fourth time. Then close SV501 and wait for 10 minutes, open BV501 slowly, evacuate the system pipes and Dewar until PT503 is less than 0.1KPa for the fifth time, and keep evacuate the system for another 60 minutes.

7) Close BV501, keep BV502、NV501、SV502、SV503 open, open SV501, and introduce high purity helium gas to the system pipes and Dewar until PT503 pressure sensor is 4~5psig. Close SV501, SV502,keep SV503 open.

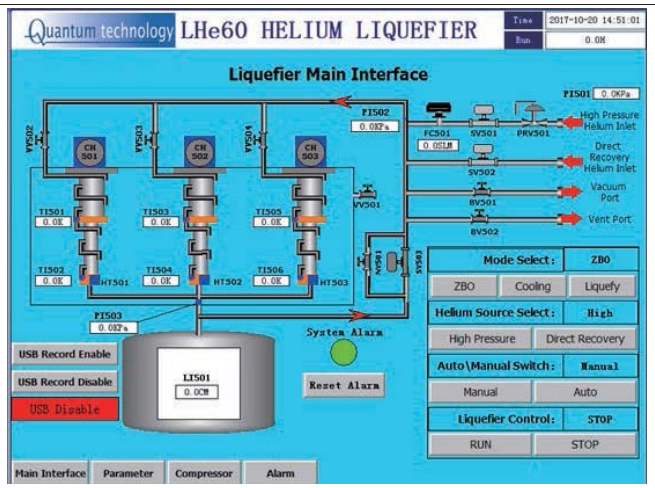
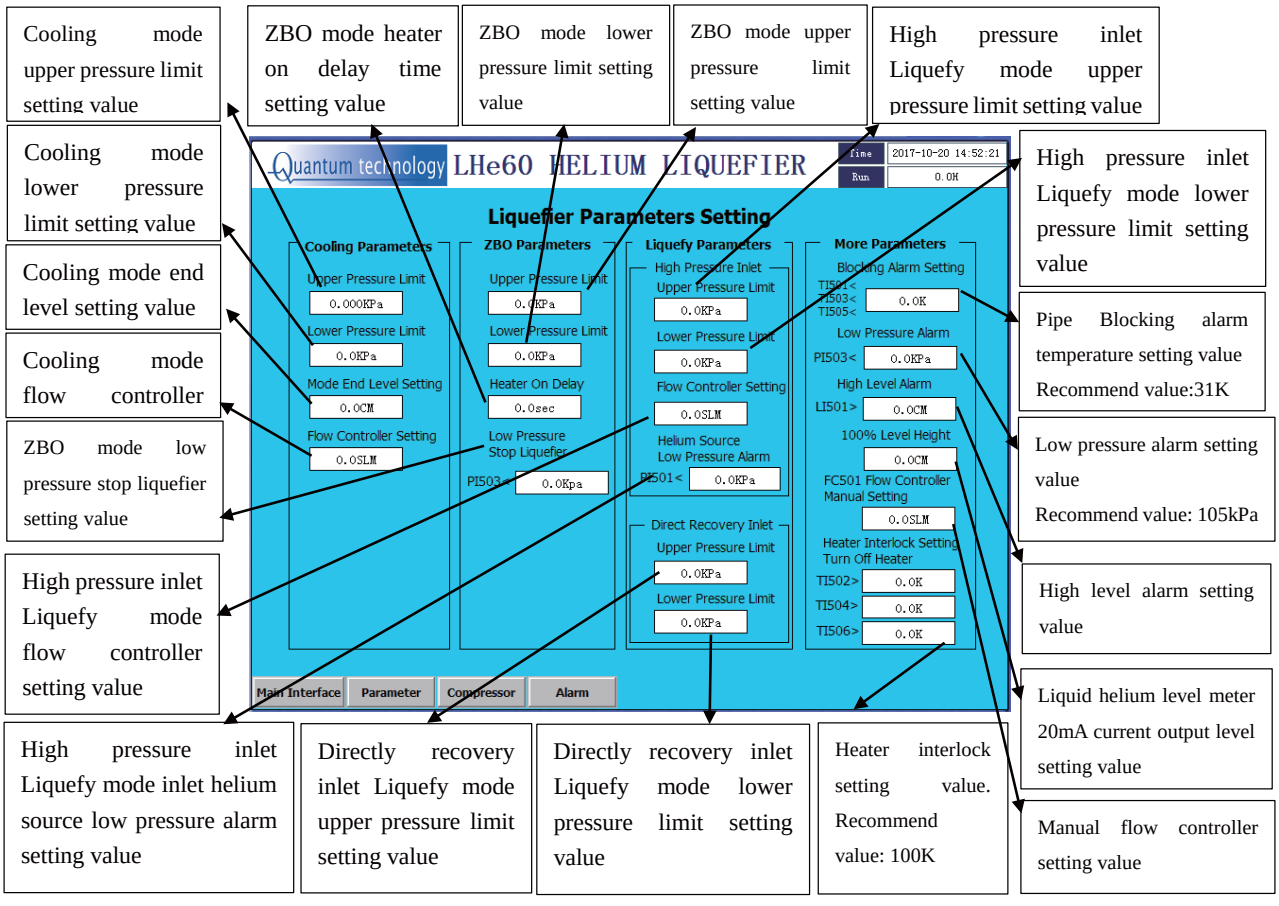


FIG.16. PLC Screen

Liquefier start-up

Set all parameters on the PLC parameter interface ready.

The parameter setting interface and the recommended parameter settings are as follows:



According to the recommend value and customer requirement, set the all parameters value on the interface.

Keep the valve VV502,VV503,VV504 open, NV501 Open four turns, BV501, BV502 closed, according to the gas supply, click the PLC touchscreen to select "high pressure helium inlet" or "Direct recovery helium inlet", click the "Run" button on the touchscreen, the system come into the automatic operation, then three compressors and coldheads will start sequence with 1 second intervals, click "Cooling" button, the system come into Cooling mode, confirm the status of the liquefier at the status bar whether the state is correct.

The system will start to cool and supply the helium according to the selected "high pressure helium inlet" or "direct recovery helium inlet" to open the solenoid valve. About 4 hours later, the coldhead temperature will reach the lowest. If the liquid helium level of Dewar reaches the Cooling mode end level setting value, the system automatically enters the Liquefy mode or manual press the "Liquefy" button. In the Liquefy mode, the system will operate in another control logic, and can continue to better liquefaction. If liquid helium level of Dewar reaches High level alarm setting value, the liquefier will automatically come into "ZBO" mode, if it is not necessary to continue liquefaction, the liquefier needs to be selected "ZBO" mode. In the ZBO mode, the system will stop gas supply. The self-boiling helium gas from Dewar will go to liquefier through NV501 and the pressure will decrease. When the pressure drops below the lower limit, the heater will be turned on delay and the pressure will increase. The pressure of liquefier will keep between the lower and upper limit pressure of ZBO mode.

Liquid helium transport

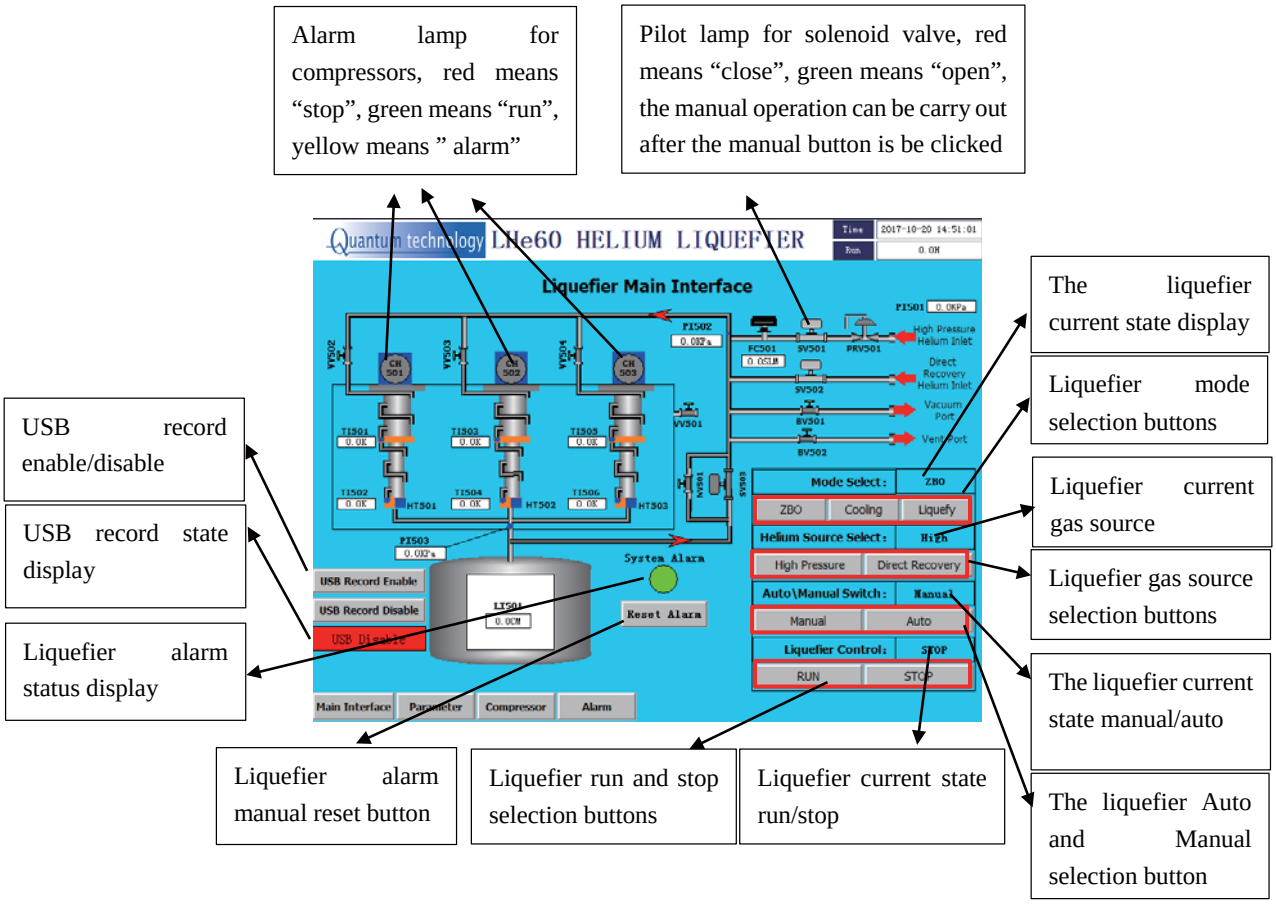
When you need transport the liquid helium, please insert the liquid transport tube into the transport Dewar, open the exhaust valve BV602 (Vent valve of transfer Dewar), BV603 (If it has been installed). Manually open BV505, then the liquid helium in the 350L Dewar will be transported to the transport Dewar through the transport tube. If you find the pressure of 350L Dewar decreases quickly and you still need speed up the liquid helium infusion, please manually close VV502、VV503、VV504, and press the "Manual" button on the touchscreen, switch to manual mode, according to the helium source, open SV501 or SV502. At this time, the helium gas will be introduced into 350L Dewar directly through SV503 and NV501, the inner pressure will rise up and speed up the liquid infusion. When the pressure is too high, please open VV502、VV503、VV504, click the "Auto" button, and switch to automatic mode. When the pressure of Dewar decreases quickly again, you can pressurize again as described above. The infusion pressure should be below 5psig, otherwise too quick liquid infusion will reduce the transport efficiency. When the liquid infusion comes to its end, please confirm current state of liquefier according the requirement, if it is not the state you want, must click on the "Auto" button and "Liquefy" mode or "ZBO" mode button again, the system will enter the corresponding mode automatically.

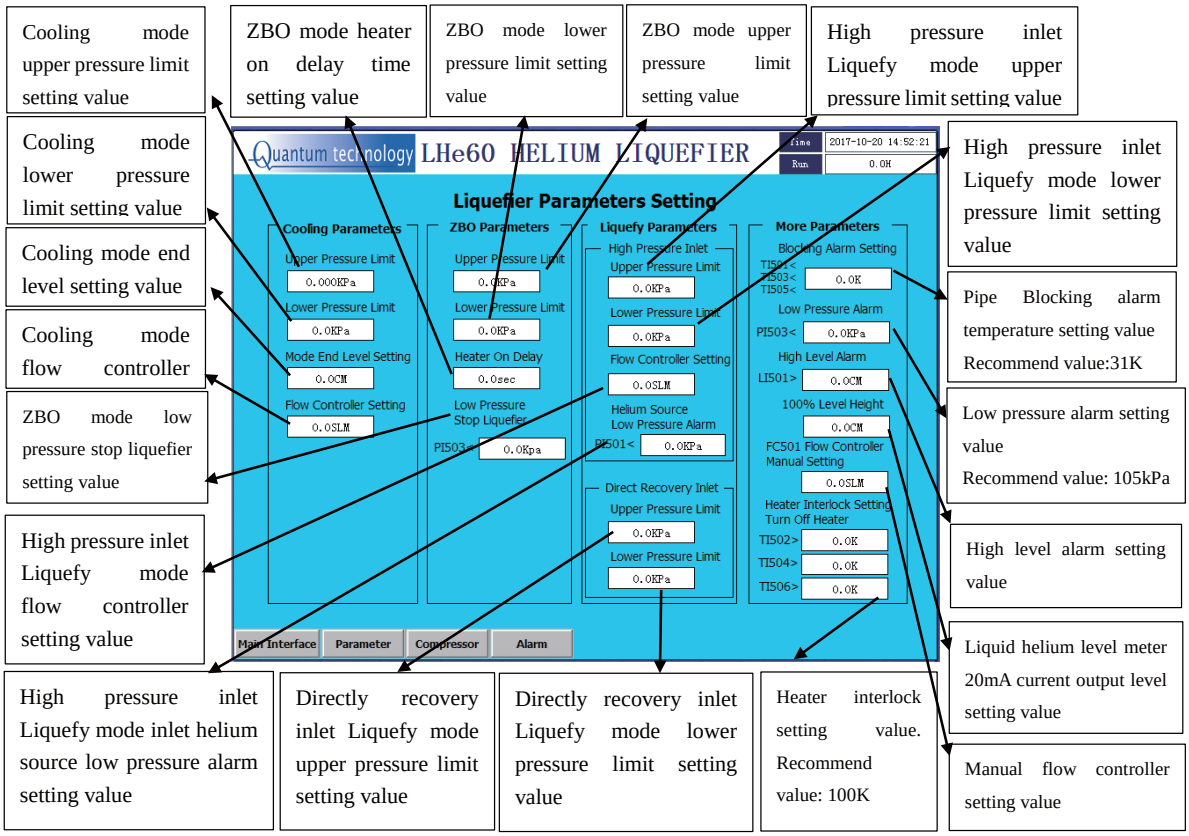
Liquefier shutdown

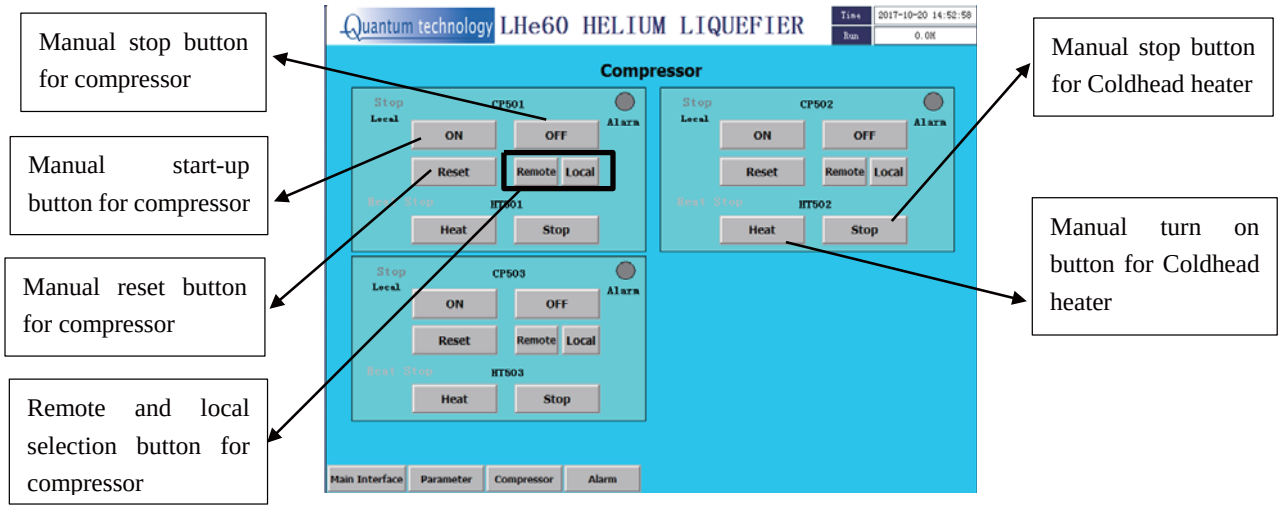
For short term shut down, you need not stop the Liquefier unit. If the liquefier will not be used for a long term, please click the “Stop” button on the Screen to stop the liquefier unit. At this time, all the 3 compressors and coldhead will shut down, the liquid helium in the Dewar will be self-boiling, and you can open the valve BV504 at front of 1psig relief valve to release the Dewar inner pressure, keep the valve open and then the self-boiling gas will discharge safely.

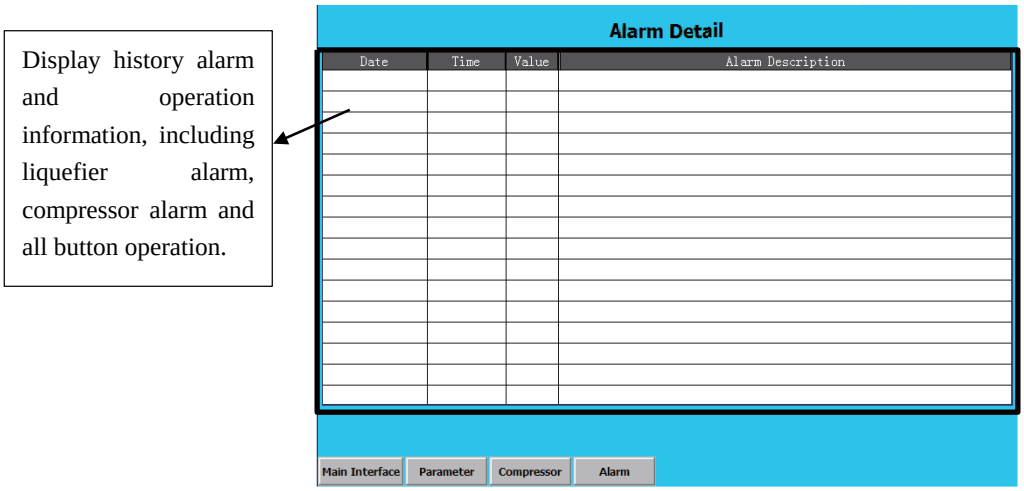
Program description and parameters setting

The following describes the PLC control interface:




Cooling mode upper pressure limit setting value
ZBO mode heater on delay time setting value
ZBO mode lower pressure limit setting value
ZBO mode upper pressure limit setting value
High pressure inlet Liquefy mode upper pressure limit setting value
Cooling mode lower pressure limit setting value
High pressure inlet Liquefy mode lower pressure limit setting value
Cooling mode end level setting value
Pipe Blocking alarm temperature setting value Recommend value:31K
Cooling mode flow controller
ZBO mode low pressure stop liquefier setting value
Low pressure alarm setting value Recommend value: 105kPa
High pressure inlet Liquefy mode flow controller setting value
High level alarm setting value
Liquid helium level meter 20mA current output level setting value
High pressure inlet Liquefy mode inlet helium source low pressure alarm setting value
Directly recovery inlet Liquefy mode upper pressure limit setting value
Directly recovery inlet Liquefy mode lower pressure limit setting value
Heater interlock setting value. Recommend value: 100K
Manual flow controller setting value
Quantum technology
LHe60 HELIUM LIQUEFIER
Time
2017-10-20 14:52:21
Run
0.0H
Liquefier Parameters Setting
Cooling Parameters
Upper Pressure Limit
0.000KPa
Lower Pressure Limit
0.0KPa
Mode End Level Setting
0.0CM
Flow Controller Setting
0.0SLM
ZBO Parameters
Upper Pressure Limit
0.0KPa
Lower Pressure Limit
0.0KPa
Heater On Delay
0.0sec
Low Pressure Stop Liquefier
PI503<
0.0Kpa
Liquefy Parameters
High Pressure Inlet
Upper Pressure Limit
0.0KPa
Lower Pressure Limit
0.0KPa
Flow Controller Setting
0.0SLM
Helium Source Low Pressure Alarm
PI501<
0.0KPa
Direct Recovery Inlet
Upper Pressure Limit
0.0KPa
Lower Pressure Limit
0.0KPa
More Parameters
Blocking Alarm Setting
TI501<
TI503<
TI505<
0.0K
Low Pressure Alarm
PI503<
0.0KPa
High Level Alarm
LI501>
0.0CM
100% Level Height
0.0CM
FC501 Flow Controller Manual Setting
0.0SLM
Heater Interlock Setting Turn Off Heater
TI502>
0.0K
TI504>
0.0K
TI506>
0.0K
Main Interface
Parameter
Compressor
Alarm


Manual stop button for compressor
Manual start-up button for compressor
Manual reset button for compressor
Remote and local selection button for compressor
Quantum technology
LHe60 HELIUM LIQUEFIER
Compressor
CP501
CP502
CP503
ON
OFF
Reset
Remote
Local
Heat
Stop
Alarm
Main Interface
Parameter
Compressor
Alarm
Manual stop button for Coldhead heater
Manual turn on button for Coldhead heater


Display history alarm and operation information, including liquefier alarm, compressor alarm and all button operation.
Alarm Detail
Date
Time
Value
Alarm Description
Main Interface
Parameter
Compressor
Alarm

PHYSICAL INTERFACE

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

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

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

3. Vacuum port--connected by vacuum corrugated hose, the connector is KF25;

4. Vent port-- connected by vacuum corrugated hose, the connector is KF25;

5. Water inlet, Water outlet,—connected by Non-Metallic Water Pipe, the connector is 1 inch bayonet type;

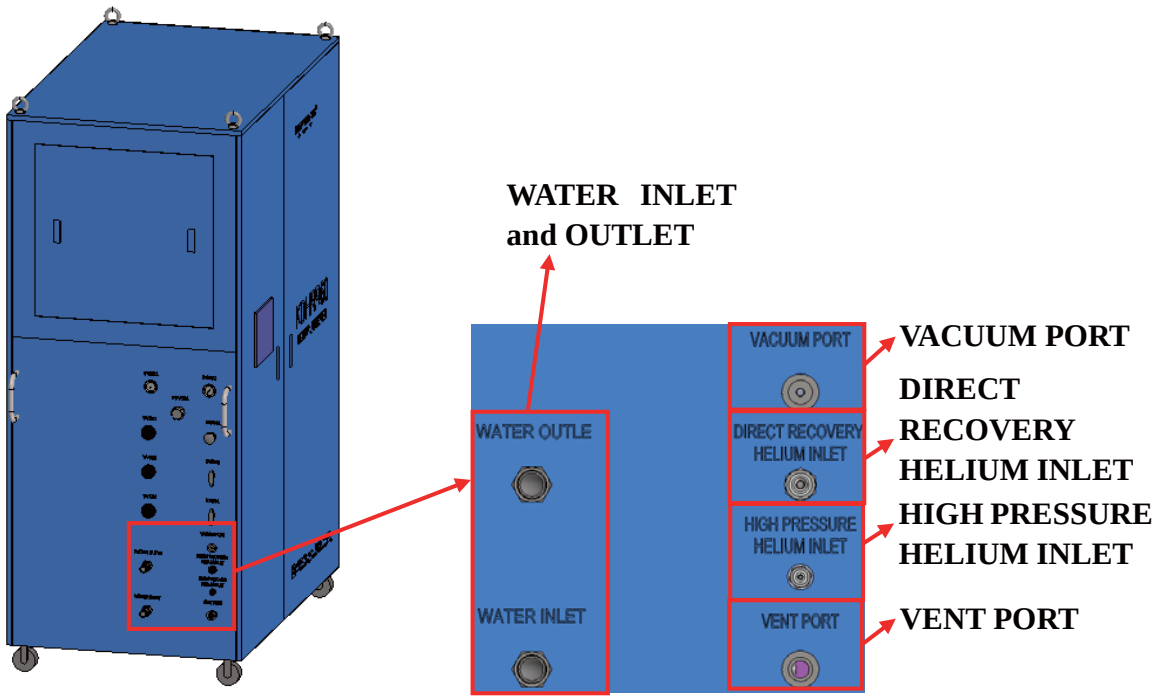
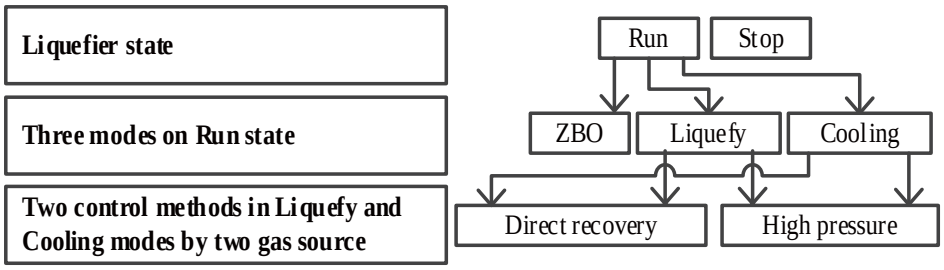


FIG.17. Physical interface

THE CONTROL LOGIC OF PROGRAM

The control mode and logic of the KDHRR60 helium liquefier



Select the helium source, there are the following two options: "Direct recovery" and "High pressure", in any state the source can be changed.

Select the liquefier run or stop, there are the following two options: "Run" / "Stop". Click "Stop" button, all the compressor and coldhead will stop one by one, interval 1 second, and all the solenoid valves will power off; Click "Run" button, all the compressor and coldhead will run one by one, interval 1 second, and default into Cooling mode;

On "Run" state, there are three modes: "Cooling" "ZBO" "Liquefy", each mode set a button;

In "Cooling" and "Liquefy" modes, according to the different helium source "Direct recovery / High pressure", there are two different control methods (NV501 need to manually open 4 turns).

Cooling mode

When the gas source selects "High pressure", the control is as follows:

Open SV501, SV503, turn off SV502, if PI503> (cooling mode parameters setting "Upper pressure limit"), set FC501 to 0 slpm;

If the PI503 < (cooling mode parameters setting "Lower pressure limit"), set FC501 to XX slpm (the value is set in cooling mode parameters setting “Flow controller setting”)

When the liquid level LI501> XX cm (the value is set in cooling mode parameters setting "Mode end level setting"), the liquefier will automatically enter Liquefy mode.

When the gas source selects "Direct recovery", the control is as follows:

Open SV503, turn off SV501, set FC501 to 0 slpm, set SV502 is off if PI503> (cooling mode parameters setting "Upper pressure limit");

If PI503 < (cooling mode parameters setting "Lower pressure limit"), set SV502 to be open;

When the liquid level LI501> XX cm (the cooling mode parameters setting "Mode end level setting"), the liquefier will automatically enter Liquefy mode.

Liquefy mode

When the gas source selects "High pressure", the control is as follows:

Open SV501, close SV503, turn off SV502, if PI503 > (liquefy mode parameters setting "High pressure inlet upper pressure limit"), set FC501 to 0 slpm;

If the PI503 < (liquefy mode parameters setting "High pressure inlet lower pressure limit"), set FC501 to XX slpm (the value is set in liquefy mode parameters setting "High pressure inlet flow controller setting")

When the helium pressure PI501 < (liquefy mode parameters setting "High pressure inlet helium source low pressure alarm setting"), the alarm is displayed and the liquefier automatically enter ZBO mode. When LI501> (Other parameters setting" High level alarm setting "), the alarm is displayed and the liquefier automatically enter ZBO mode.

When the gas source selects "Direct recovery", the control is as follows:

Turn off SV501, SV503, set FC501 to 0 slpm.

If PI503> (liquefy mode parameters setting "Direct recovery inlet upper pressure limit"), turn off SV502;

If PI503 < (liquefy mode parameters setting "Direct recovery inlet lower pressure limit"), turn on SV502;

When LI501> (Other parameters setting "High level alarm setting"), the alarm is displayed and the liquefier automatically enter ZBO mode.

ZBO mode

In this state, turn off SV501, SV502, SV503, set FC501 to 0 slpm. If the PI503 > (ZBO mode parameters setting "Upper pressure limit"), close the coldhead heater HT501, HT502, HT503; if the PI503 < (ZBO mode parameters setting "Lower pressure limit"), and continues to decrease, the duration > (ZBO mode parameters setting "Heater on delay"), the coldhead heater HT501, HT502, HT503 will turn on. If the value of PI503 still decrease, and < (ZBO parameters setting "Low pressure stop liquefier"), the low pressure alarm is displayed and the liquefier will stop.

Other alarm

In any mode of operation:

If the value of TI501, TI503 and TI505 < (Other parameters setting "Blocking alarm setting"), the liquefier is blocked and enters the ZBO mode, waiting for the operator shut off the liquefier.

If the value of PI503 < (Other parameters setting "Low pressure alarm setting"), the low pressure alarm is displayed and the liquefier enters the ZBO mode;

If the value of LI501> (Other parameters setting "High level alarm setting"), the high level alarm is displayed and the liquefier enters the ZBO mode.

If one of compressor and coldhead has an alarm and stops automatically, the liquefier will automatically stop and display the same alarm.

Set Manual / Auto buttons. In the automatic state, all manual operation does not take effect, in the manual state, all automatic operation does not take effect. The input value of flow controller FC501 is the value in other parameters setting "FC501 flow controller manual setting".

The heater for regeneration setting: The heater on the coldhead is interlocked with the temperature. When the value of TI502 > (other parameters setting "Heater interlock setting"), the HT501 is forced to close. When the value of TI504 > (other parameters setting "Heater interlock setting") the HT502 is forced to close. When the value of TI506 > (other parameters setting "Heater interlock setting") the HT502 is forced to close.

The parameters settings are placed in an interface, and automatically save the parameters after power failure, and read again after power on.

Record all alarms and operations in the alarm interface

TROUBLESHOOTING GUIDE

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

NO.	Problems	Causes	Solutions
1	KDC6000V Compressors alarm or shutdown	KDC6000V Compressors internal fault or cooling water supply failure	Refer to << KDC6000V compressor operation manual >>
2	The GM cryocooler has an abnormal sound	The internal moving parts of the cryocooler are seriously worn or malfunctioned	Contact the manufacturer for service or repair
3	Condensation occurs on the surface of the cold box and infusion pipes	The liquefier cold box sandwich vacuum is not good, may be outside air, or internal helium leak into the vacuum.	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 pipe is blocked, may be air or hydrogen or water vapor blocked in the pipeline	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	The thermometer is damaged, or the temperature monitor is faulty	Contact the manufacturer for service or repair
		Poor data connection	Check the data acquisition connection is good
		If the gas line is blocked, it will cause TI501, TI503 and TI505 less than 31K	Stop the liquefier, open the valve BV504 at front of 1psig relief valve, release the pressure, open BV502, turn on HT501~503, a few hours later, if TI501~506 are all above 100K, close BV504、BV502, turn off HT501~503, start the liquefier.
6	The liquefier cold box inlet pressure or internal pressure is too low or too high	Pressure sensor is damaged	Contact the manufacturer for service or repair
		Poor data connection	Check the data acquisition connection is good
		If the gas line is blocked, it will cause the inlet pressure too high or internal pressure too low	Stop the liquefier, rewarm and reverse purge the pipes.
7	When the liquefier is on the liquefy mode, the pressure is below the liquefaction pressure setting but no gas is	The inlet solenoid valve is damaged	Contact the manufacturer for service or repair
		The power supply connection of the inlet solenoid valve is poor	Check the power supply line is good
		The inlet pressure exceeds the upper opening pressure limit of the solenoid	Check the inlet pressure, the pressure of high pressure helium input should not be higher than 50barg, the

8	Condensation or frost occurs on the surface of the Dewar	The Dewar sandwich vacuum is not good, may be outside air, or internal helium leak into the vacuum.	Use the helium mass spectrometer leak detector to check the external and internal tanks of the Dewar
9	In the ZBO or liquefy mode, the pressure or liquid level constantly drops	The system has a helium leak at the connection	Use liquid leak detector or the sniffer of helium mass spectrometer leak detector to check all the connectors
10	In the ZBO or liquefy mode, the pressure constantly increases and exceeds 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 the external and internal tanks of the Dewar
		Liquefier performance decreased	The cold head and compressor need fault diagnosis or maintenance
		The bypass valve is not open or damaged	Contact the manufacturer for service or repair

NOTES

1. Familiar with the whole process of the liquefier and familiar with the liquefier operating manual;

2. Please read KDC6000V operating manual and KDE415 operating manual carefully before you start the system for the first time;

3. Please make sure that the water chiller works well and the cooling water meets the requirements;

4. Do not change on the configuration parameters, and do not change on the control program, if it has to be changed, please communicate with the manufacturer;

5. All the charts, technical schemes, 3D model pictures and other related technical information prohibit be sent to other companies;

6. If you have any other questions, please call our engineers.

MAINTENANCE

Equipment maintenance

When the KDHRR60 helium liquefier is not on use, please regularly carry out leak detection, check all the pressure gauge’ s reading, and prepare dust-proof. Record the relevant information after inspection. If you find any problems, please contact the manufacturer.

Maintenance of the KDHRR60 helium liquefier requires maintenance of the individual components. The maintenance period for cold head is 1.5 years, and the maintenance period for compressors is 3 years. Please notify the manufacturer when the required maintenance period is approaching. The manufacturer will maintain the different components of liquefier according to the actual usage.

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