Quantum-I*Plus* NMR Spectrometer

Cryogen Level Meter Product Manual

WMR/3-YF/P-B/YMJ/YHSC/A1

Q.One Instruments Ltd.

Level Meter of Superconducting Magnet User Manual

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Note: this icon is used to prompt you for these considerations, and failure to comply with these prompts may result in device damage or loss of data.


Prompt: this icon is used to indicate information you can refer to.

Table of Contents

Cryogen Level Meter User Manual

1 Brief Introduction

1.1 Brief Introduction

The level meter of superconducting magnet is designed specially for measuring cryogenic liquid nitrogen and helium level in the magnet vessels. It is made form non-magnetic material to work within the strong magnet field environment. It uses curve current control and leak current detect technique to ensure safely current output under any conditions and reduce consumption of liquid helium.

Features

✓ Light and small size：

Level meter has a small size benefited from high integration design, it could be directly installed on the top of nitrogen vessel tube.

✓ Work independently：

Level meter can work both with the spectrometer and independently once been calibrated.

✓ Completed data records：

When working with PC software, level meter has extra functions, data is recorded continuously, automatically level alarm, automatically helium measuring, forecast next refill time, record refill history and so on.

✓ Safety design：

Leak current of level meter endangers the safety of magnet directly, the level meter’s safety is ensured by several technology: real time current monitor, the unique curve current control technology, the current of working status is safely controlled and shut down in standby status, this technology also keep the consumption of liquid helium at the lowest level.

Components

1）Level meter

a) Measuring nitrogen level automatically；

b) Helium level is measured passively；

c) Touchscreen displays the last measured levels and the interval from last helium measuring；

d) Triggered helium level measuring by pressing the touchscreen；

e) Could be connected to PC and controlled by software to measure automatically。

Fig. 1 Level meter

2）Power supply module

Level meter power supply converts single phase AC power to dual DC power for level meter. It's connected to level meter and AC power supply through wires.

When used with the Quantum-I^{Plus} NMR spectrometer, the power supply is built inside the console.

WARNING Level meter power supply is a switching power which includes a lot of inductance and magnetic parts, it must be settled far away from the magnet.

Fig. 2 Level meter power supply

3）Nitrogen probe

Nitrogen probe is used to measure the liquid nitrogen level. It is made from two coaxial stainless steels and installed in nitrogen vessel. The level meter is connected to nitrogen probe by the screw connector on the top of probe, which reduces measuring tolerance caused by connecting wires and ensures measuring accurate.

Fig.3 Nitrogen probe

4）Helium probe

Helium probe is used to measure liquid helium level, it is made from a superconductive wire installed in a stainless steel, and a connector used to connect with the level meter.

Fig.4 Helium probe

1.2 Theory

1.2.1 Level meter connection

The connections of level meter is showed in Fig. 5. The level meter, helium probe and nitrogen probe are installed on the magnet vessel and connected to power supply module and

PC with cables.

Nitrogen probe is installed in the liquid nitrogen vessel tube, and connected to level meter via screw directly. Helium probe is installed in liquid helium vessel and connected to the level meter via a cable. The level meter power supply module coverts AC power to DC power and connects with level meter DC power supply cable. Control software is installed in computer and connects with level meter by a CAN converter.

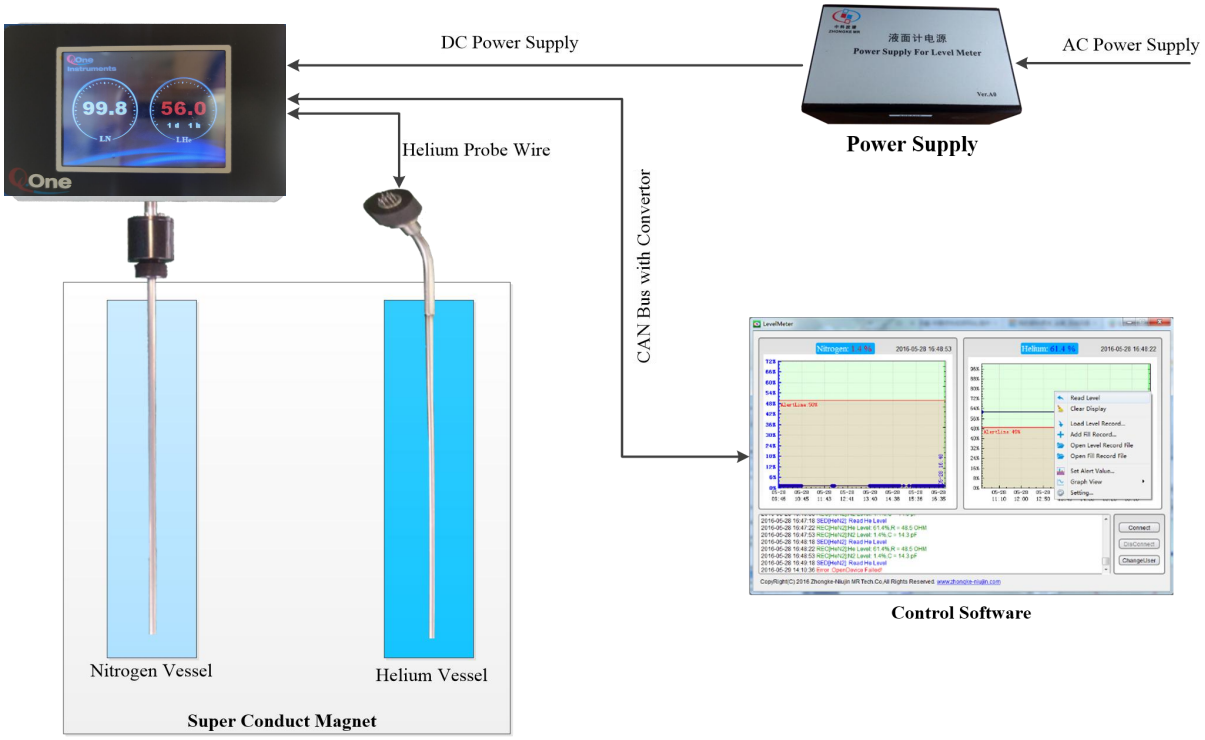


Fig. 5 Level meter system connection

1.2.2 Nitrogen Measuring Theory

Nitrogen probe measures the nitrogen level via a capacity sensor, as shown in Fig. 6. The capacity sensor is made of two coaxial stainless steels, and fixed with wound insulation string between the two steels. Some drilled holes on the outside steel are used to make sure liquid nitrogen can flow in.

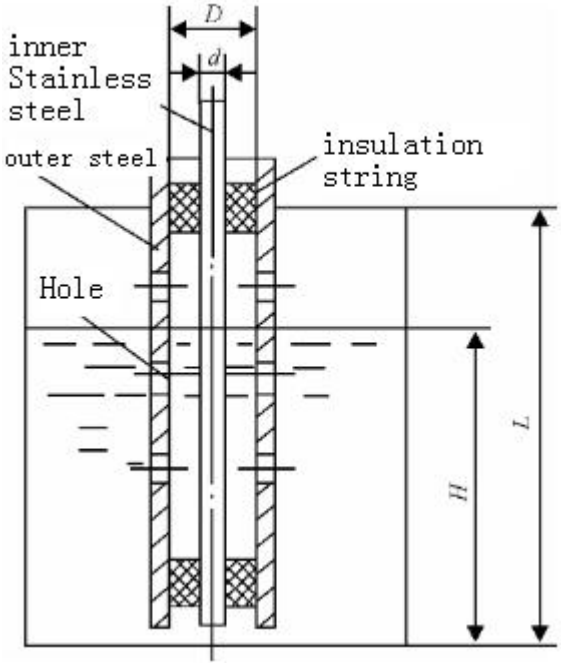


Fig.6 Theory of nitrogen level measurement

When nitrogen probe is filled with liquid nitrogen, the capacity changes to :

$$C = k\varepsilon H + k\varepsilon_0(L - H), k = \frac{2\pi}{\ln(D/d)}$$

In the formula:

——*H Height of Level of nitrogen*

——*L Length of sensor*

——*C Capacity of sensor*

——*D Diameter of outer pipe*

——*d Diameter of inner pipe*

——ε_0 *Electric medium constant of air*

——ε *Electric medium constant of liquid nitrogen*

The capacity of probe changes with the liquid nitrogen level, so it's able to get the nitrogen level by measuring the capacity of sensor.

1.2.3 Helium Measuring Theory

Helium probe measures resistance of the sensor to measure the helium level, as shown in Fig.7.

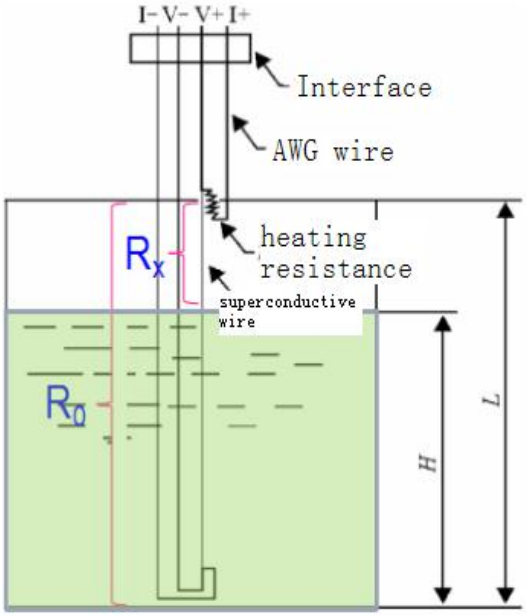


Fig.7 Theory of liquid helium level measurement

Helium probe is made of a superconductive wire with a heating resistor. As it's immersed in liquid helium, the bottom part of the helium probe becomes superconductive and its resistance changes to zero, the top part has normal resistance after heating by the resistor . he The whole resistance of probe can be calculated with the formula:

$$H = L \times (1 - R_x / R_0)$$

In the formula:

——H Height of liquid helium

——L Length of superconductive wire

——R_x The measured resistance of the probe

——R_0 The resistance of the probe when helium level is zero

The changes of helium level could be got by measuring the resistance of helium probe.

1.2.4 Trig method of level measuring

Liquid nitrogen level is measured from capacity directly and there is only a low voltage between two steel pipe layers, which has no heat dissipation, so the nitrogen is measured continually and the liquid nitrogen level is shown in real time.

The helium level is measured by injecting current into the helium probe, which produces

heating and consumes liquid helium. So the interval time between two measurements should be as long as possible.The helium level meter works passively and could only be triggered by external methods:

1) Press the display area of liquid helium level on the touchscreen and select "Yes" in the popped confirmation prompt.
2) Use the SpinStudioJ software to send command to level meter.

The latest measured data and interval time are shown on the touchscreen. The level meter will send measuring data to computer if a CAN cable is installed.

1.3 Specification

Measuring method	
Helium	Superconductive resistor
Nitrogen	Capacitor
Probe length	
Nitrogen	Adjustable
Helium	Adjustable
Helium measuring parameter	
Current	Adjustable，default 110mA,120mA maximum
Current output time	Adjustable，1s～15s
Probe resistance	88Ω/m
Voltage	15V
Measuring Interval	controlled by software，1minute～100days
Leak current of helium measuring	<0.03nA
Resistor measuring tolerance	<0.5Ω
Capacitor of nitrogen probe	390pF/m
Display	
Display type	LCD with touchscreen
Display Range	0%～110%
Alarm	
The data displayed on the touchscreen is marked in red	

Alarm if helium probe error or not installed

Leakage current overflow

Parameter setting error

Low level alarm

Communication interface

Communication	CAN bus
Baud Rate	1Mbps
Frame	Stand Frame
Converter	USBCAN mini or Quantum NMR console

Connector

CAN bus connector	ODU S21L0C-P06MFG0-720S
Power supply connector	ODU S21LAC-P06MFG0-720S
Helium probe connector	ODU S21L0C-P05MJG0-720S or 10Pin connector
Nitrogen probe connector	TNC-50JF

Power converter(optional)

AC Power In	200~260V 50/60Hz,standard 3 pin connector
DC Power Out	PLT-16-4Pin
Max current	0.3A

Power consumption 5W

Material

Level meter	Aluminium alloy
Power supply	Aluminium alloy
Nitrogen probe	Stainless steel
Helium probe	Stainless steel

Dimensions

Level meter	14cm x 9cm x 6cm
Power supply	15cm x 9cm x 6cm

Weight

Level meter	0.5kg

Power supply	0.55kg

2 Operation Requirements

Power：VAC 200~260V , 50/60 Hz；

Temperature：15℃-30℃；

Humidity：30%-70%；

OS：Windows XP / Windows 7(Windows 8 and Windows 10 should also work but not tested)

3 Operation Notice

- Level meter is used in strong magnetic field and cryogenic environment, please take your attentions on following security items:

Strong magnetic field of superconducting magnet

Please following the operation specifications of strong magnetic field when installing or operating the level meter, DON'T bring any magnetic things in, people with implanted or attached medical devices such as pacemakers and prosthetic must remain far away 5 Gauss line of the magnet.

Cryogenic liquid

Please follow the operation specifications of cryogenic liquid when installing or disassembling the level meter. Wear eyeglass protection and protection gloves, and avoid any effect to magnet while installation.

High voltage

The power converter operating with a high voltage above 200V, do not open the shell of power supply module.

Warning Helium consumption

Measuring the helium will consume extra helium, avoid measuring frequently. Please confirm the interval is set correctly when you use the automatic measure function.

Warning Avoid water and wet floor

All electric components in level meter and power module are not waterproof processed, be careful DON'T splash water into them.

Warning Wrong installation may cause damage

If the level meter is not installed properly, there may be nitrogen leaked from bottom of level meter, which will cool down the level meter, and the electronic parts may damage from the dew caused by low temperature.

4 Installation

4.1 Install the Level Meter

Install level meter as Fig.8 to Fig.10.

1） Install nitrogen probe

a) Loose the nut of nitrogen probe and slide down the nut, gasket and O ring at least 2cm as shown in Fig.8.

b) Take off the heat dissipation or any other things on the nitrogen pipe.

c) Insert nitrogen probe into nitrogen neck pipe slowly, trap the gasket and O ring onto nitrogen neck pipe and press probe in until the top of nitrogen neck pipe touches the bottom nitrogen probe head.

d) Press the nitrogen probe and screw up the nut to probe tightly.

2） Install level meter

Fix up the TNC connectors between level meter and nitrogen probe and screw them up tightly.

3） Install helium probe

a) Heat the helium probe with a heat gun.

b) Take off the oscillation damper assembly on the helium blow off pipe.

c) Take off the screw top on the helium probe insert siphon, and take off the inside plug.

d) Pull the nut, gasket and O ring from down to up through the helium probe tube.

e) Insert helium probe into the siphon slowly until fully inserted, screw up the nut tightly.

The helium blow off pipe and helium probe siphon CAN'T open in the air more than 5 seconds during installation if helium exists in the vessel!

4） Connect cables

Power supply module must be settled as far as possible from the magnet, DON'T put it into the 5 Gauss area!

a) Take out helium probe connect cable, plug the 10pin connector into the plug on the top of helium probe, plug the other end into the port printed "He Probe" on back panel of level meter.

b) Take out DC power connect cable, connect the power supply module and level meter.

c) Take out the AC power cable, connect the power supply module and AC power supply socket.

d) Take out communication wire with CAN bus converter, plug the RJ45 connector into "CAN" port on the back panel of level meter, plug the other end with USB connector into USB port of computer.

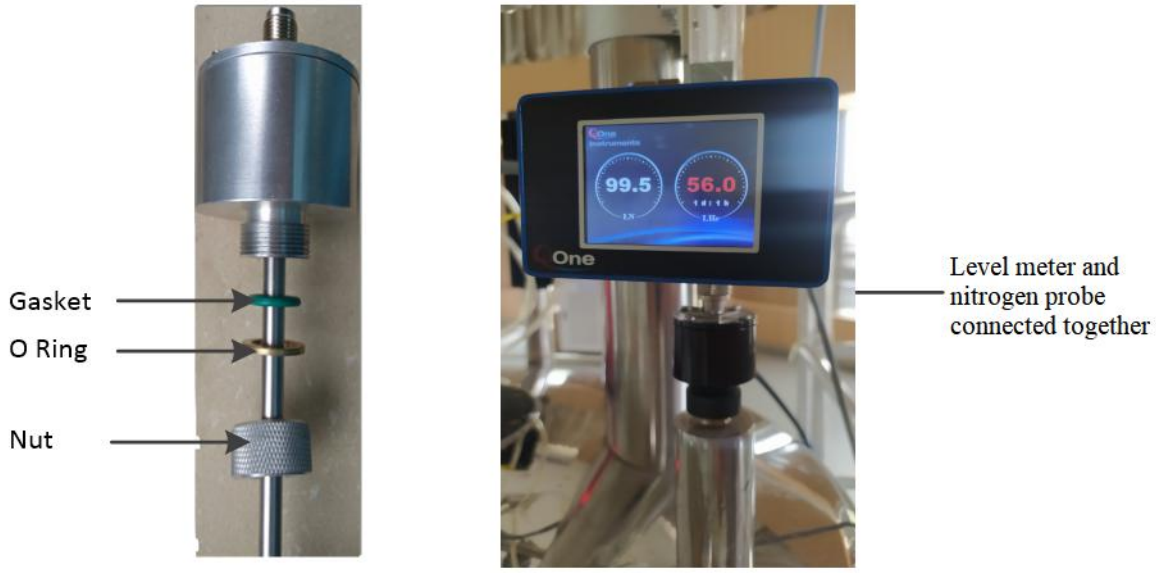


Fig. 8 Install nitrogen probe reference

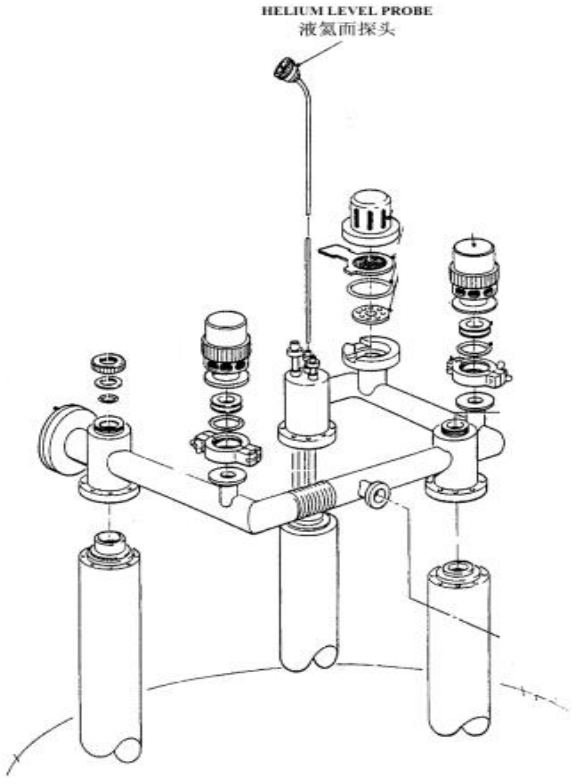


Fig.9 Install helium probe reference

Fig. 10 Cable connection reference

4.2 Stand alone software installation(optional)

4.2.1 Install Driver

If the level meter is proposed to be used stand alone, a USB-CAN must be used to read and record the measured data, then the driver must be installed.

Copy driver folder into computer and double click “DriverSetup.exe” in 32bits operation system or “DriverSetup64.exe” in 64bits operation system, click the button 

to install driver until it shows installation completed.(see Fig.11, 12). After driver installation , a new USBCAN equipment will show in the device management window shown as Fig.13.

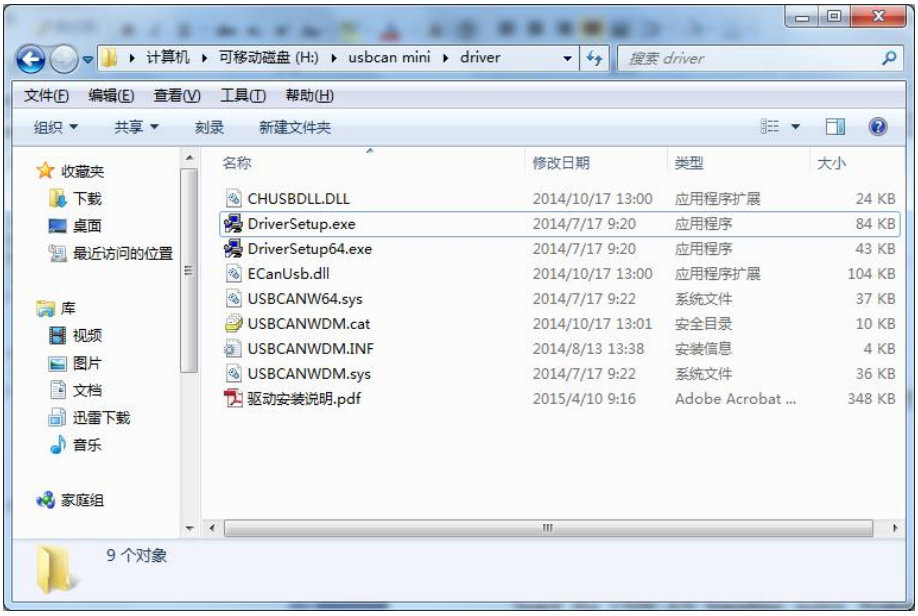


Fig. 11 USBCAN Driver Content

Fig.12 Install Driver

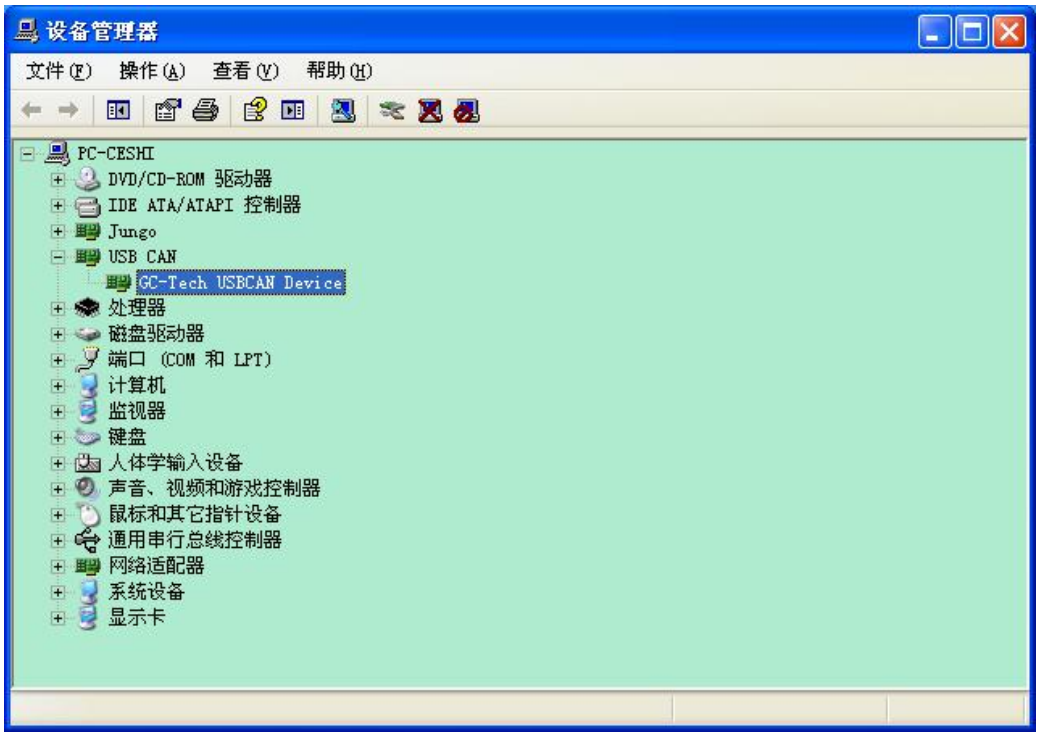


Fig. 13 A new installed USBCAN device in the device management window

4.2.2 Install Control Software(optional)

If the level meter is proposed to be used stand alone, a USB-CAN must be used to read and record the measured data, then the software must be installed.

The control software is a “green software” which doesn’t need to install, just copy the control software folder into computer and double click “LevelMeter.exe” to run it, see Fig.14-15.

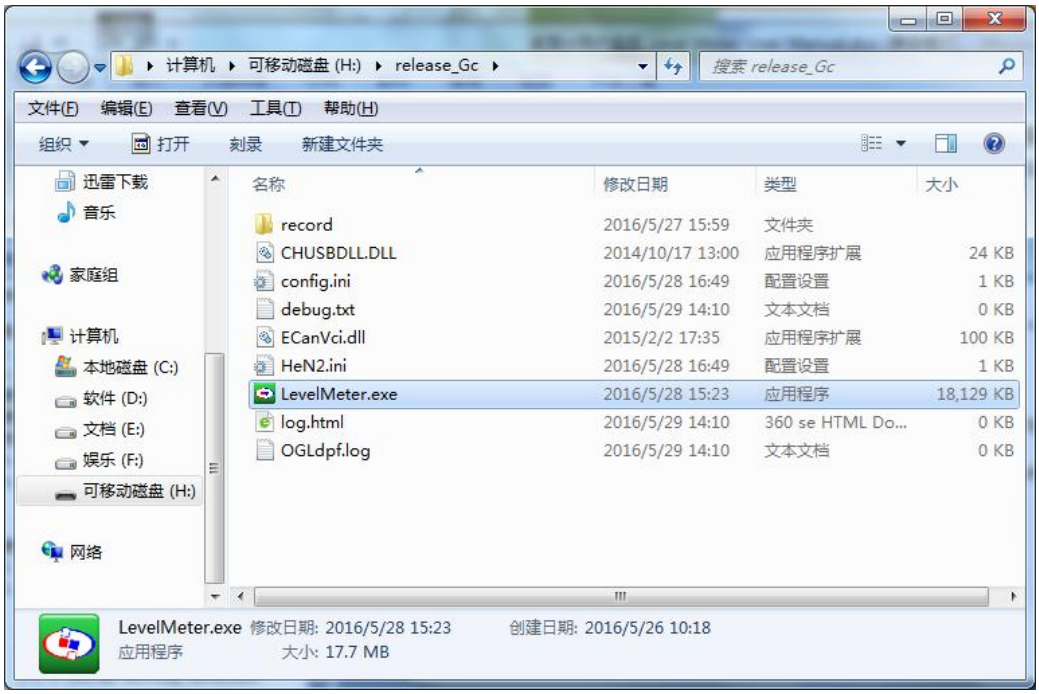


Fig.14 Control software folder

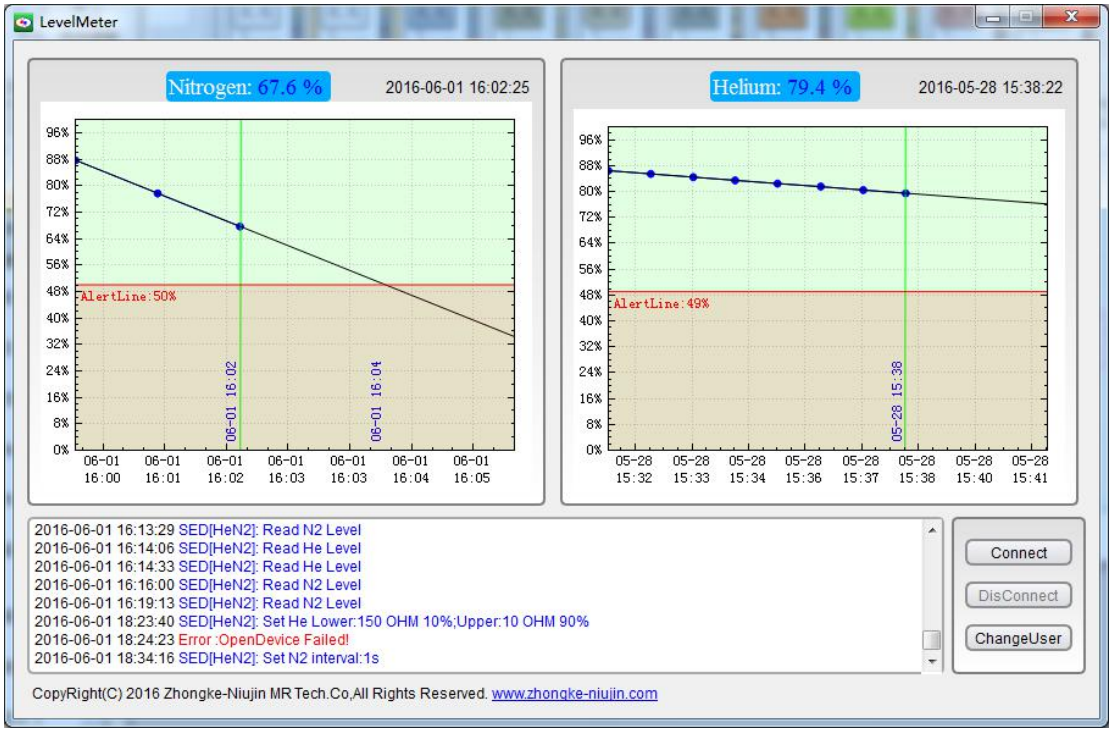


Fig.15 The main frame of the control software

5 How to use the level meter

5.1 Use Level Meter to Measure Level

Turn on the power switch.

The level meter start to measure nitrogen level automatically, Press the display area of liquid helium level on the touchscreen and select "Yes" in the confirmation prompt, the level meter start to measure the helium level, and the touchscreen will display the nitrogen and helium level as shown in Fig. 16.

Fig.16 Display interface of level meter

Warning If the level meter is opened on its first time, it must be calibrated to show the correct level percent.

5.2 Stand Alone Control Software Operation Introduction

5.2.1Software Main Frame

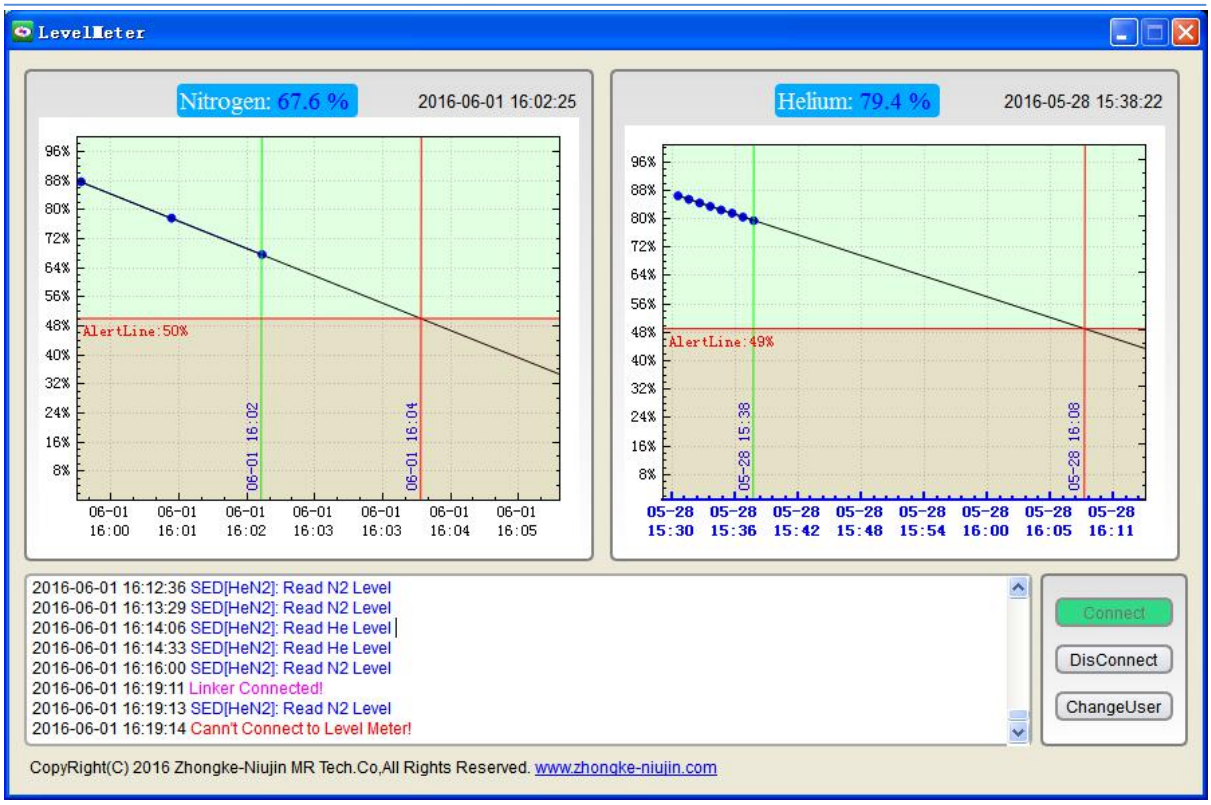


Fig. 17 Main Frame of the control software

On the main frame of the software, the top part is the nitrogen and helium level chart display area, the bottom part shows operation logs, and the bottom right part is the connection and user managing area.

5.2.2 Level Display Area

The chart title shows the latest measure value and time. The chart shows the history data during a period, which is same as user setting in the last time(by default, nitrogen will show the data of a week and helium will show 3 months). There are six kind of traces on a chart and all the graphs can be set only by Admin.

1) Measured level data trace

A series disperse points and lines consisted of measured level values. It shows as a blue color curve by default.

2) Measured capacity or resistance data trace

A series disperse points and lines consisted of measured capacity or resistance value. It shows as a red curve and hides by default.

3) Level trending line

A calculate the trending line according to the data displayed on the chart, it shows as a gray line by default.

4) Alert value line

According to the alert value set by user, the alert line shows as a red line and separates the chart into two parts.

5) Forecast refill line

A forecast refill time is calculated according the crossing point of the trending line and alert line. It shows as a red line and display the refill time beside.

6) The latest measuring trace line

The latest measuring data trace line indicates the latest measuring time and is parallel to the Y axis,it shows as a green line by default.

5.2.3 Device Management

Click 

button to connect the level meter, it will turn to green if connect successfully.

When the software run, it will start to connect the level meter automatically.

5.2.4 Change User

The level meter calibration can be operated only by Admin. Some functions are disabled with the default user Guest. Press 

button to open the user manage window and select Admin to enable calibration function.

5.2.5 Right Click Menu

Right click on nitrogen or helium chart, a right click menu will show as below.

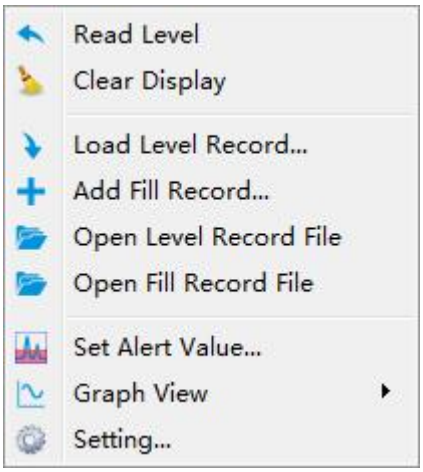
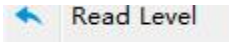


Fig. 18 Right click menu of the chart

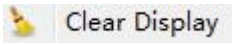
1)  Read nitrogen or helium level after connecting

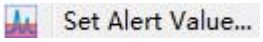
2)  Open the level record operating interface

3)  Open refill record operating interface

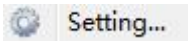
4)  Open refill record file

5)  Open level record file

6)  Clear graph data on the chart

7)  Set alert value

8)  Graph view setting

9)  Open setting interface

5.2.6 Operation on the chart

Zoom in and zoom out

Click the x axis or y axis , wheel mouse to zoom in or zoom out the chart.

Move graph

Click the y axis to move the chart up and down by pressing left button of mouse.

Click the x axis to move the chart left and right by pressing left button of mouse.

Review data

Click on the level trace and then click the target point to check data information.

5.2.7 Read Nitrogen Data and Setting

5.2.7.1 Load nitrogen level record

Right click on the chart and click 

to pop up operation interface.

Fig. 19 Load nitrogen level record interface

1）From：Set the start time to display.

2）To：Set the end time to display.

3）Click 

button to show a graph of the selected level values between start and end time.

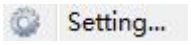
4）Press 

button to open level record file.

5）Press 

button to hide operation interface and return to main frame.

5.2.3.2 Nitrogen Setting

Right click on the nitrogen chart and click 

menu to pop up the setting interface.

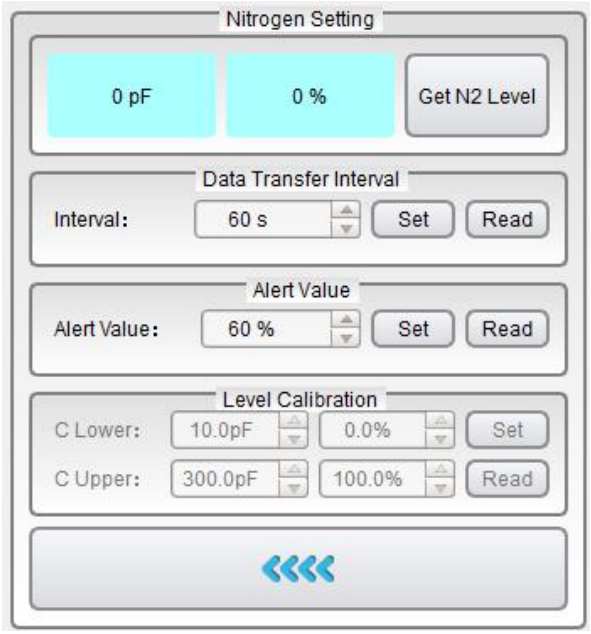


Fig.20 Nitrogen setting interface

1) Read nitrogen level

The latest measured capacity and level value is displayed on the top.

Press 

button to get current nitrogen level from level meter.

2) Transmission interval setting

Interval box: the inputted interval value or value read from level meter.

Press 

button to set a new inputted interval value to level meter.

Press 

button to get interval setting value from level meter.

3) Alert value setting

Alert Value box: the inputted alert value or value read from level meter .

Press 

button to set a new inputted alert value to level meter.

Press 

button to get alert setting value from level meter.

4) Nitrogen calibration

This function is only for Admin

C Lower and C upper boxes: two capacity and percent calibration vales. The capacity can read from selected point on the chart trace, the percent value should be set with an actual value.

Press 

button to set calibration values to level meter.

Press 

button to get calibration values form level meter.

Read more about calibration reference in chapter 6.

5) return

Press  button to hide setting interface and return to main frame.

5.2.4 Read Helium Data and Setting

5.2.4.1 Load Helium Record

Right click on the chart and click 

menu to pop up the operation interface.

Fig.21 Load helium level record operation interface

1）From：Set a start time to display.

2）To：Set a end time to display.

3）Press 

button to show a trace of the level values between the start and end time.

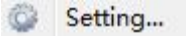
4）Press 

button to open level record file.

5）Press 

button to hide operation interface and return to main frame.

5.2.4.2 Helium Setting

Right click on the chart and click 

menu to pop up setting interface.

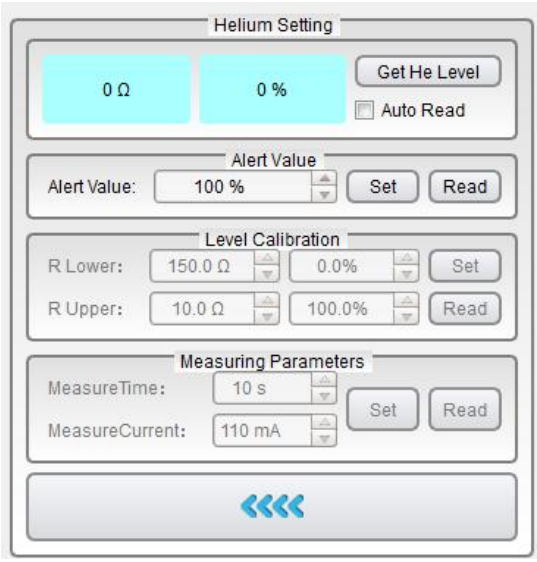


Fig. 22 Helium setting interface

1) Read helium level

The latest measured resistance and level value displays on the top.

Don't check Auto Read and click Get He Level button to measure helium level once.

Check Auto Read and click Get He Level button, it will pop up a dialog for setting measuring interval, and level meter software will send measure command to level meter at a setting interval time. Once you want to stop auto measure, uncheck the Auto Read check box.

2) Alert value setting

Alert Value box:shows the inputted helium alert level value or that read from level meter.

Press Set button to set the new inputted helium alert value to level meter.

Press Read button to get helium alert setting value from level meter.

3) Helium level calibration

This function is only for administrator!

R Lower and R upper box: the two resistances and percents for calibration. The resistances can read from chart trace, and the percent should be set as the actual value.

Press Set button to set inputted calibration values to level meter.

Press Read button to read calibration values form level meter.

Read more calibration reference in chapter 6.

4) Measuring parameters setting

This function is only for administrator.

Measure Time：Current output duration time,1～15s.

Measure Time：Measuring current, 0~120mA.

Press Set button to set inputted helium measuring time and current to level meter.

Press Read button to read helium measuring time and current form level meter.

5) Return

Press «« button to hide setting interface and return to main frame.

5.2.5 Refill Record Interface

Right click on the chart and click + Add Fill Record... menu to pop up refill record operation interface, which is used to record refill information such as time, volume, cost and operator.

Fig.23 Refill record operation interface

N2/He：Select nitrogen or helium.

Date：Refill date.

Volume：Refill volume

Name：Refill operator's name.

Price：Price of per liter nitrogen or helium.

Cost：Total price,it's calculated automatically.

Comment：Any comment information added by user.

Save Record：Click to save refill information.

Open Fill Record：Click to open record fill.

Hide：Click to hide operation interface.

5.3 SpinStudioJ Software Operation Introduction

5.3.1 Open the Level Meter Control Panel

It's recommend to use SpinStudioJ software to read and record the liquid nitrogen and helium level.

Double press the button He: 96.9% N2: 72.3% in the bottom status bar to open the helium and nitrogen control window, as shown in the following figure.

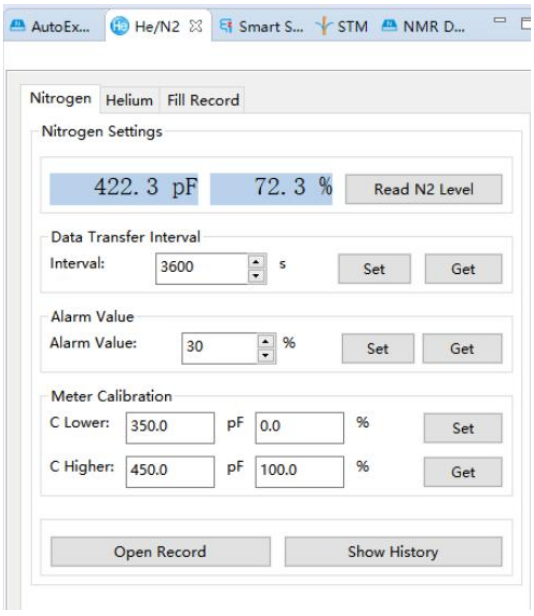
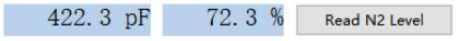


Fig.24 Liquid Helium and Nitrogen Control Window

5.3.2 Nitrogen Control Panel

The "Nitrogen" frame shows the functions of nitrogen measurement, calibration and

record.



：shows the latest measured nitrogen sensor's capacitor value and percentage. Press 

button to read a new data.

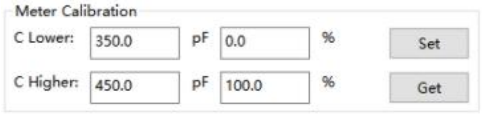
：Fill a new interval time value as expected, press 

button to set the value to the level meter. Press 

button to get the set value from level meter.

Tip: *All setting parameters are saved in the level meter and there is no need to set any parameter after any restart.*

:Used to set and read the alarm level of nitrogen, please set the value according to the specification of the magnet.



：Used to set and read the calibration parameter of nitrogen. Don't modify these values except you understand what the value means. These value can only be set the administrator or magnet engineers. Generally, "C Lower" corresponds to the capacitor value when the nitrogen vessel is nearly empty. "C Higher" corresponds to the capacitor value when the nitrogen vessel is fully filled.

: Press this button to open the history recorded data.

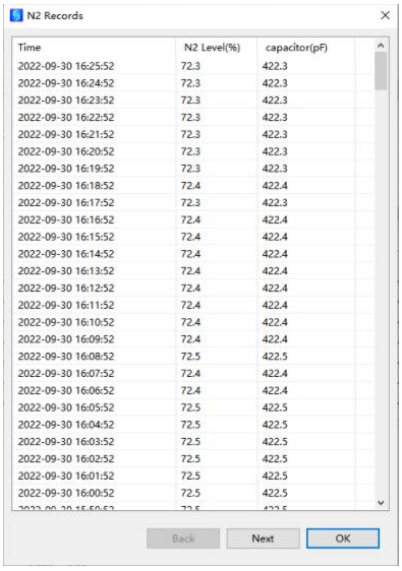


Fig.25 Liquid Nitrogen Measurement History Data

Show History ：Press this button to open the window of Nitrogen and Helium history record curve window. Shown as the following figure.

Fig.26 Liquid Helium and Nitrogen History Window

In the Liquid Helium and Nitrogen History Window, you can use mouse wheel to change the range of time and data value.

5.3.3 Helium Control Panel

The Helium panel provides the functions of helium measurement, alarm level, calibration and measurement parameters.

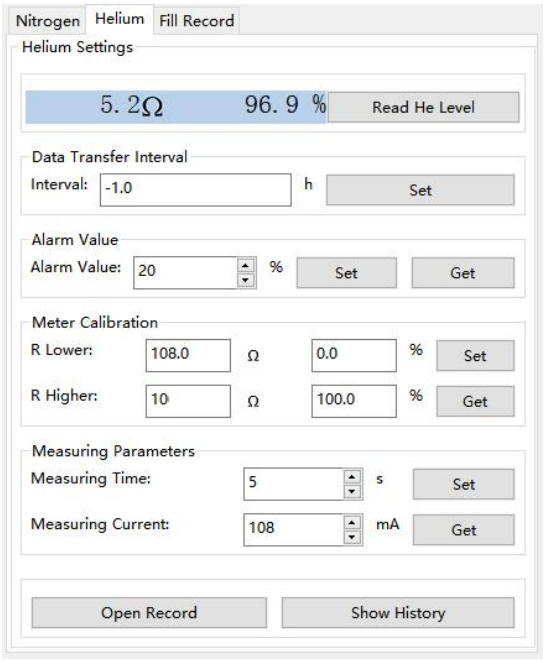
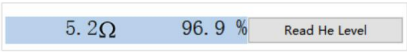
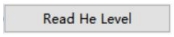


Fig.27 Liquid Helium Control Panel

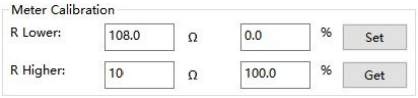


：Shows the latest measured helium probe resistor value and percent value. Press 

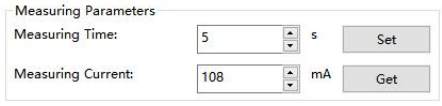
button to read a new helium value.

: Set the automatically read time interval, if a negative value is set, the auto helium read function will be turned off. Set this value as expected if the auto helium measure is needed. It's recommend to set this value not less than 24 hour.

: Set and read the helium alarm level value.



：Set and read the helium probe calibration data. **Don't** modify these values except you understand what the value means. These value can only be set the administrator or magnet engineers. Generally, "R Lower" corresponds to the helium probe resistor value when the helium vessel is fully filled. "R Higher" corresponds to the helium probe resistor value when the helium vessel is nearly empty.



：Set and read the helium measurement parameters. **Don't** modify these values except you understand what the value means. Measuring time controls the current output time when measuring the helium. Measuring current controls the current output. The longer measuring time and larger output current , the more heat will be

produced while measuring and cause more helium loss. Please set these values according the specifications of helium probe. If the helium percent is always read as 100%, please try to increase the output current at first and then increase measuring time.

Open Record: Press this button to open the recorded helium read data.

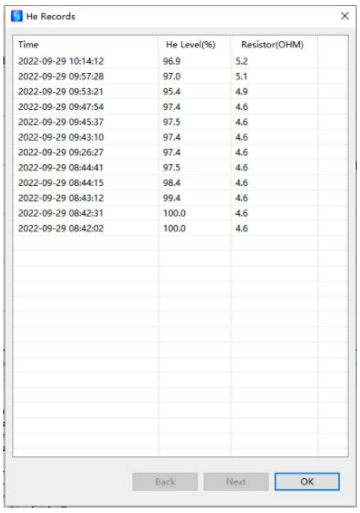


Fig.28 Liquid Helium Measuring Record Data

Show History: Press this button to open the window of Nitrogen and Helium history record curve window. Shown as the following figure.

Fig.29 Liquid Helium and Nitrogen History Window

In the Liquid Helium and Nitrogen History Window, you can use mouse wheel to change the range of time and data value.

6 Calibration

Level meter should be calibrated before working, to suit for different probes and different magnet vessels and get actual percent value. Calibration value is consisted of two group parameters vary between 0% and 100%.

Note that the 0% point is normally not so accurate for either nitrogen or helium probes. and the 100% point is more accurate.

6.1 Nitrogen Calibration

6.1.1 Nitrogen Calibration on Magnet Initial Installation

The calibration should have a more accurate parameters when level meter is installed and calibrated before filling nitrogen and helium.

1) Install level meter.

2) Turn on level meter and run control software before filling nitrogen and helium.

3) Read a capacity value when nitrogen starts to collect during cooling down and set it as the initial 0% point value.

4) Fill nitrogen until vessel is full.

5) Read a capacity value and set it as the 100% point value.

6.1.2 Nitrogen Calibration on In-use Magnet

1）Measure a level height using a detect pole before refill nitrogen, convert it as percent value according the magnet datasheet.

2）Read the current capacity value of the probe in software, set the capacity and converted percent as the lower calibration group.

3）When nitrogen refill completed, read another capacity value and set it as the upper calibration group, fill the percent with 100%.

4）Click 

button to send calibration values to level meter. Level meter automatically remembers the settings and returns the recalculated level value.

6.2 Helium Calibration

6.2.1 Helium Calibration in Magnet Initial Installation

1) Install level meter, turn it on and run the control software

2) Read a resistance value when liquid helium starts to collect and mark the resistance as R_L.

3) Fill helium until vessel is full, and then read the resistance value as R_u.

4) Set R_L as the initial 0% point and R_u as the full 100%point.

5) Click 

to set the calibration value.

3.2.3 Helium Calibration on In-use Magnet

1）Measure a level value using a detect pole before refill helium, and convert it as percent value P, according magnet datasheet.

2）Read current resistance of probe in software as R_L,

3）Refill helium fill until full, wait 10 minutes, then read another resistance Ru.

4）Set Ru as the 100%point and R_L as the P% point.

5）Click 

button to send calibration values to level meter. Level meter automatically remembers the settings and sends back the recalculated level value.

7 FAQ

1) Q：The software shut down directly at start.

A： The USBCAN driver was not installed successfully, please install it again and retry. See section 4.2.1.

2) Q：Level value shows 0%

A： Check all the connector and wire connecting to probes, and make sure no loosening happened. If no causes found , contact WMR.

3) Q：Level value shows above 100%.

A：It is normal, the real level may pass the calibrated top level when refilling.

4) Q：Level value shows up and down

A： It is normal the probe changed unstably when measure after refilling. If it always happened, contact WMR.

5) Q：The data displayed on the touchscreen is marked in red

A：It indicates that level is above the alert level and need to refill cryogenic.

If the error can not be solved, shut down the power supply of the level meter and contact Q.One.