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SMAGALL
MEASURING EQUIPMENT CO.,LTD

HS-2000 External Ultrasonic Liquid Level Meter

Manual

Executive Standard: Q/XHS 001-2015

Version: V2.0

Xi'an Huashun Measuring Equipment Co.,Ltd.

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1. Introduction

The intelligent external ultrasonic liquid level meter (hereinafter referred to as “liquid level meter” or “meter”) utilizes advanced signal processing technology and a high-speed signal processing chip. Its signal penetrates the wall of the tank and ultimately achieves completely non-contact measurement of liquid height in hermetic tanks. The ultrasonic sensor (probe) is installed at the bottom of the tank’s external surface without the need for drilled holes in the tank. This allows for quick, simple installation that does not interrupt the tank’s operation. Because of the non-intrusive nature, the meter can be used to acquire accurate liquid level measurements for high-pressure hermetical tanks containing toxic, highly acidic or alkaline, and various types of pure liquids. The liquid level meter has no special requirements related to the material of the tank, and it is explosion proof as designed. Its robust, engineered design allows it to be used in a wide variety of applications and conditions.

2. Features

- **Non-Contact Liquid Level Measurement**

The ultrasonic sensor (probe) is designed to be installed on an external surface of a tank wall without the need to drill holes on the measured tank.

- **Self-Calibration**

This function eliminates accuracy loss due to long term usage.

- **Infrared Debugging During Operation**

This function is especially suitable for conditions where it is dangerous to open the meter cover to debug, making the debugging process simple.

- **Self-Test**

The liquid level meter can self-test its own operating status and hardware conditions, ensuring reliability and stability.

- **One-Key Recovery**

If the liquid level meter is not functioning properly, the user can press the one-key recovery button on the remote control to allow the liquid level meter to return to normal working condition.

- **On-Site Display and Remote Transmitting**

The liquid level meter can not only display data on site, but also transmit data to a control room located away from the site via signal wire.

3. Working Principle

The system kernel of the liquid level meter is based on special ultrasonic processing technology capable of high-speed digital signal processing. After processing, the liquid volume percentage value is precise enough that additional CPU analyzing, comparing or judging is unnecessary. Once the CPU acquires the liquid level value, the value is transmitted directly to NVRAM for storage and display. In addition, the liquid level meter can output a 4 ~ 20mA standard signal or transmit measurement results to a computer (or secondary meter) via an RS-485 interface.

As shown in Fig. 3-1, during the process of measuring liquid volume percentage, the modulated acoustic signal is transmitted from the probe and echoed from the liquid surface. The probe then detects the echoed signal. After going through preprocessing, processing and post-processing, this signal provides the accurate time t directly. The CPU then calculates the liquid level height value through a mathematical model.

$$h = act/2$$

h: Liquid level height

a: Correction factor

c: Ultrasound transmitting velocity in liquid

t: Time duration between transmission and reception of ultrasound signal

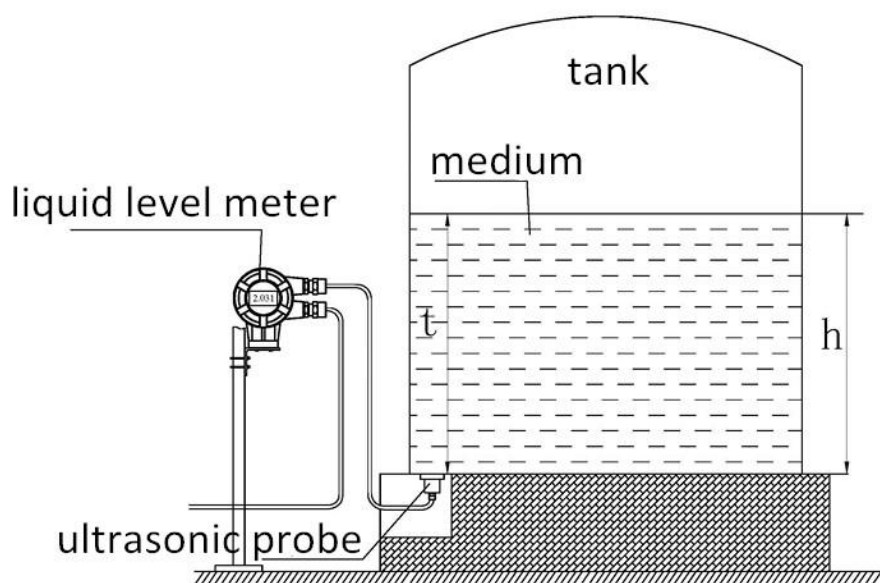


Fig. 3-1 Working principle of liquid level meter

4. Parameters

Measuring range	3m, 5m, 10m, 20m, 30m
Display resolution	1mm
Short time repetition	1mm
Measurement error	$\pm 1\%FS$ (Excessive wall thickness and temperature/pressure instability may affect measurement precision.)
Span shift	± 10 m
Current output	4~20mA, Max load 750 Ω
Communication interface	RS-485, IrDA
Operating ambient temperature for liquid level meter	-30 $^{\circ}C$ ~+70 $^{\circ}C$

Operating ambient temperature for ultrasonic probe	-50℃～+100℃ (A probe with wider temperature range can be provided upon request)
Operating ambient humidity	15%～100%RH
Explosion proof mark	Ex d II C T6 Gb
Housing ingress protection	IP 67
Volume percentage display	4 digit OLED display
Blind area	There is a blind area for the liquid level meter

5. Application Requirement

5.1 Medium Purity Degree

- Liquids should not contain dense foam
- There should be minimal suspended objects in the liquid, such as crystallized particles, etc.
- There should be minimal precipitation in the tank, such as mud, sand and so on.

5.2 Viscosity of Medium

When the dynamic viscosity is less than 10mPa•S, the meter can operate normally. If the dynamic viscosity is between 10mPa•S and 30mPa•S, the measuring range of the meter may decrease, and the meter will not work if the dynamic viscosity is above 30mPa•S.

Note:An increase in temperature will result in a decrease in viscosity. Since temperature variation has a more obvious effect on most liquids with high viscosity, liquid temperature should be considered when measuring a high viscosity liquid.

5.3 Requirements for the Measured Tank

- **Material:** The tank wall where the probe is to be installed should be made of a hard material that can transmit a signal well. Typical tank materials include carbon steel, stainless steel, various hard metals, glass fiber-reinforced plastics, epikote, rigid plastics, ceramics, glass,

ebonite and other composite materials. Both the internal and external surface of the installation area on the tank wall should be smooth. If the tank wall is made of multiple layers of different materials, the inner layers should be compact and be absent of bubbles or air. Typical multi-layer structures are: lining of vulcanized ebonite, epikote, stainless steel and titanium, for example.

- Tank wall thickness: 2~70mm
- Tank type: spherical, horizontal, vertical, etc.

6. Meter Structure

6.1 Meter Dimensions (mm)

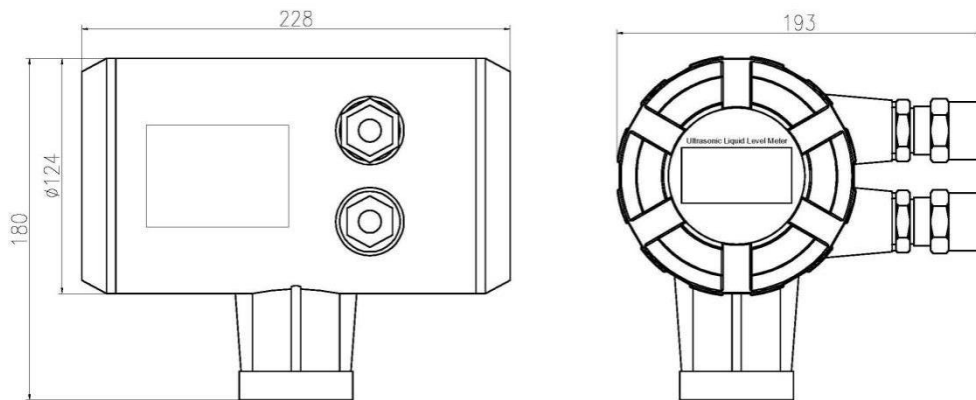


Fig.6-1 Meter Appearance

6.2 Probe and Suction Cup Components

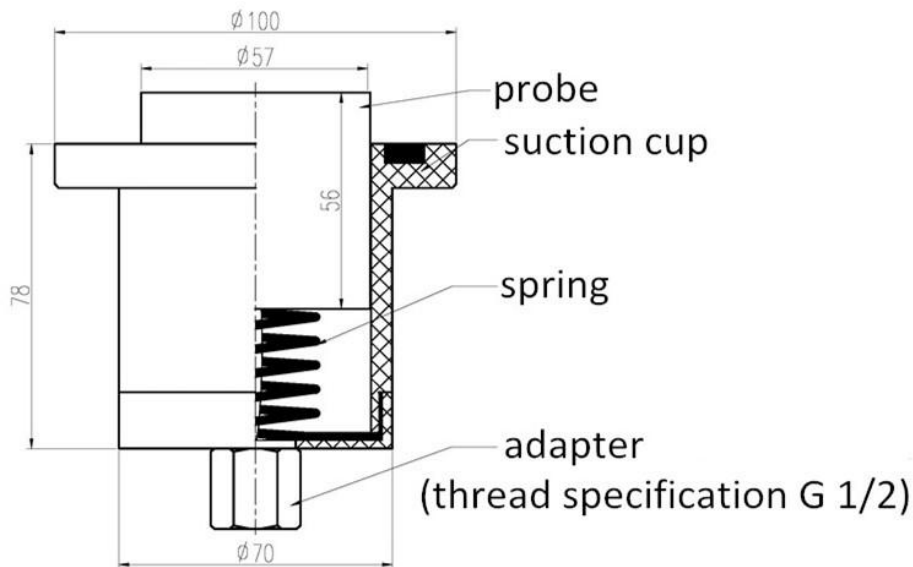


Fig.6-2 Appearance of Probe and Suction Cup Components

7. Installation Guide

7.1 Meter Installation

7.1.1 Meter Installation Requirement

- The meter should be installed in a shaded area away from direct exposure to sunlight to ensure the display screen is not exposed directly for long periods.
- If the meter is operating in a cold area (under -20°C), it is suggested to apply insulation measures(e.g. insulating layer or heating device) to prevent negative influence on the meter from significantly low temperatures.

7.1.2 Meter Installation Procedures

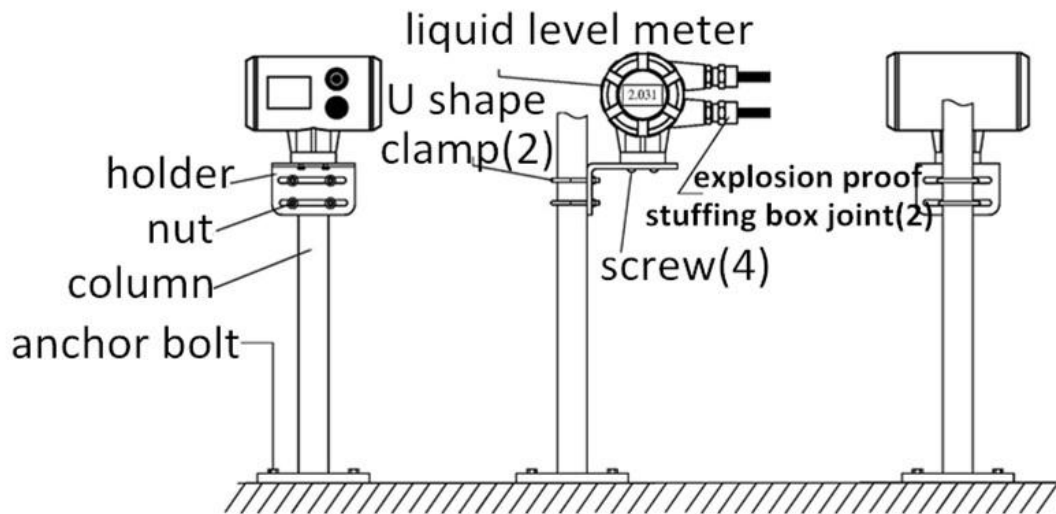


Fig.7-1 Meter Installation

- ① According to meter installation requirements and real site operation conditions, select a proper location in the tank farm. Users should prepare a cylindrical column with a 60mm diameter (standard U shape clamp matches with tube with 60 diameter) and fix the device with an anchor bolt in the desired area on the ground.
- ② Fix the standard meter holder and two U-shape clamps on the cylindrical column at a proper height (see Fig. 7-1).
- ③ After installing ultrasonic probe, connect the power wire, probe cable and signal output line with their corresponding terminals on the back side of the meter. Fill and seal the explosion proof stuffing box joint in the electrical interface of the meter according to installation requirements of the provided explosion proof mortar.
- ④ Tightly fix the back cover of the meter to complete liquid level meter installation.

Appendix: Installation of Explosion Proof Stuffing Box Joint

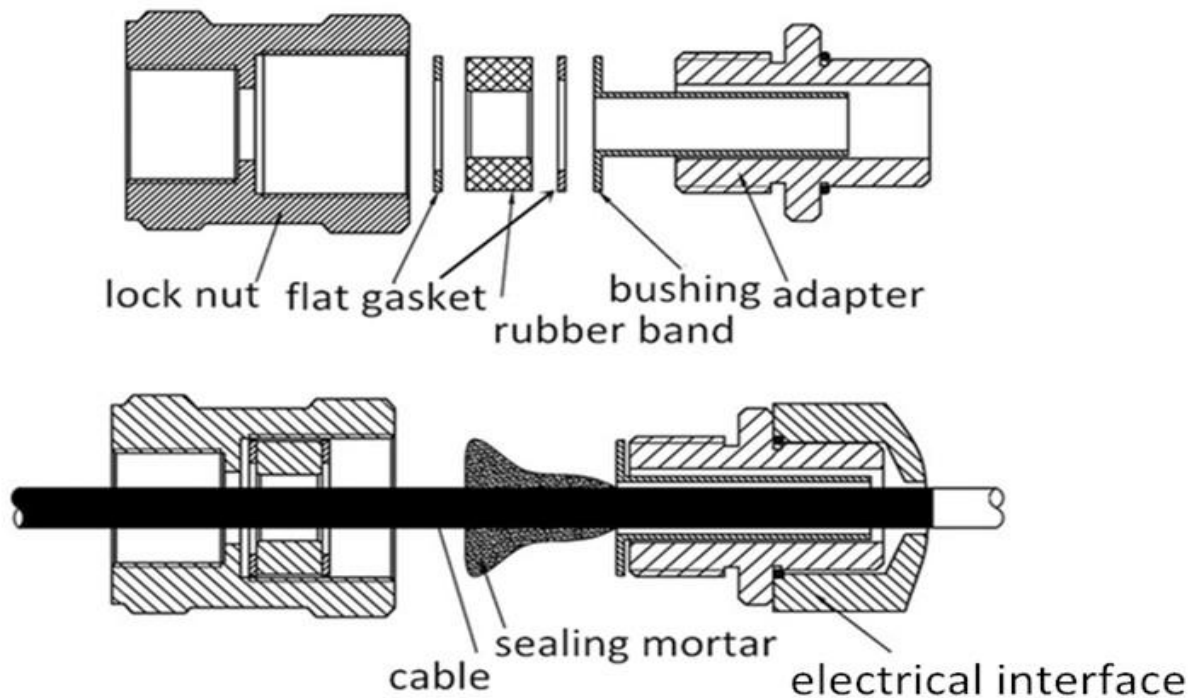


Fig. 7-2 Installation of Explosion Proof Stuffing Box Joint

- Disassemble explosion proof stuffing box joint and prepare explosion proof
- Use the following order of the spare parts to cross cable (starting from the point away from liquid level meter) :
lock nut→flat gasket→rubber band→ flat gasket→ bushing→adapter (screw it tightly in electrical interface beforehand and thread cable. Reserved cable length inside meter housing is 30mm);
- Apply explosion proof mortar. Be sure to press enough explosion proof mortar into the shape shown in Fig.7-2; then stuff into the interval between bushing inside and cable.
- Tightly screw the lock nut. Press explosion proof mortar completely into the nut to complete the installation of the explosion proof stuffing box joint.

7.2 Ultrasonic Probe Installation

7.2.1 Probe Installation Requirements

- The installation area on the tank wall should be circular, with a diameter no less than 100mm, surface roughness of at least 1.6 and a gradient be less than 3° (except the by-pass pipe).
- The surface used for probe installation should be clean and smooth. Ensure there is no slag, paint stain or other block so that the probe can contact properly and tightly without impacting the measurement.
- Apply coupling agent on the sensing surface of the probe and the installation surface of the tank to ensure smooth transmission of ultrasonic signal.
- The direction of the measuring probe should be perpendicular to the liquid surface.
- There should be no obstacles, such as a stirring machine or coils, located in front of the probe.
- The installation surface should be located away from any liquid inlets or outlets, including any sewage outlet on the bottom. This helps to avoid negative influence on measurement caused by turbulent liquid flow.
- If there is an insulation layer on the tank's external surface, any installation layer in excess of 250x250mm should be removed in the installation area.
- For tanks made of ferromagnetic material, the probe can be attached on the external bottom of the tank with a magnetic suction cup, as shown in Fig. 7-3-A. If the tank shell is made of glass, stainless steel or other similar materials, glue or supporter can be used to fix the probe on the external bottom of tank, as shown in Fig. 7-3-B.

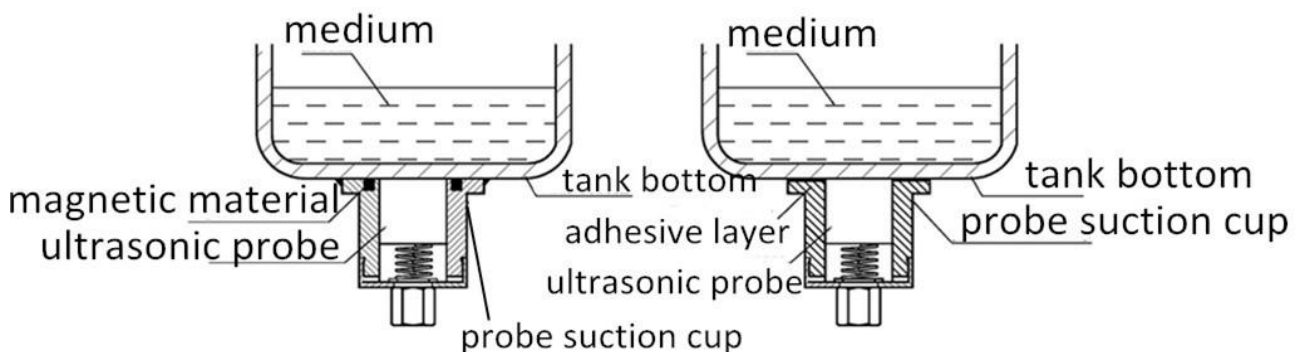


Fig.7-3-A

Fig.7-3-B

7.2.2 Detailed Requirements

A. Installation Requirements of Horizontal Tank

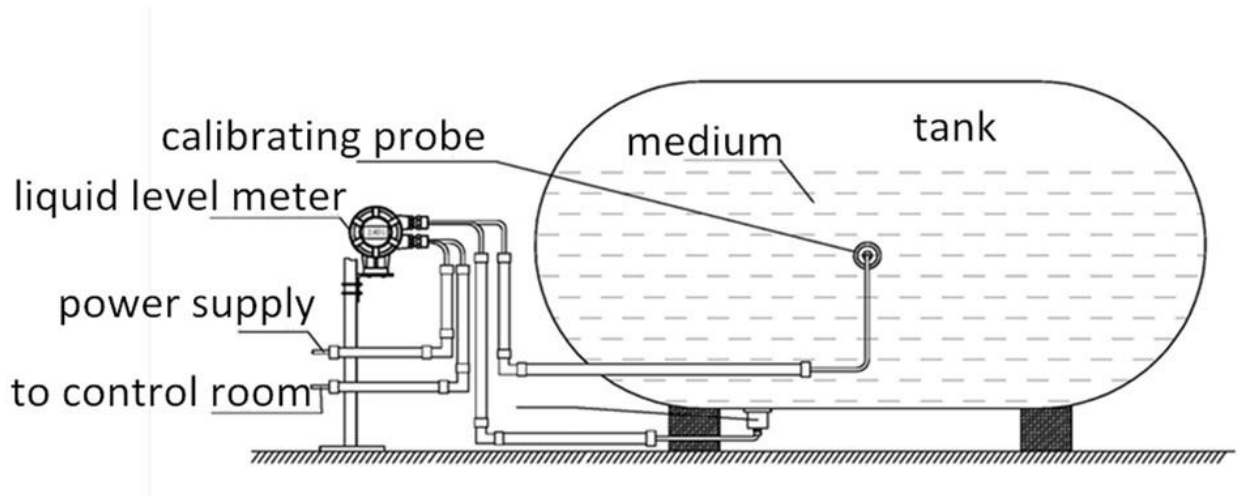


Fig.7-4 Ultrasonic Probe Installation on Horizontal Tank

- The measuring probe is installed on the bottom external surface of the tank, and the calibrating probe is installed at the midway point of the height and length.
- It is better to install the measuring probe of the meter at the lowest point of the bottom of the tank, and it should be perpendicular to the liquid surface. The calibrating probe should be installed at the midpoint of the height and length (See Fig. 7-4).

B. Spherical Tank Installation Requirements

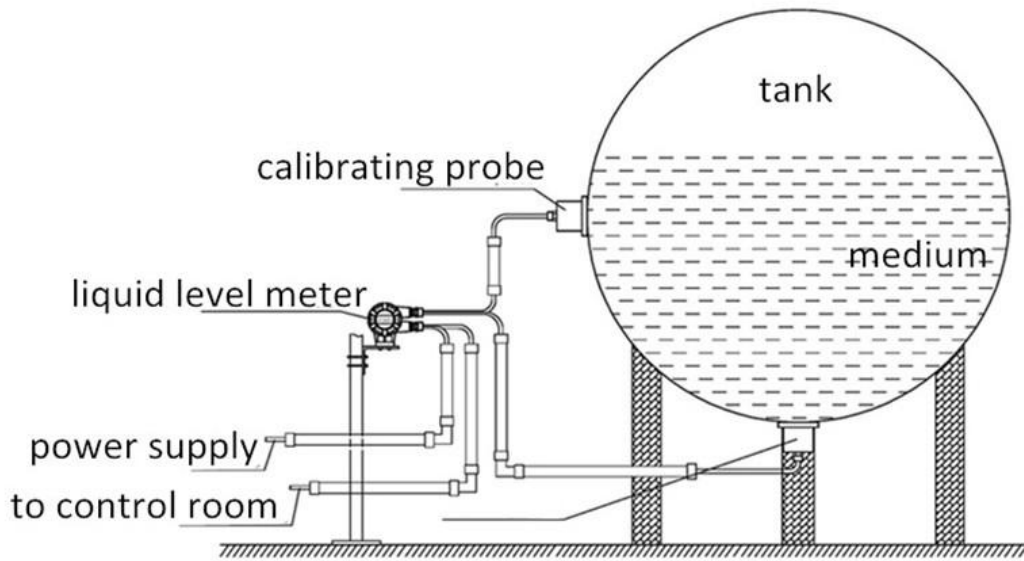


Fig.7-5 Ultrasonic Probe

- The measuring probe should be located close to the manhole on the external bottom surface of the tank, and the calibrating probe should be installed on the equator line of the spherical tank (near a winding ladder for easy operation and maintenance).

C. Vertical Tank Installation Requirements

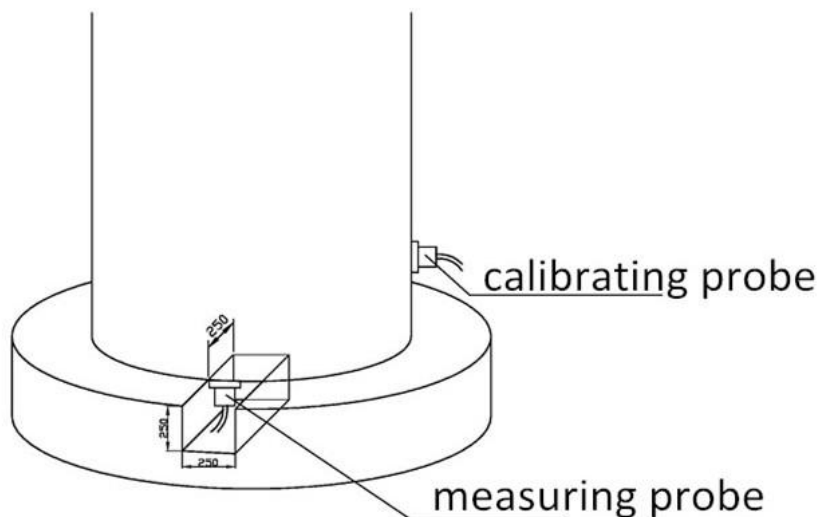


Fig. 7-6 Slot in Vertical Tank

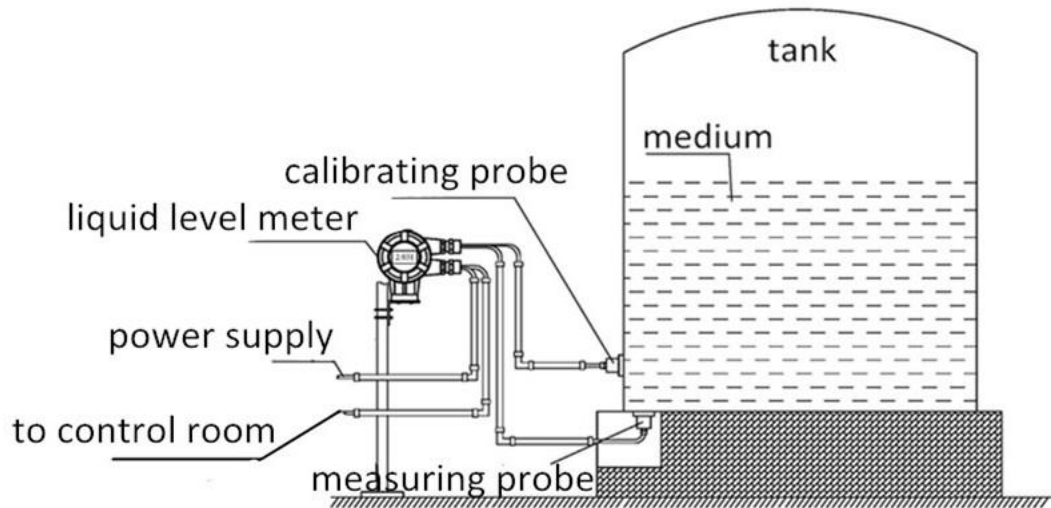


Fig.7-7 Ultrasonic Probe Installation on Vertical Tank

- Normally, there is a cement base that serves as pedestal for installation on vertical tank. It is recommended to leave space on the pedestal to install the measuring probe. (The suggested dimension is 250x250mm).
- The measuring probe should be installed on the external surface on the bottom of the tank, and the calibrating probe should be installed on an external surface of the tank's side wall. The calibrating probe should be 0.5-1m away from ground.

8. Electrical Connection

8.1 Meter Power

	Max.	Typical	Min.	Unit
DCV	30	24	18	V
	Transient (Power on)		Normal Operating	
Current	0.5		0.25	A
Power			10	W

8.2 Wiring of the Liquid Level Meter

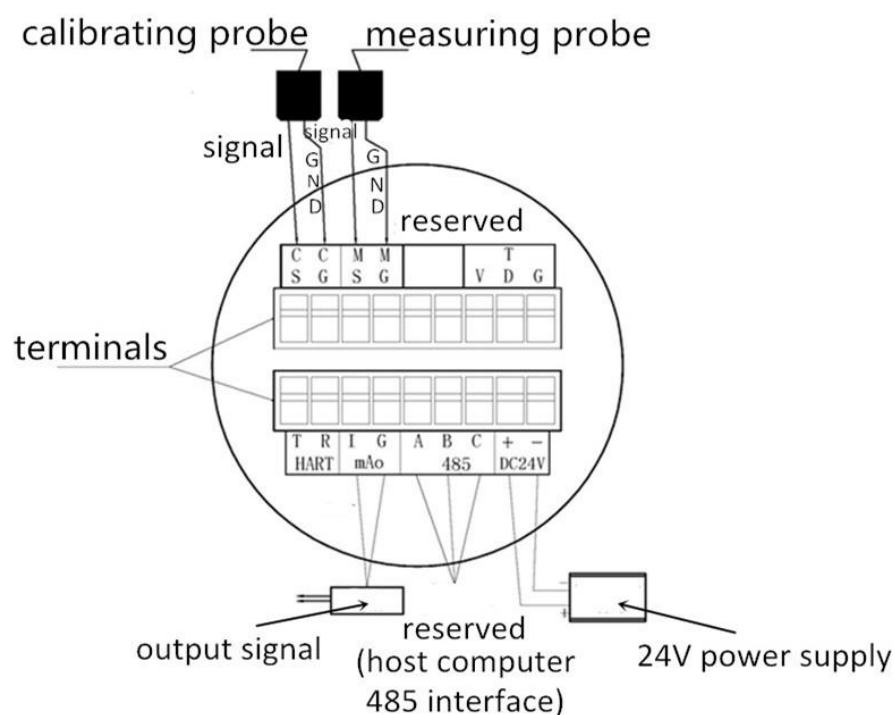


Fig.8-1 Meter Wire Connection

8.3 Description of the Liquid Level Meter's Wiring Terminal

Sign	Connection	Indication
CS	Calibrating probe	Signal
CG		GND
MS	Measuring probe	Signal
MG		GND
		Reserved
I	Current Output Signal	Current Output Signal
G		GND
A	Host computer (RS485)	RS485 +
B		RS485 -
C		GND
IN+	Power supply (24V)	Positive
IN-		Negative

9. Operating Procedure

- Check whether the surface of the liquid level meter is intact and verify the glass display window has not fractured.
- Install liquid level meter (See chapter 7) and arrange wiring on site (power supply and signal output);
- Install ultrasonic probe of liquid level meter (see chapter 7);
- Connect the wire. **Note: Liquid level meter shell requires reliable grounding.**
- Check if the front and back covers of the liquid level meter are loose and, before using tools, fasten bolts located on the front and back cover and wiring ports to ensure reliable performance of the explosion proof function.
- Connect the meter to the power source. The device will then move through a self-test process and automatically enter its measure-and-display status, in which the liquid level meter measures continuously in real-time. Users can read the liquid volume percentage directly on the meter's OLED screen.

10. Debugging

10.1 Function Code Format

- The function code consists of two parts: the function name and function value. The function name refers to the name of the function, such as Measuring Range Setting. Function value describes the parameter of the function. For example, in the Measuring Range Setting, function value refers to the measuring range.
- Pressing the enter button separates function name and function value. The corresponding button on the remote control is "200+".
- Normally, a function name has 3 digits. For example, 202 indicates Measuring Range Setting. The function value varies according to variation of real conditions.

10.2 Example of Function Code (“_” means the enter button 200+)

Function code “ 202_3000_ ” means the setting measuring range is set to 3m, which refers to pressing 9 buttons on the remote control: 2,0,2, 200+, 3,0,0,0, 200+.

10.3 Enter or Exit from Function Code Setting

In normal working status of liquid level meter, press the button 200+ twice continuously on remote control towards receiver on screen. Then the OLED screen of meter will display *Please input function code!*. User can input function code now. If the input function code is valid, after the button 200+ is pressed, the meter will go back to normal measuring mode automatically. If user wants to exit, the button 100+ can be pressed.

10.4 Error Indication During Function Code Setting

- If the user inputs an incorrect data format (letters for example), after the button 200+ is pressed, an error will be displayed: *Your input is wrong!* This will be displayed on the meter's OLED screen.
- If a function name is entered but a function value is not, after the button 200+ is pressed, the following error is indicated on the OLED screen: *Please input a function value!*
- When a nonexistent function name is entered, after the button 200+ is pressed, the following error is indicated on the OLED screen: *This function code does not exist!*

10.5 Function Code Table

Note: Main probe means measuring probe.
Auxiliary probe means calibrating probe.

Function Code	Meaning	Example&Remark
002	Main frequency	002_166000_ The default working frequency of measuring

		probe is 166000Hz, range: 140000 Hz ~250000 Hz。
003	Main blind start	003_600_ Bind area is the liquid height which can not be measured. The unit here is samples, not mm. The default of blind area starting point of measuring probe is 600,range: 300~4000。
007	Main gain 1	007_1_ The default of Gain 1 of the measuring probe is 1, range:0~100.
008	Main gain 2	008_1500_ The default of Gain 2 of the measuring probe is 1500, range: 10~4000.
102	Auxil frequency	002_166000_ Default working frequency of the auxiliary probe is 166000 Hz,range: 140000 Hz ~250000 Hz.
103	Auxil blind start	003_600_ Default blind area starting point of the auxiliary probe is 600, range: 300~4000. Unit: samples
107	Auxil gain 1	007_1_ The default of Gain 1 of the auxiliary probe is 1, range 0~100.
108	Auxil gain 2	008_1500_ The default of Gain 2 of the auxiliary probe is 1500, range 10~4000.
208	Cal distance	208_200_ Default calibration distance is 200mm,range 100mm~30000mm.
209	Calibrate period	209_600_ Default calibration period is 600s, range:

		6s~7200s.
210	Probe height	210_1_ Default auxiliary probe height is 1mm, range: 1mm~30000mm.
251	Device ID	251_1_ The default device ID is 1, range:1~255.
252	Tank Radius:mm	252_1675_ Set radius value of horizontal tank. Default: 1675mm.
253	Tank Length:mm	253_10587_ Set length value of horizontal tank. Default: 10587mm.
254	Sphere Radius:mm	254_1655_ Set max radius of spherical head or elliptical head of horizontal tank. Default: 1655mm.
901	Intellige Repair	901_any digit_ (Start intelligent repair. Normally enacted by users.) When users find liquid level meter cannot measure properly, this function can be used.)
902	Reset	902_any digit_ Restart liquid level meter

10.6 Horizontal Tank Volume and Communication Parameters Setting and Debugging

- Function code 252_1675_ sets the radius value R of the measured horizontal tank. For horizontal tanks, $D=2R$. Default is 1675mm.
- Function code 253_10587_ sets the length L of the measured horizontal tank. L does not include either spherical heads or elliptical heads. Default is 10587mm.
- Function code 254_1655_ sets the maximum radius C of the spherical head or elliptical head in

measured horizontal tank. Default is 1655mm.

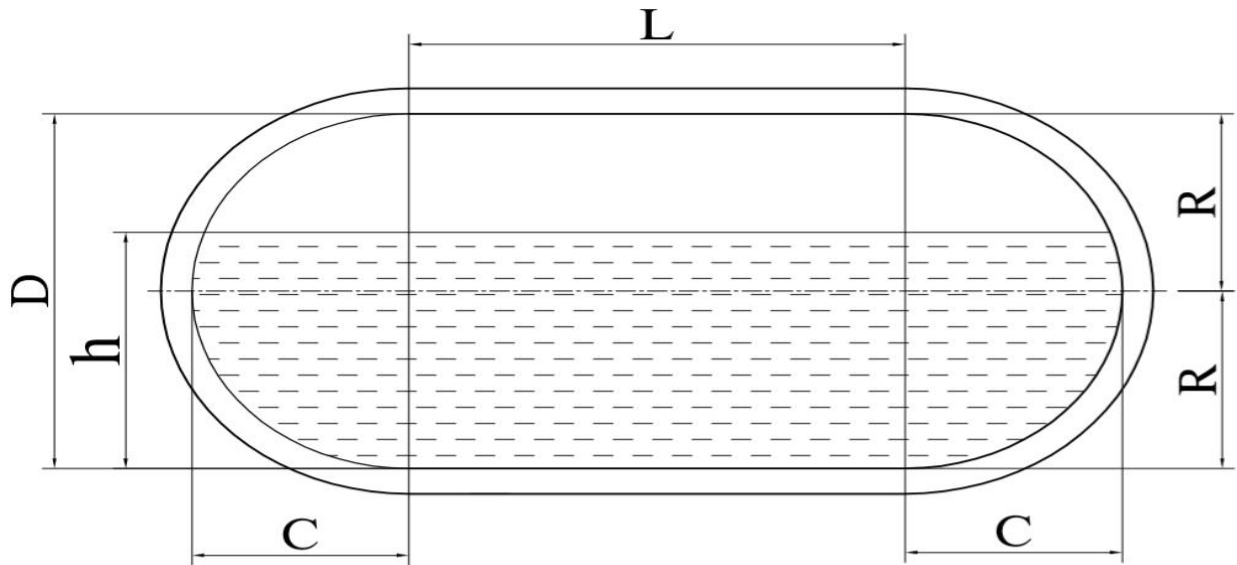


Fig.10-1 Volume Calculation Parameters in Horizontal Tank Structure

11. Error Analysis and Solution

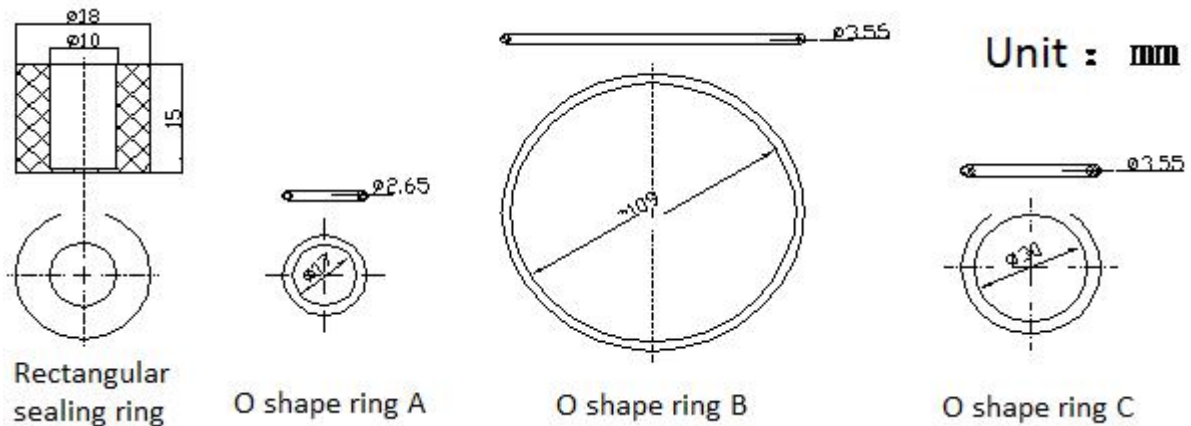
Error Description	Analysis	Solution
After connecting meter to power, there is no action (no display, no light, no sound)	① The power supply is not connected properly.	Check and reconnect power supply properly.
	② The positive and negative poles of the power supply are reversed.	Correct the wiring.
	③ The Power module is damaged	Change the entire circuit board on which the damaged power module is mounted.
	④ Power is not enough.	Inspect and solve the problem of power supply.
	⑤ Circuit boards do not connect with each other when being assembled.	Reassemble circuit boards inside meter.
	⑥ Voltage is not correct.	Provide DC 24V power supply.
5 L are displayed in screen	① Current liquid level is in blind area.	As the liquid level rises, it will be normal automatically.
	② Blind area value by setting is smaller than the one by auto searching.	Reset blind area value.
	③ Wire connection of ultrasonic probe is not proper.	Connect wire again.
	④ Probe is damaged.	Change probe.
After self-test, the screen freezes and can not enter measuring mode.	① The meter has not been initialized.	Send back to factory for initialization.
	② Initialization parameters have been modified abnormally.	
	③ CPU board breakdown	Send back to factory to replace CPU board.
Measurement result is generally correct but fluctuates significantly.	① Liquid level fluctuates significantly.	a. Keep liquid level calm b. Increase meter's damping

Error Description	Analysis	Solution
	② Connection of ultrasonic probe cable is loose, meaning it cannot connect properly.	Replace ultrasonic probe cable
	③ Initialization parameters are incorrect.	Reinitialize
	④ Parameters are not set properly.	Reset parameters.
Measurement result is generally stable, but incorrect.	① Incorrect initialization parameters.	Reinitialize.
	② There may be baffle or pipes in tank.	Move ultrasonic probe away from baffle or pipes.
Measurement result fluctuates irregularly.	① Ultrasonic probe is damaged.	Replace ultrasonic probe
	② The ultrasonic probe cable connection is loose, so it cannot connect properly.	Replace ultrasonic probe cable
	③ Receiving/Transmitting circuit board failure.	Replace receiving / transmitting processing circuit board
	④ Digital circuit board failure	Replace digital processing circuit board
The volume percentage in display is many times more than the real percentage.	Main echo is weak.	Install probe again or reset parameters.

12. Maintenance

- Keep meter clean and away from water, damp, corrosion and potential collision with other objects.
- If meter is installed outdoors, it should be kept away from direct sunshine and other heat sources, and the environment should be ventilated. If ambient temperature exceeds the rated range, corresponding protection measures should be taken to reduce device temperature.

- If the ambient temperature is too low, the meter protection box or other protection equipment can be used as protection. Additionally, the meter should be kept dry.
- Both the meter and the probe should be inspected regularly. (Inspection frequency should be determined by users according to the actual operating circumstances.)
- Vulnerable parts (rubber sealing ring) should be replaced regularly.



13. Cautions and Warnings

- When the extension wire of the meter requires branching or other connection, the explosion-proof junction box with explosion-proof certificate must be used (the box must have an Ex mark). If there are surplus ports in the explosion-proof junction box, to ensure protection, the user must use the sealing tools which strictly matches the model of junction box to seal the ports.
- The ambient temperature range for the meter is $-30^{\circ}\text{C} \sim +70^{\circ}\text{C}$. If the temperature of the measured medium exceeds the specified range, measures must be taken for protection.
- The installation position of meter should be kept away from the influence of heat source.
- The user must not replace any internal components of the meter randomly. DO NOT OPEN METER COVER WITH POWER ON IN HAZARDOUS AREAS (EXPLOSIVE GAS ENVIRONMENT!)
- During installation, operation and maintenance of the meter, users must comply with this manual and related regulation in GB3836.15-2010, part 15 of *Application of Electrical Equipment in Explosive Gas Environment: Electrical Equipment Installation in Hazardous Place*.

14. Transportation and Storage

- The meter should be stored in a dry and ventilated environment with an ambient temperature between 0℃ and 40℃, and humidity less than 80%.
- During transportation and storage of the meter, extra attention should be paid to avoid collision, moisture, and contact with corrosive substances.

15. Inspection

When opening the liquid level meter carton for the first time, please check the following items:

- Verify the name, model and other contents on nameplate are correct;
- Verify there are no cracks or broken parts on the shell and the glass speculation cover;
- Verify contents in carton are complete according to packing list.



Made in Shaanxi No. 01000231



Approval Certification of Measuring Instrument Pattern



Explosion Proof Certification for Meter



Explosion Proof Certification for Probe

Executive standard: Q/XHS 001-2015

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