LM7000
Ultrasonic Level Meter

APRIL 2019

Contents

About this Manual

This manual provides important information about the installation, wiring, operation, and control of LM7000. Please read this manual before installing or operating the product. In addition to operating the product, this manual is very important. Please keep it in a safe place for easy reference.

Please note that the contents of this manual are subject to change without prior notice if the product is modified, upgraded or improved.

Although we have checked all contents of this manual but there would be the possibility to remain errors. Therefore the contents of this manual are regularly updated. We welcome all suggestions for improvement.

II. PRODUCT

The LM7000 is an ultrasonic non-contracting level meter which will increase the effectiveness of your liquid management process. It is available to connect up to two sensors. Depending on the sensor, the measurement range is 33 feet or 50 feet. S330 is 33 foot sensor. S500 is 50 foot sensor.

The sensor cable can be extended up to 1000 feet. The friendly user interface offers the user easy installation and calibration. It is also simple and inexpensive to maintain. All functions are optimized which enables you to effectively monitor the liquid level and keep your facilities running safely and reliably.

Application:
Suitable for liquids level monitoring in all industries, particularly in the water and wastewater industry.

- Depending on the sensor material, the application can be restricted. Before installing the sensor, please check the chemical compatibility chart.

1. Principle of operation

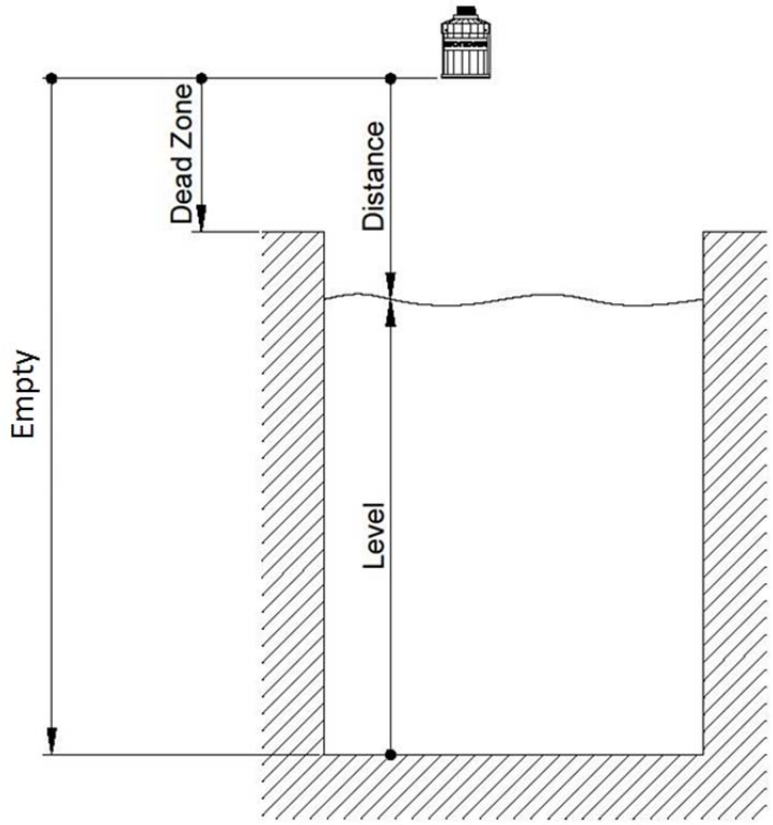
The sensor transmits ultrasonic pulses to the measurement target.
The pulses are reflected from the surface of the target and received back by the sensor. The running time is converted into the distance and it shows as level or volume on the display.

D=(C•T)/2

D: DISTANCE

C: SOUND VELOCITY

T: TIME OF FLIGHT



- Distance: from the sensor bottom to surface of the target
- Level: from the bottom of storage to surface of the target
- Empty: from the sensor bottom to the bottom of storage

2. Specification

LM7000 CONTROLLER	
Measurement	Ultrasonic non-contacting
Accuracy	0.2% of F.S
Resolution	1mm
Damping Rate	0.1m/min - 100m/min adjustable
Output Analog	Analog 4~ 20mA,max 750Ω isolated
	Relay 3 ea or 6 ea
	Digital RS232, RS485, Modbus
Display	Illuminated Graphic LCD
IP Rating	IP65
Temperature	-20℃~ 60℃(-4°F~ 140°F), 80% relative humidity
Material	Polycarbonate
Dimension	166(W)× 250(H)x95(D) mm
Weight	ca. 2kg
Power Supply	• 100~ 230V AC± 15%, 50/60Hz, 29VA(12W) Fuse: 250V T1.0A • DC 9~ 30V, Max 8W

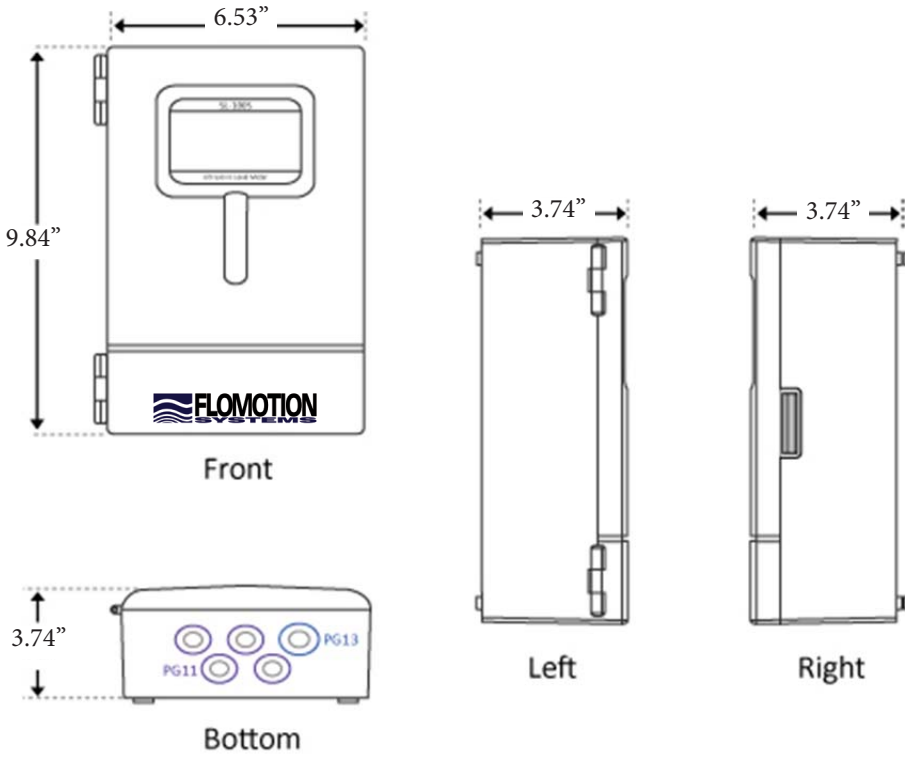
S330 (LXD-10) & S500 (LXD-15) SENSOR	
Range	0.3~ 5m (0.98- 16.4ft), LXD-05
	0.3~ 10m (0.98- 32.8ft), LXD-10
	0.3~ 15m (0.98- 49.2ft), LXD-15
Bean Angle	10°at -3dB
Process Connection	1" PF
Weight	1.5kg - 2.0kg
Material	PP, PVDF
Temperature	-30℃~ 70℃ (-22°F~ 158°F), 80% relative humidity
Temperature Compensation by a built-in temperature sensor	
IP Rating	IP68
Cable	2 Core Shield (AWG18)
Cable Extension	up to 360m (1,181ft)

External Temperature Sensor	
Type	NTC, 10 kΩ
Temperature	-30℃~70℃ (-22°F~158°F)
Process Connection	1/8" PT
IP Rating	IP68
Cable	RG174

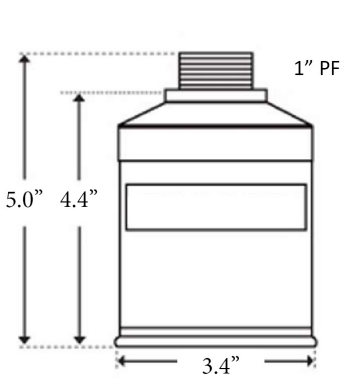
* The Specification is subject to change without prior notice.

3. Dimensions

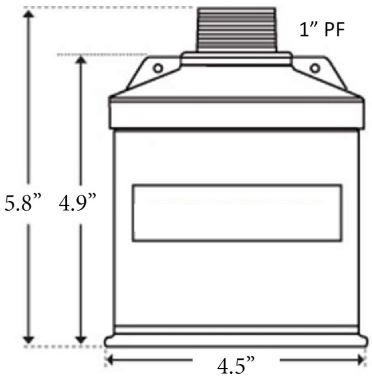
1) The enclosure material is polycarbonate and the protection grade is IP65.
2) Using the whole in the back of the controller it is mounted on the wall.



The transducer cable is a shielded two-wire cable.
When the cable needs to be extended, the extension cable has to be an 18AWG shielded two-wire cable. Do not use a coaxial cable. It is recommended to use a grounded metalic conduit and junction box for cable protection.



S330



S500

III. Installation

1. General Guide

Before mounting the product, read this manual and specification. It is installed in a place that is within the temperature range specified in this manual and that is suitable to the enclosure rating and materials. If the products are installed improperly, it may cause malfunction.

- ✓ Remove the obstacles in the space between the sensor and the measured target such as ladders, limit switches, heating spirals etc.
- ✓ When mounting the sensor, keep the distance to the vessel wall.
- ✓ The bottom of the sensor should be perpendicular to the surface of water.
- ✓ Do not set the maximum level into the Dead Zone range.
- ✓ Avoid the intense winds and excessive exposure to direct sunlight. The strong winds change the path of ultrasound and may cause a malfunction. If you need to install the unit in a spot exposed to direct sunlight, sun screen must be installed.
- ✓ Keep the distance from the place where are strong noise by high voltage, high current etc.
- ✓ Install the unit in the place vibration free.

2. Controller installation

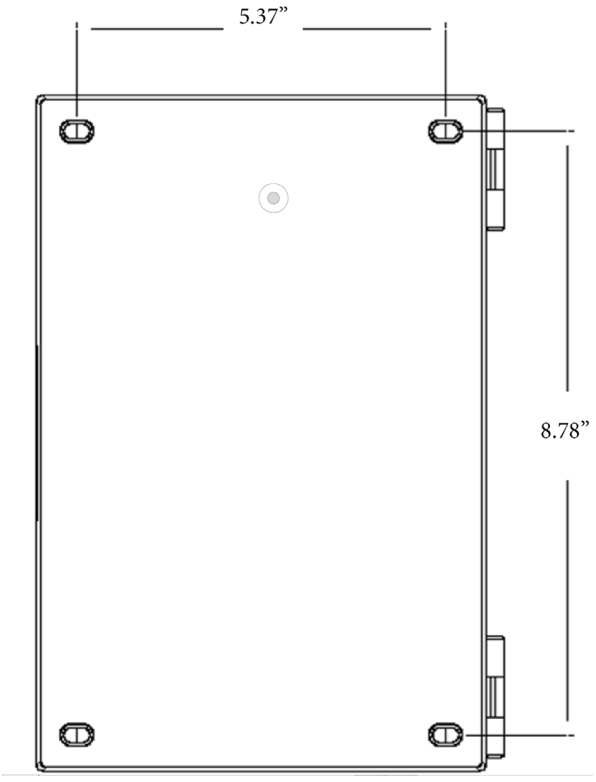
2.1 Environment condition

- ✓ In a place where ambient temperature is between -20 to +60 ° C (-4°F ~ 140°F)
- ✓ In a place required minimum cable length.
- ✓ In a place where it can be operated conveniently
- ✓ In a place out of direct sunlight
- ✓ In a place free from vibration
- ✓ In a place that has suffi cient space when its door is opened.

- Do not install near high voltage, current runs or variable frequency motors.

2.2 Installation

- ✓ Open the controller door and check the four screw holes.
- ✓ Mark and drill four holes in the mounting wall.
- ✓ Fasten the screw bolt by a screwdriver and mount the controller.
- ✓ Check the controller leveled off on the wall.
- ✓ Close the controller door.



3. Sensor Installation

3.1 Environment condition

- ✓ In a place where ambient temperature is between -30 to +70 ° C (-22°F ~ 94°F)
- ✓ Suitable to the housing rating and materials for applications.
- ✓ In a place where is perpendicular to the measuring target surface

3.2 Dead Zone

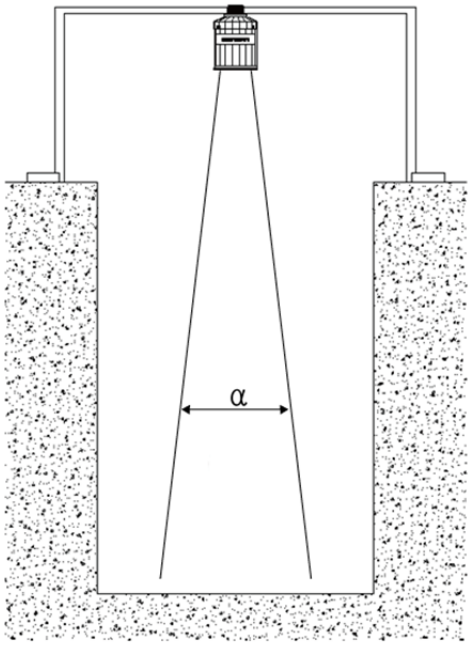
The Dead Zone is the area which the ultrasonic sensor can t measure. The maximum liquid level should not reach into the Dead Zone. The echo signal isn t calculated within Dead zone area. Thus the measurement value may not be correct or may display an error (LE). The Dead Zone is 11.81".

- The sensor cable should not be laid parallel to high voltage line and nearby frequency converters.

3.3 Beam Space

Make sure there is no interference on the emitted beam space area such as a limit switch, temperature sensors, and ladders. .

Measurement distance (ft)	Beam Width (α) (ft)
3.3	0.3
6.6	0.6
9.8	0.9
13.1	1.2
16.4	1.5
19.7	1.9
23.0	2.3
26.2	2.8
29.5	3.3
32.8	3.9
36.1	4.7
39.4	5.7
42.7	7.0
45.9	9.0
49.2	12.2



3.4 Installation

Vessel Installation

- ✓ Do not install the sensor in the middle of the tank. Keep the distance from the vessel wall over 300mm.
- ✓ There should be no interference on the emitted beam path.
- ✓ If there is vibration, it could result incorrect measurement value.
- ✓ Use a flexible conduit for protecting the sensor cable.

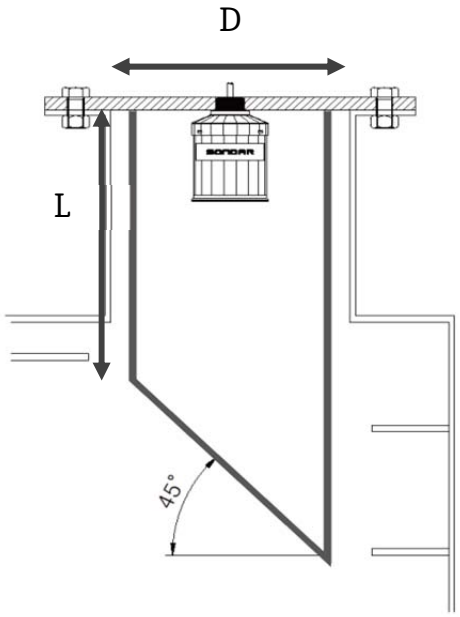
Nozzle Installation

When the maximum level is filled over dead zone in the tank, use the pipe nozzle.

The interior of the nozzle must be smooth and may not contain any edges or welded joints.

There should be no burr on the inside of the tank side nozzle end.

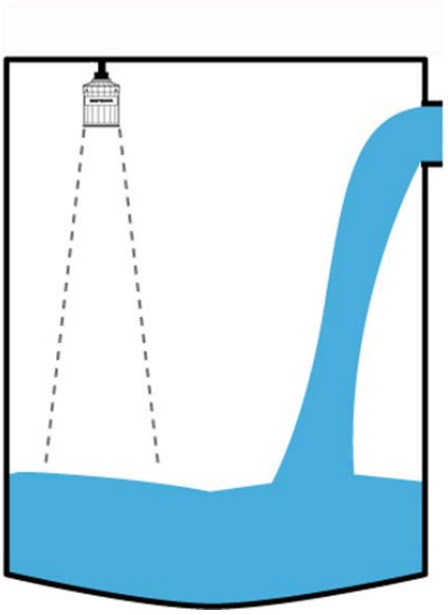
For making the pipe nozzle, specify the diameter and length as the table below.



D (in)	LENGTH (L (in)	
	S330 (LXD-10)	S500 (LXD-15)
4	9	-
6	14	14
8	19	19

Filling flow Outlet

Do not install the sensor in or above a filling flow outlet. Secure enough distance from the filling flow.



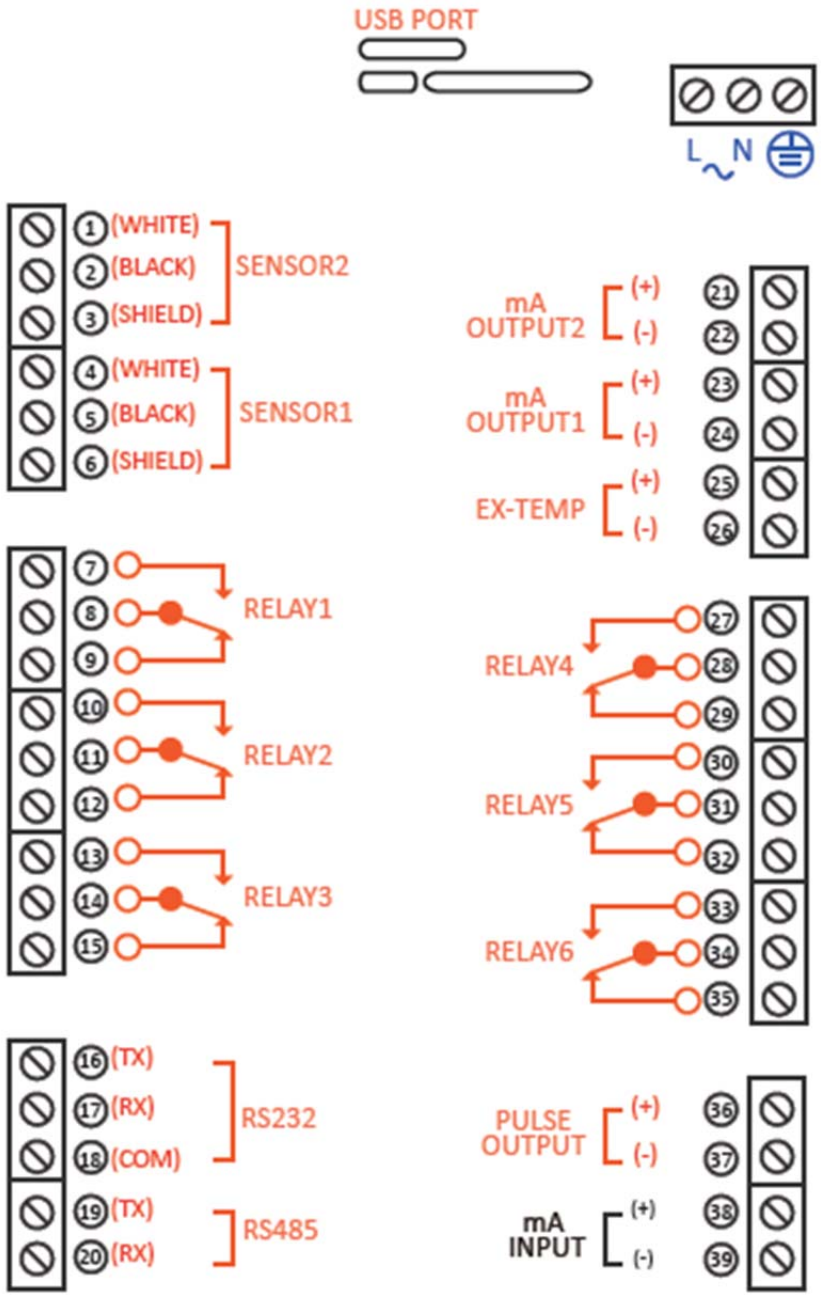
Foam

After filling, stirring and other process in the vessel, dense foam, that can considerably dampen the emitted signals, may form on the surface of the measuring target. It could result in measurement errors. It is recommended to use a standpipe.

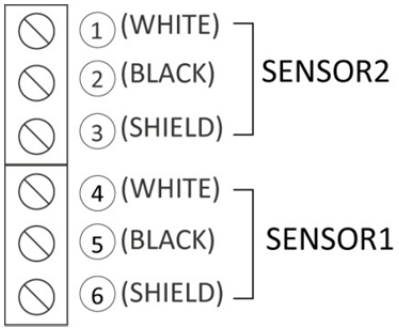
IV. Wiring

1. Wiring

CONTROL TERMINAL BOARD



TRANSDUCER



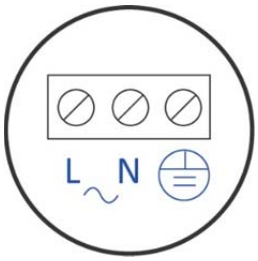
Sensor 2 terminal block is only installed on dual channel models.

- Do not use coaxial cable.
- Do not use connect the shield and white transducer wires together

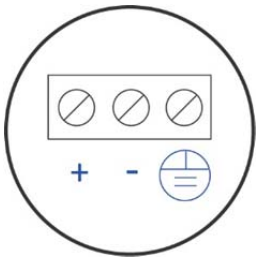
- Do not use old version sensors. Connect only the sensors stated in this manual.

Power

The standard power type is AC power. DC power can be selected as an option if requested when ordering.



AC Power Terminal



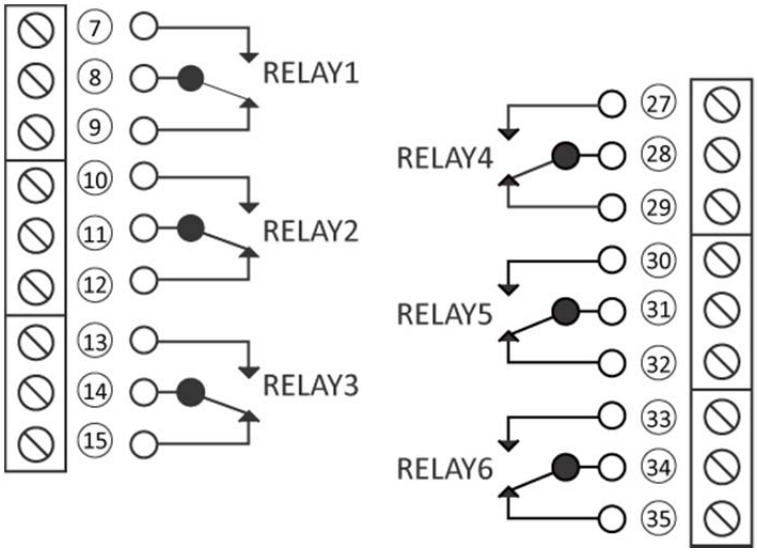
DC Power Terminal

- When turning on the power for the first time, make sure any connected devices are disabled until all system functions are confirmed and to be operating properly.
- The system must be protected by a 10A fuse; otherwise it should be installed in a place where there is a circuit breaker or switch in the building. The switch must be easily accessible.

Relay

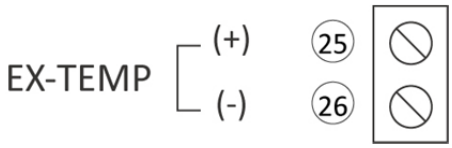
The Relay form is two Form C type. The relays can be wired either normally open or normally closed. The standard model has 3 relays. 3 relays more can be selected as an option if requested when ordering.

- ✓ Two Form C, NO or NC relays
- ✓ 4A at 250Vac



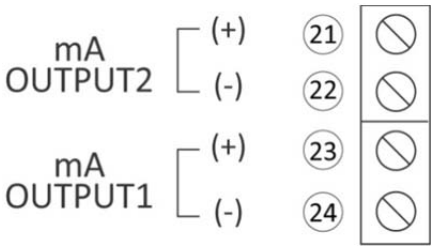
Temperature Sensor

The temperature information is a critical factor for measurement. The sensors have built-in temperature sensor inside the sensor to compensate. If the ambient temperature is changed rapidly, an external temperature sensor is recommendable.



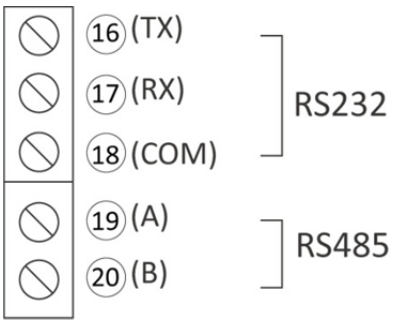
Analog output

mA OUTPUT1 is the analog output for SENSOR1. mA OUTPUT2 is the analog output for SENSOR2. Make sure that each output is wired to the correct terminal block.



Digital Communication

The standard communication type is RS232. RS485, Modbus can be selected as an option if requested when ordering.



V. Operation

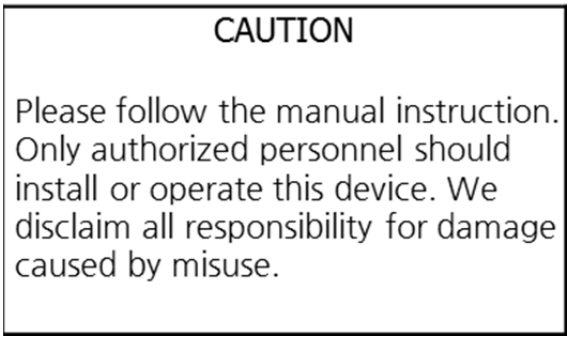
1. Start-up Display

When LM7000 is powered on, the screen displays as shown below.

Item

Model Name

Firmware Version

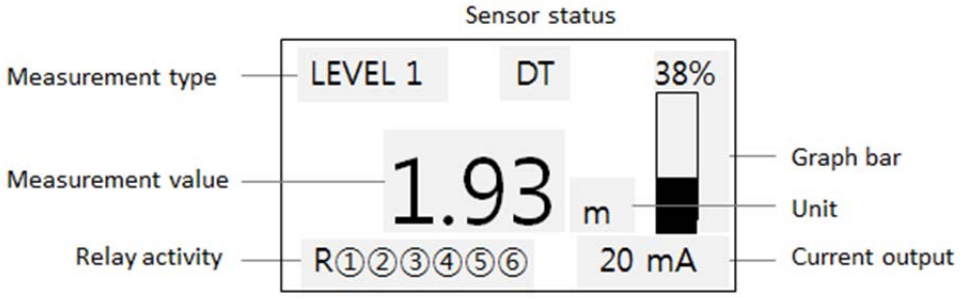


2. Display

2.1 Measuring Mode

There are 4 different display types in Measuring Mode. Switch through different display by using up and down buttons. When only SENSOR1 is wired, DISPLAY B and DISPLAY C aren't shown.

DISPLAY A



1) It shows the measurement type currently being measured and the sensor No. currently installed.

- LEVEL 1 :Level measured by SENSOR1
- LEVEL 2 : Level measured by SENSOR2
- DISTANCE 1 : Distance measured by SENSOR1
- DISTANCE 2 : Distance measured by SENSOR2
- SPACE 1 : Space measured by SENSOR1
- SPACE 2 : Space measured by SENSOR2
- VOLUME 1 : Volume measured by SENSOR1
- VOLUME 2 : Volume measured by SENSOR1

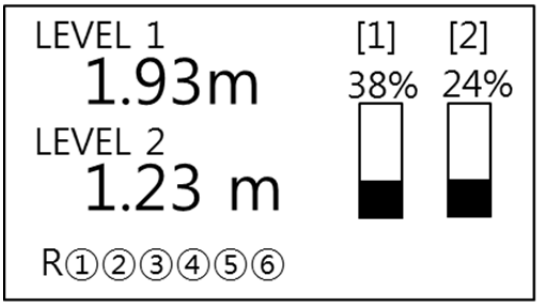
2) It shows the current measurement value

3) It shows the relay currently wired.

4) It shows a sensor condition.
   - DT: when it operates normally
   - D: when it receive the reflected signal
   - S1: when the measurement value is over than DAMPING SPEED
     (The value is held)
   - S2: when it research the signal
   - LE: when it lost the signal
5) It shows the percentage of LEVEL/DISTANCE/SPACE/VOLUME currently being measured.
6) It shows the unit of measurement value.
7) It shows the current output value or ambient temperature.

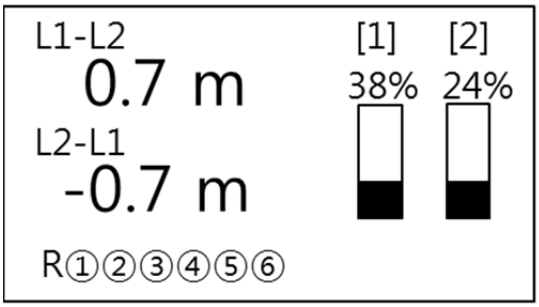
DISPLAY B

All the factors displayed are the same as those shown DISPLAY A. DISPLAY B shows two sensors measurement at the same time. When only SENSOR1 is wired, DISPLAY B isn't shown.

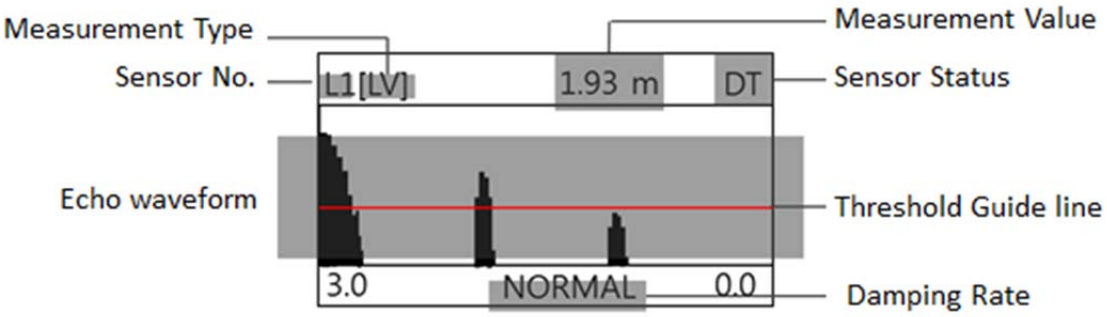


DISPLAY C

All the factors displayed are the same as those shown DISPLAY B. DISPLAY C shows the difference between LEVEL1 and LEVEL 2



Echo Trend DISPLAY



1) It shows the measurement type currently being measured.
   - [LV]: LEVEL
   - [DIST]: DISTANC
   - [VOL]: VOLUME
   - [SPACE]: SPACE
2) It shows the sensor no. currently activated.
   - L1: SENSOR 1
   - L2: SENSOR 2
3) It shows the echo waveform received by sensor.

4) It shows the measurement value currently measured.

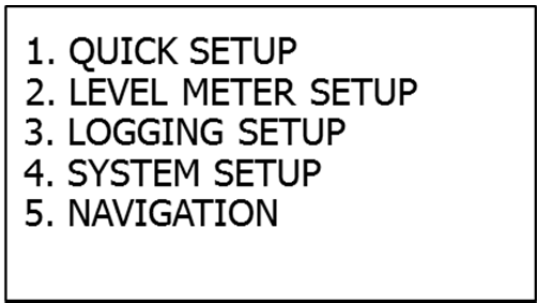
5) It shows the sensor condition.
   - DT: when it operates normally
   - D: when it receive the reflected signal
   - S1: when the measurement value is over than DAMPING SPEED (The value is held)
   - S2: when it research the signal
   - LE: when it lost the signal

6) It shows the threshold guide line.

7) It shows the damping rate. The Setting Level is as below.
   - SLOW
   - NORMAL
   - FAST
   - VERY FAST

2.2 Operating Mode

Operating Mode is to be set the menus for measurement. Operating Mode can be switched by [MENU] button in measuring mode. It shows as the picture as below.



QUICK SETUP

This menu is the collection of often used menus.

LEVEL METER SETUP

This menu is for detail parameter setup of measurement.

LOGGING SETUP

This menu is for logging data management.

SYSTEM SETUP

This menu is for system setting

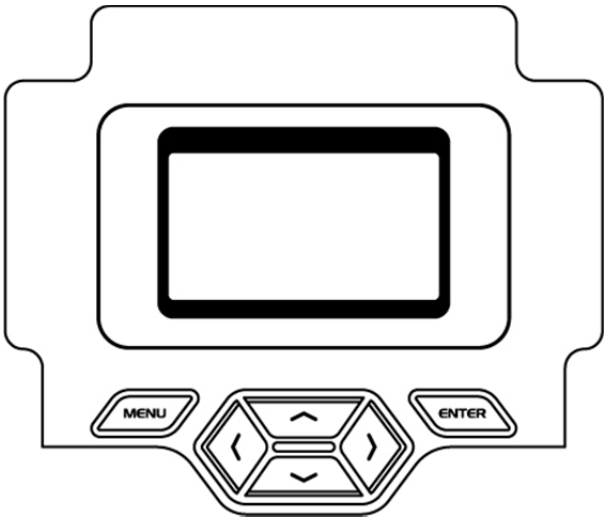
NAVIGATION

This menu allows for quick access to specific menus directly by entering the preset menu number. Refer to the menu list of LM7000.

* The menu list is page95.

3. Buttons

The LM7000 has 6 buttons to operate the system and to setup the menus.

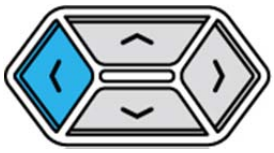


- Measuring mode and Operating mode is switched by [MENU] button.

- Select a menu in Operating mode.
- Complete menu setting

- Move up menus or change the parameters on each menu.

- Move down menus or change the parameters on each menu.



- Return to the previous category
- Move the cursor to the left when entering numbers.

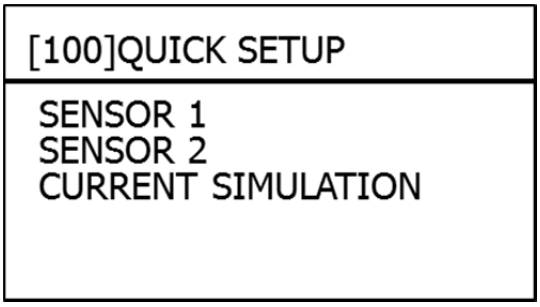
- Return to the next category
- Move the cursor to the right when entering numbers.

- If you press [ENTER] button, after changing the value in Program Mode, every time the user is asked whether the changed value is saved or not. If you select [YES] then the value is changed and Measuring Mode is switched. When you want to change several menus in same directory, press [ENTER] button after all parameters are changed.

VI. Programming

1. QUICK SETUP

QUICK SETUP is the menus frequently used. Parameters can be set conveniently in short time.

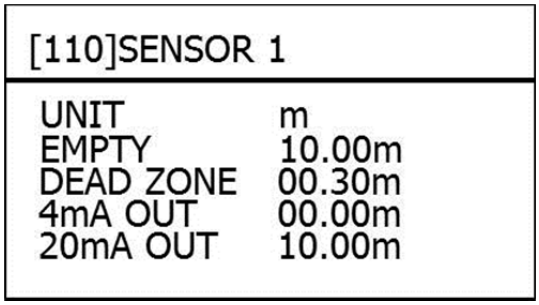


- The captured menu screen is based on the condition that the sensor channel 1 and the sensor channel 2 are both connected. If the sensor channel 1 is connected only, the screen might display differently.

1) SENSOR 1: The menus for SENSOR1 which is wired at SENSOR1 on the terminal block.
2) SENSOR 2: The menus for SENSOR2 which is wired at SENSOR2 on the terminal block.
3) CURRENT SIMULATION: This menu is that tests the current output of OUTPUT 1 and OUTPUT 2. According to the selection; 3.8mA / 4mA / 12mA / 20mA /22mA, the current output is transferred to the control system.

1.1 SENSOR 1

Set the detail menu of the sensor 1.



1) UNIT

This menu is to select the unit of the value being measured.

- Measuring range: mm, cm, m, yd, in, ft

Units	
mm	10000
cm	1000
m	10
in	393.70
yd	10.94
Ft	32.81

**Round off the numbers to two decimal places

2) EMPTY

This menu is for setting the distance between the bottom of the sensor and the bottom of the measured storage when it is empty. The input unit is changed depending on the measurements unit.

SENSOR	SETTING RANGE	DEFAULT
S330 (LXD-10)	.98 - 328 ft (0. 30 - 99.99m)	33 ft (10m)
S500 (LXD-15)	.98 - 328 ft (0. 30 - 99.99m)	50 ft (15m)

- The setting value of the bottom distance is mostly maximum measuring range of the sensor. However, the bottom distance could be set as 99.99m depending on the application conditions. The incorrect bottom distance value causes the incorrect measurement.

3) DEAD ZONE

This menu is for setting DEAD ZONE of a sensor. The ultrasonic sensor is both transmission and reception sensor. The sensor is not able to measure the distance between the surface of the sensor and the certain point. That distance is called DEAD ZONE.

SENSOR	SETTING RANGE	DEFAULT
S330 (LXD-10)	.98 - 328 ft (0. 30 - 99.99m)	0.98 ft (0.3M)
S500 (LXD-15)	.98 - 328 ft (0. 30 - 99.99m)	0.98 ft (0.3M)

4) 4mA OUT

This is a mode for setting a distance that the current output is 4mA. This setting is normally set at the point that the water level is zero.

SENSOR	SETTING RANGE	DEFAULT
S330 (LXD-10)	-328 - +328 ft (-99.99 - +99.99m)	0
S500 (LXD-15)	-328 - +328 ft (-99.99 - +99.99m)	0

5) 20mA OUT

This is a mode for setting the distance that the current output is 20mA. This setting is normally set at the point that a water level is Maximum (100%).

SENSOR	SETTING RANGE	DEFAULT
S330 (LXD-10)	-328 - +328 ft (-99.99 - +99.99m)	33 ft (5M)
S500 (LXD-15)	-328 - +328 ft (-99.99 - +99.99m)	50 ft (15M)

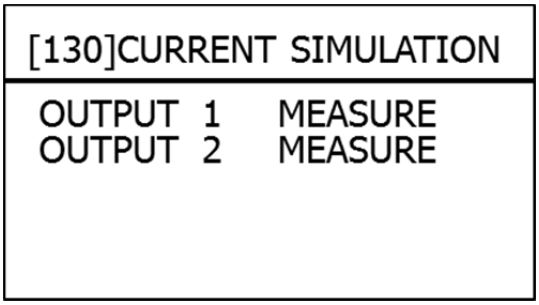
A DEAD ZONE of 30cm should be excepted when setting 20mA OUT. If the level approaches in the DEAD ZONE, It might be displayed incorrect measurement value instead of the actual measurement level.

1.2 SENSOR 2

It is same as the settings menu of the sensor 1.

1.3 CURRENT SIMULATION

This function can simulate the cable connection status and the current output between the central control room and this device. When you move to the CURRENT SIMULATION menu, the measuring process is stopped and the current output becomes initialized to 0.



1) OUTPUT 1

When you select a value of the Current Output 1and 2, it is output by the value of the corresponding current.

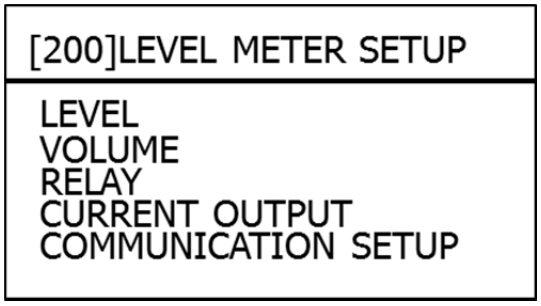
- MEASURE
- 3.8mA
- 4mA
- 12mA
- 20mA
- 22mA

2) OUTPUT 2

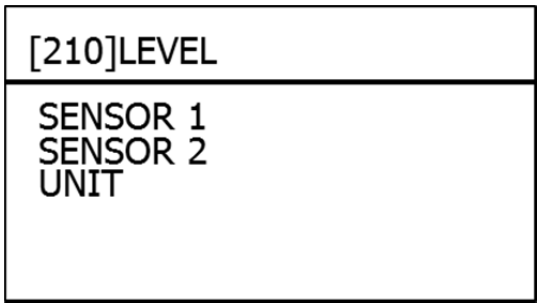
Same as the OUTPUT 1

2. LEVEL METER SETUP

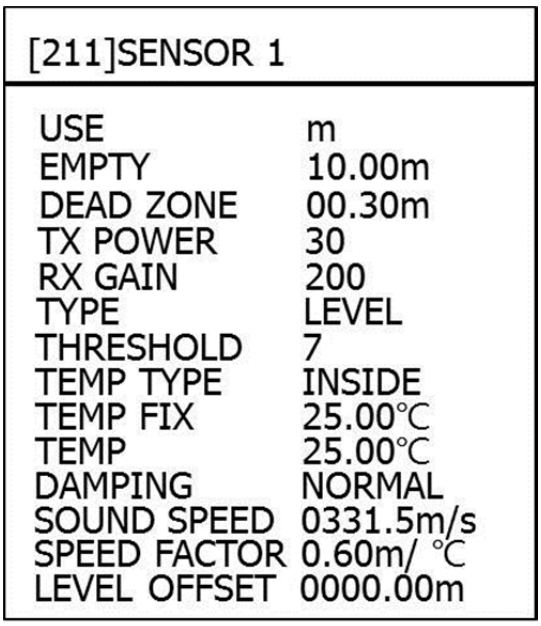
This menu is for setting the Level, Distance, Volume measuring, Relay, Current Output, and Communication of the sensor.



2.1 LEVEL



SENSOR 1



1) USE

This menu is for selecting the sensor use state. If you are using the sensor, please select ENBLE. If you are not using the sensor, please select DISABLE.

2) SENSOR TYPE

This is the menu for selecting the type of the sensor connected.

- S330 (LXD-10)
- S550 (LXD-15)

- If the wrong sensor is selected, it causes incorrect measurement.

3) EMPTY

This menu is for setting the distance between the bottom of the sensor and the bottom of the measured storage when there is empty. The input unit is changed depending on the measurements unit.

SENSOR	SETTING RANGE	DEFAULT
S330 (LXD-10)	0.98 - 328 ft (0.30 - +99.99m)	33 ft (5M)
S500 (LXD-15)	0.98 - 328 ft (0.30 - +99.99m)	50 ft (15M)

- The setting of the EMPTY is normally the maximum measuring range of the sensor. However, it could be set up to 99.99m according to the application conditions.

4) DEAD ZONE

This menu is for setting DEAD ZONE of a sensor. The ultrasonic sensor is both transmission and reception sensor. The sensor is not able to measure the distance between the surface of the sensor and the certain point. That distance is called DEAD ZONE.

SENSOR	SETTING RANGE	DEFAULT
S330 (LXD-10)	0.98 - 328 ft (0.30 - +99.99m)	0.98 ft (0.3M)
S500 (LXD-15)	0.98 - 328 ft (0.30 - +99.99m)	0.98 ft (0.3M)

5) TX POWER

This menu is for adjusting the strength of the transmission signal output from the ultrasonic sensor. By using the function that adjusts the intensity of the ultrasonic wave generated form the sensor, this product is applicable for the various environments.

[Default setting: 30, Maximum setting range: 1~ 100]

- 10: When ultrasonic output is weak.
- 30: The general case (Standard mode)
- 50: When ultrasonic output is strong.
- 70: When ultrasonic output is very strong.

6) RX GAIN

This menu is for adjusting the sensitivity of the signal received from the sensor. Attenuation of the ultrasonic signal is occurred depending on the install location, environment, and surface of measurement object. Please to correct this on the basis of the setting of the following criteria.

[Default setting: 85, Maximum setting range: 0~ 100]

- 30 or less: The Amplification degree is weakest. When the amplification degree of the received signal is about 20dB. (Short-range measurement of enclosed space or underground water pipe.)
- 50: When the amplification degree of the received signal is about 25dB. (Short-range measurement of enclosed space or underground water pipe.)
- 80: The general case. When the amplification degree of the received signal is about 30dB. (Standard mode),
- 90: When the amplification degree of the received signal is about 40dB. (Long-range measurement in open space)

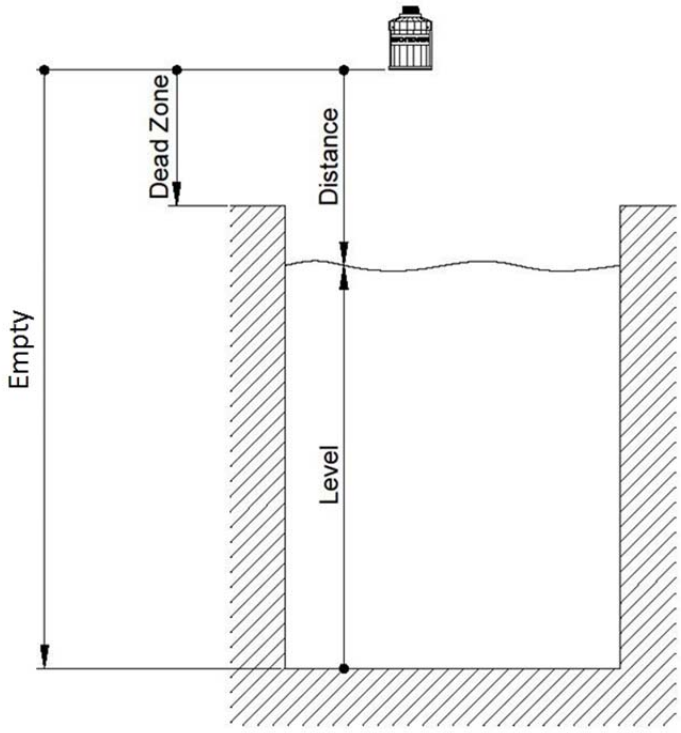
- 95: When amplification degree of the received signal is about 50dB.
- (When the dust, powder, and solid there is a risk of diffuse reflection of the ultrasonic wave.)

- The setting range is changed according to the sensor range.

7) TYPE

This menu is for selecting the type of the measured value to be displayed in the measurement mode.

- Distance : Display the distance to the measured object from the sensor bottom
- Level : Display the distance to the measurement point from the floor
- Space: Display the distance to the measured object, excluding the DEAD ZONE
- Volume: Display the capacity of the contents of the tank being measured(Volume)
- Differential: Display the difference between the measured value of the sensor channel 1 and the sensor channel 2.



8) N.THRESHOLD / F.THRESHOLD

This is the menu for setting the reference value used to detect the received signal reflected. To avoid false detection, please set THRESHOLD value high in the noisy environment and please set THRESHOLD value low when environmental noise is low.

- [Default setting: 3(0.5V), Maximum setting range: 1~10]

9) TEMP TYPE

This is the menu for selecting the type of the temperature value used in the ultrasonic distance measurement.

- INSIDE: Use the temperature sensor that is built inside the sensor for ultrasonic measuring.
- OUTSIDE: Use the value of the external temperature sensor for ultrasonic measuring. (optional)
- FIX: Set a fixed value without using a temperature sensor when the device is used in the places where the temperature is changed rapidly.
-

- When using the external temperature sensor for measurement, TEMP TYPE should be selected as OUTSIDE always. If it is set as OUTSIDE, but the external temperature sensor is not actually connected, it might be displayed incorrect measurement value instead of the actual measurement value.

10) TEMP FIX

This menu is for setting the value of the temperature manually when TEMP TYPE is FIX.

Sensor	Celsius(℃)	Fahrenheit(℉)
Range	0~60	32~140

11) TEMP

This menu is for checking the temperature value measured currently.

12) DAMPING

This menu is for setting the speed of output change corresponding to the change in water level.

	Slow	Normal	Fast	Very Fast
Speed	0.005 fps (0.1m/min)	0.05 fps (1m/min)	0.5 fps (10m/min)	5 fps (100m/min)

13) SOUND SPEED

This menu is for setting the sound speed value of the environment used. Please enter 331.5 in general. (in the air) If this product is operated in other gases, please enter the sound speed value of the corresponding gas when the temperature is 0 ℃. (unit: m/sec)

Name of gas	Sound speed (ft/sec)	Sound speed (m/sec)
Chlorine	676	206
Carbon dioxide	850	259
Argon	1010	308
Oxygen	1037	316
Air	1088	331.5
Ammonia	1362	415
Ethane	1411	430
Neon	1427	435
Helium	3166	965

14)SOUND SPEED FACTOR

This menu is for setting the sound speed change value due to temperature. Sound speed is changed depending on the temperature. In the air, please enter 0.60 (m / ℃) in general. In the case of special circumstances, please enter the sound speed change value obtained by experiment to obtain an accurate measured value.

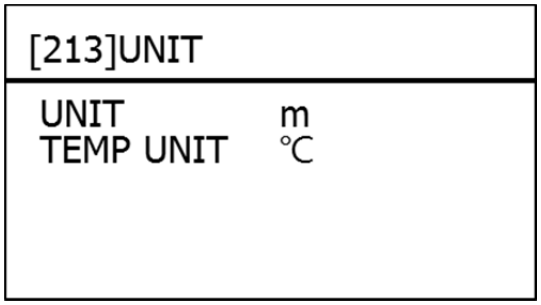
15) LEVEL OFFSET

This menu is to add and display a particular value (Offset) for the special environments on the display. The value of the water level is measured in the usual way, and it will display on the screen after being adjusted based on the specific value.

Actual Value	OFFSET	Displayed Value
15M	+10	25M
15M	-10	5M

SENSOR 2

Same as the setting menu of the sensor 1



1) UNIT

This menu is for selecting the unit that displays the measured value.

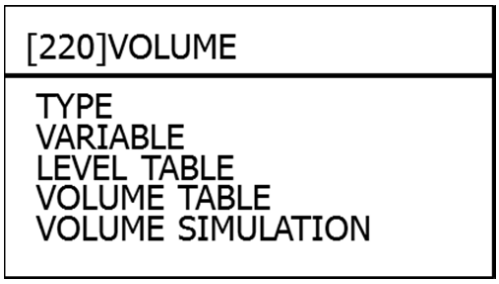
- Available setting unit: mm, cm, m, in, yd, ft

2) TEMP UNIT

It is a menu for choosing the units that display the temperature value. You can choose between ℃ and ℉.

2.2 VOLUME

VOLUME is the capacity of the contents of the tank that being measured currently. When measuring VOLUME, unit mm, cm, and m are converted to m^3, and unit in, yd, ft are converted to gallon automatically.



1) Type

- TANK TYPE

This menu is for selecting the shape of the tank.

- VERTICAL CYLINDER
- HORIZONTAL CYLINDER
- SPHERE
- USER DEFINE

- HEAD TYPE

This menu is for selecting the HEAD TYPE of the tank.

- CONICAL HEAD
- ELLIPSOIDAL HEAD
- GUPPY HEAD
- SPHERICAL HEAD
- FLAT HEAD

- HORIZONAL type is applied to the cylinder only, and not applied to other tank.

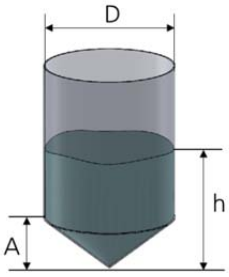
- BOTTOM TYPE

This menu is for selection the bottom type of the tank.

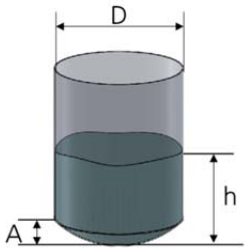
- CONICAL BOTTOM
- ELLIPSOIDAL BOTTOM
- SPHERICAL BOTTOM
- FLAT BOTTOM

- VERTICAL This type is applied to the cylinder only, and not applies to other tank.

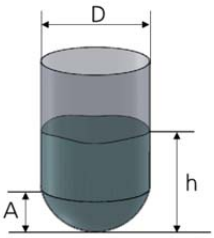
- VERTICAL CYLINDER TANK TYPE



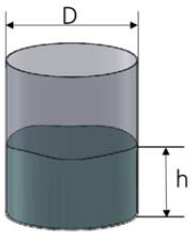
CONICAL BOTTOM TYPE



ELLIPSOIDAL BOTTOM TYPE



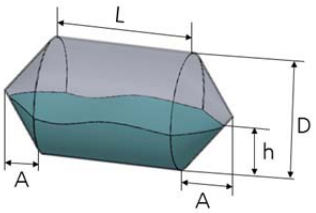
SPHERICAL BOTTOM TYPE



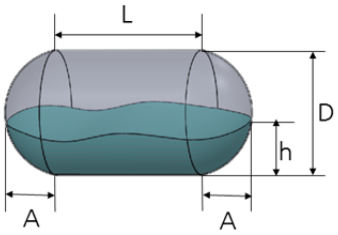
FLAT BOTTOM TYPE

D: Diameter of tank
A: Distance of bottom
h: Measured level (calculated by LM7000)
L: Height of tank (or maximum level) in a full vertical cylinder tank, or length of main section of horizontal cylinder tank.

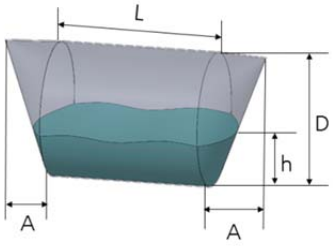
- HORIZONTAL CYLINDER TANK TYPE



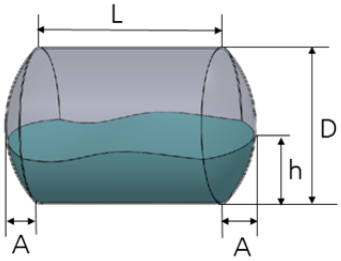
CONICAL HEAD TYPE



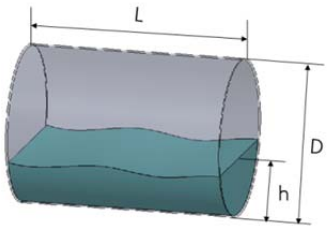
ELLIPSOIDAL HEAD TYPE



GUPPY HEAD TYPE



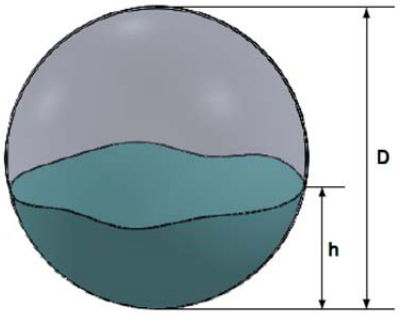
SPHERICAL HEAD TYPE



FLAT HEAD TYPE

- D: Diameter of the tank
- L: The length of the straight section
- A: Distance of HEAD
- h: Measured level

- SPHERE TANK TYPE



- D: Diameter of the tank
- h: Measured level

2) VARIABLE

[222]VARIABLE	
D	05.00m
L	10.00m
A	+00.50m

- D

  This is the menu to enter the diameter of the tank. If you use the SPHERE TANK, please enter 2r as value.

- L

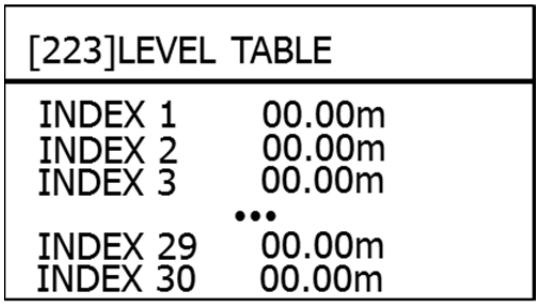
  This menu is to enter the length of the straight section of the HORIZONTAL CYLINDER.

- A

  This menu is to enter the length of the HEAD and the BOTTOM of the VERTICAL CYLINDER and HORIZONTAL CYLINDER.

3) LEVEL/ VOLUME TABLE

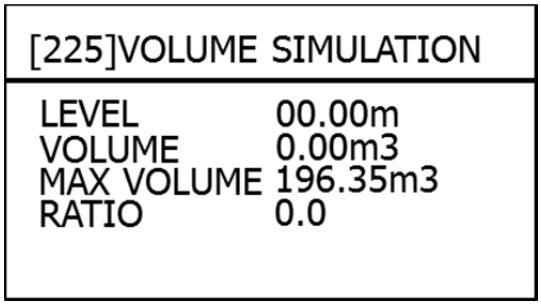
This menu is used when setting the type of tank as USER DEFINE.



- INDEX

  This menu is for setting the point of 30 places within the tank. LEVEL value and VOLUME value at each point is entered in the same INDEX and saved as TABLE.

4) VOLUME SIMULATION



- LEVEL

  This menu is for setting the certain LEVEL value that is used to calculate VOLUME.

- VOLUME

  This menu is for the output the VOLUME value that is calculated by the LEVEL value that was entered.

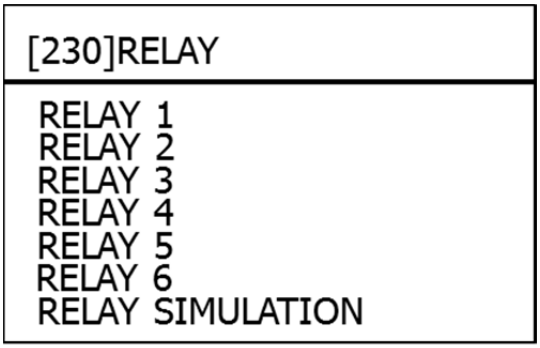
- MAX VOLUME

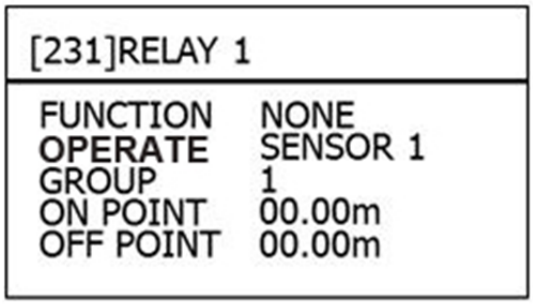
  This menu is for the output the MAX VOLUME of the tank that set currently.

- RATIO

  This menu is for the output the VOLUME and MAX VOLUME.

2.3 RELAY





Relay 1-6

1) FUNCTION

This menu is for selecting RELAY use state.

- NONE: Not use this RELAY
- LIMIT: Operate each RELAY depending on the value of the ON / OFF.
- ALTERNATE: Operate RELAY in sequence on the basis of the measured value and the ON / OFF POINT value of the group that has been set.

  Ex) If There are RELAY1 and RELAY 2 at the GROUP1, RELAY 1 is working to the first ON / OFF point and then RELAY 2 is working at the second ON / OFF point.
- ALARM: This menu is for generating alarm signals when errors that caused by error on the Fail Safe Time value occurs consistently.

2) OPERATE

It is a menu for selecting a sensor the corresponding relay is operating.

- Selection: SENSOR1/ SENSOR2

3) GROUP

This menu is for setting a group for ALTERNATE.

- Selection range: 1~3

4) ON POINT

This menu is for setting a point that RELAY is ON. If OFF POINT is less than ON POINT, RELAY become ON when the measured value is bigger than ON POINT. If OFF POINT is bigger than ON POINT, RELAY become ON when the measured value is less than ON POINT.

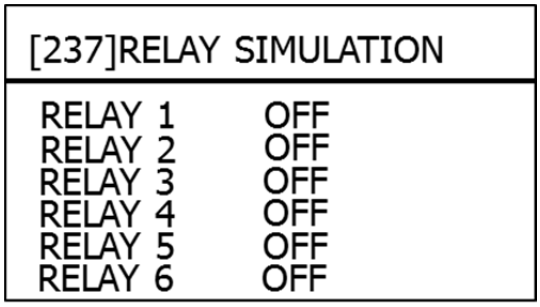
5) OFF POINT

This menu is for setting a point that RELAY is OFF.

If OFF POINT is less than ON POINT, RELAY become OFF when the measured value is less than OFF POINT. If OFF POINT is bigger than ON POINT, RELAY become ON when the measured value is bigger than OFF POINT.

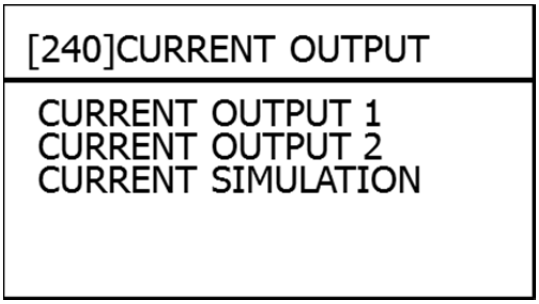
RELAY SIMULATION

The ON / OFF test of RELAY is available.

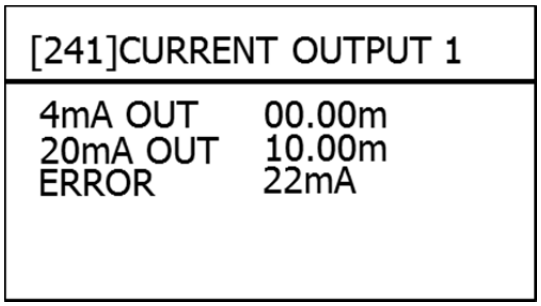


2.4 CURRENT OUTPUT

This menu is for setting that is needed to convert the measured value to current output.



1) CURRENT OUTPUT 1



- 4mA

  This menu is to enter the minimum level that the current output is 4mA.
- 20mA

  This menu is to enter the maximum level that the current output is 20mA.
- ERROR

  This menu is for setting the operation of the current output when an error occurs.
  - 3.8Ma
  - HOLD
  - 22mA

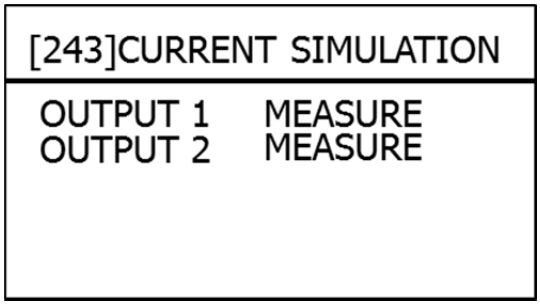
2) CURRENT OUTPUT 2

Same process as the CURRENT OUTPUT 1

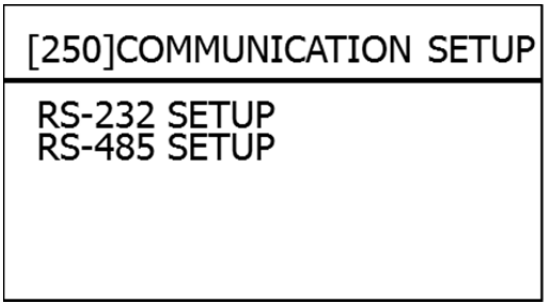
3) CURRENT SIMULATION

This menu is that displays the output of CURRENT OUTPUT SENSOR1 and SENSOR2 as selected value.

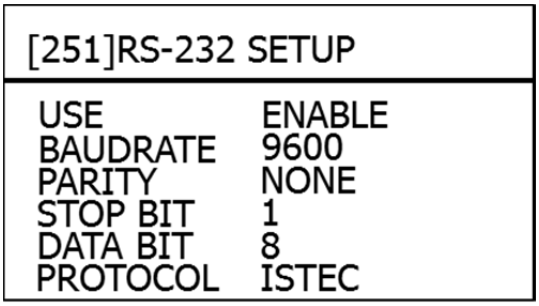
- MEASURE
- 3.8mA
- 4mA
- 12mA
- 20mA
- 22mA



2.5 COMMUNICATION SETUP



RS-232 SETUP



1) USE

This menu is for selecting the RS-232 use state.

- ENABLE / DISABLE

2) BAUDRATE

This menu is for selecting the transmission speed of RS-232.

- 4800 bps
- 9600 bps
- 14400 bps
- 19200 bps
- 38400 bps
- 57600 bps
- 115200 bps

3) PARITY

This menu is for selecting the Parity bit use state.

- None
- Odd
- Even

4) STOP BIT

This menu is for selecting the size of the STOP BIT of RS-232 data transmission.

- 1 bit (default)
- 2 bit

5) DATA BIT

This menu is for selecting the size of the transmission data of RS-232.

- 8 bit (default)
  9 bit

6) PROTOCOL

This menu is for selecting the protocol of the measurement data that is output by RS-232.

- FLOMOTION
- BKCM
- Modbus – RTU
- Modbus–ASCII

- The protocol list can be different according to the communication option when you ordered.

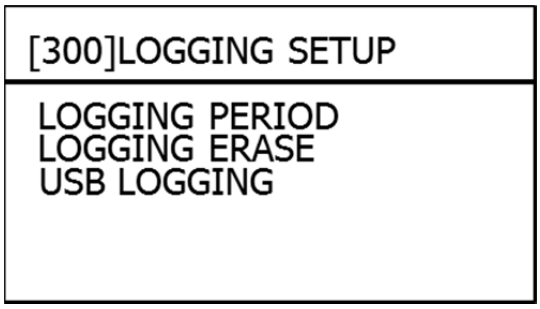
RS-485 SETUP

[252]RS-485 SETUP	
USE	ENABLE
BAUDRATE	9600
PARITY	NONE
STOP BIT	1
DATA BIT	8
PROTOCOL	ISTEC

- The setting method is the same as the RS-232 SETUP on page 53. 6.3 LOGGING SETUP

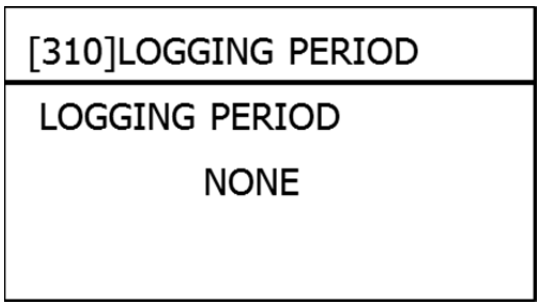
3. LOGGING SETUP

This menu is for setting LOGGING PERIOD, LOGGING ERASE, USB LOGGING.



3.1 LOGGING PERIOD

This menu is for setting the Logging period of measurement data.



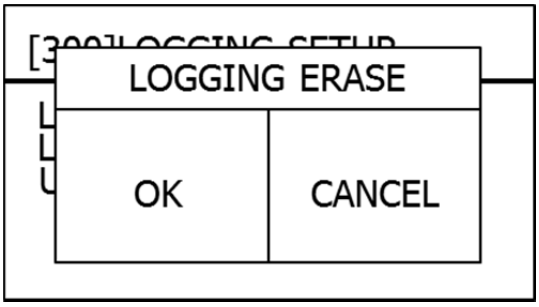
- NONE
- 10 SEC
- 1 MINUTE
- 5 MINUTE
- 10 MINUTE
- 15 MINUTE
- 30 MINUTE
- 60 MINUTE

Maximum storage period according to the data logging period (16,128 point)

Data logging period	Maximum storage period
NONE	-
10 SEC	2 days
1 MINUTE	11 days
5 MINUTE	56 days
10 MINUTE	112 days
15 MINUTE	168 days
30 MINUTE	336 days
60 MINUTE	672 days

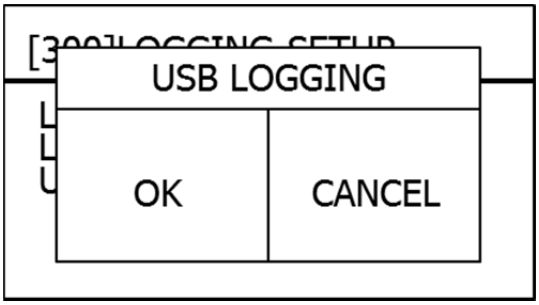
3.2 LOGGING ERASE

If you select LOOGING ERASE, Screen will be displayed as shown in [Figure 6-25] . By selecting OK, it initializes the saved logging.

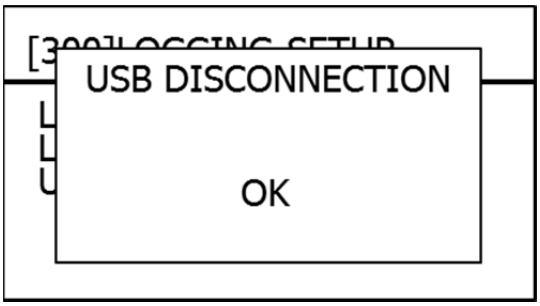


3.3 USB LOGGING

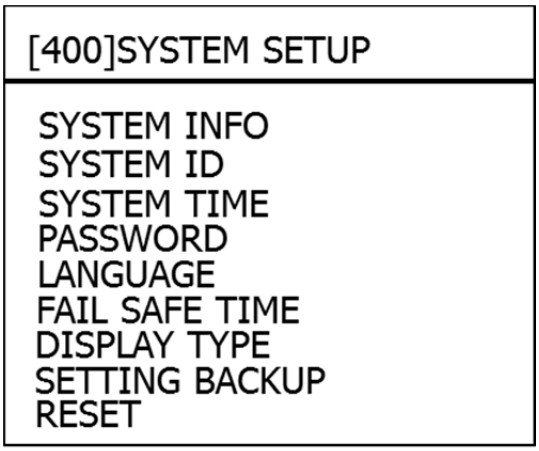
When USB is connected, screen will be displayed as shown in [Figure 6-26] . By selecting OK, it transfers logging data to USB as EXCEL file.



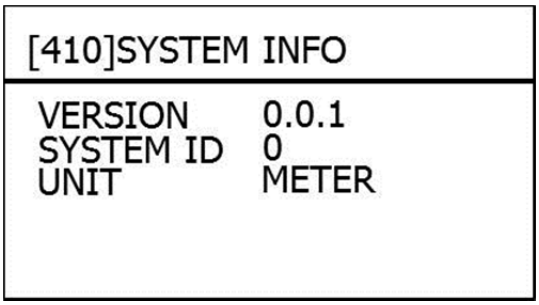
When USB is not connected, screen will be displayed as shown in the picture below. Please connect USB, and then click the OK button, the error pop-up will disappear.



4. SYSTEM SETUP



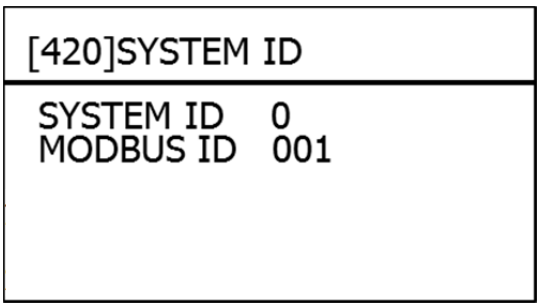
4.1 SYSTEM INFO



This menu is for showing system information.

1) Version: Firmware version
2) SYSTEM ID: System ID for FLOMOTION protocol
3) UNIT: Measurement unit selected by a user

4.2 SYSTEM ID



1) SYSTEM ID

This menu is for setting the SYSTEM ID to be used for FLOMOTION protocol

- SYSTEM ID: 0 ~ 99
- MODBUS ID: 1~247

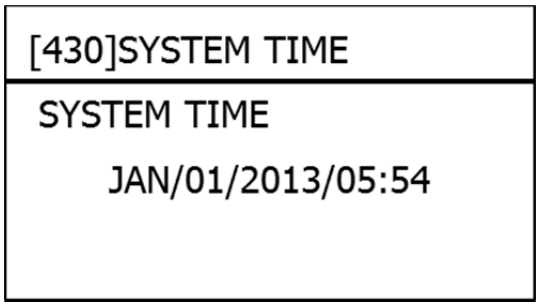
2) Modbus ID

This menu is for setting the Slave ID required when using Modbus Protocol.

4.3 SYSTEM TIME

This menu is for setting the system time. By using the Left / Right direction button, move the cursor to the year / month / day / hour / minute, change the setting using the Up / Down direction button.

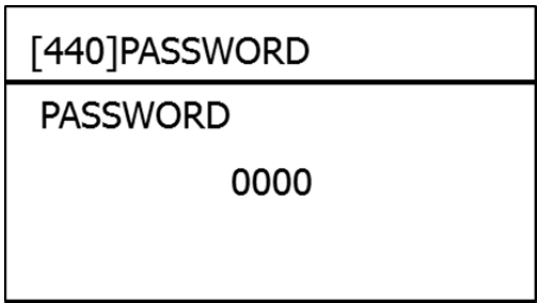
- Setting range: JAN/01/2000 00:00 ~ DEC/31/2099 23:59



4.4 PASSWORD

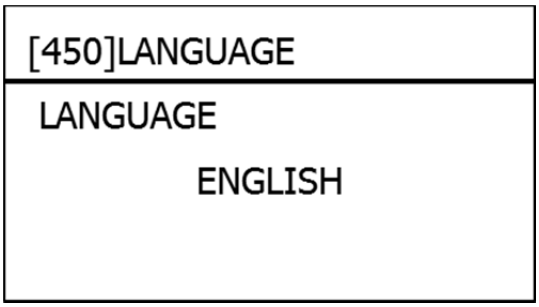
This menu is for setting a password by its user. No password is set at the factory. After you set a password, you must enter the password each time there is a menu change.

- Password setting range: 0000~9999



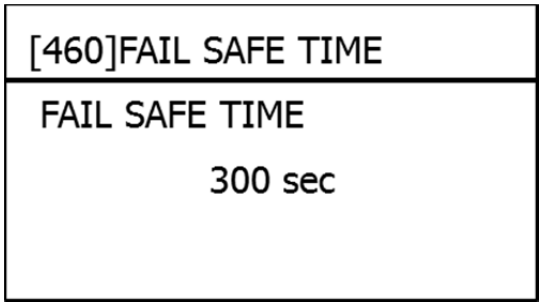
- User can't configure the menus when user forgets the password. Please note password number and pay attention not to lose it.

4.5 LANGUAGE



This is the menu for setting the system language. The current support language is English only.

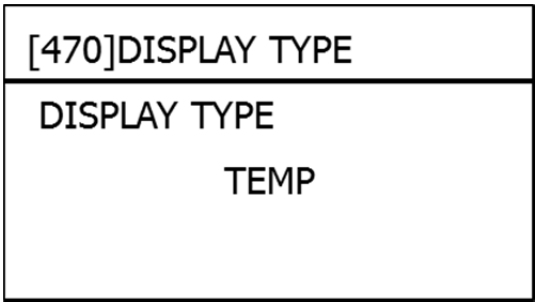
4.6 FAIL SAFE TIME



This menu is for setting the time for then alarm when the device malfunctions or there is no receiving signal.

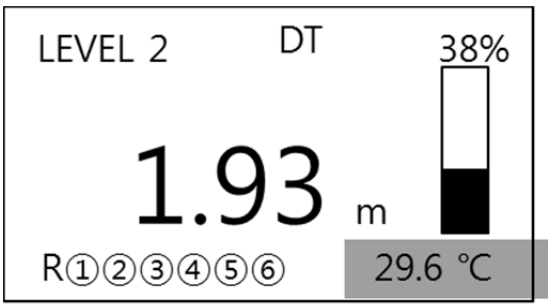
- [Default setting: 300sec, Setting range: 20 ~ 999sec]

4.7 DISPLAY TYPE



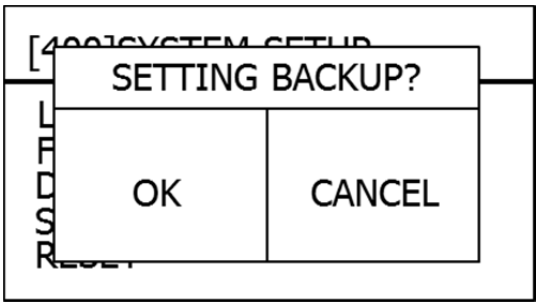
This menu is for selecting the display option in DISPLAY A. The ambient temperature or the current output can be displayed by user's selection.

- Setting range: TEMP or CURRENT

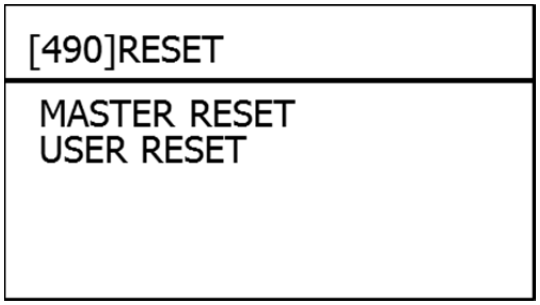


4.8 SETTING BACKUP

This menu is for saving the menu setting value by user. When user select menu, screen will be displayed as shown in picture below.

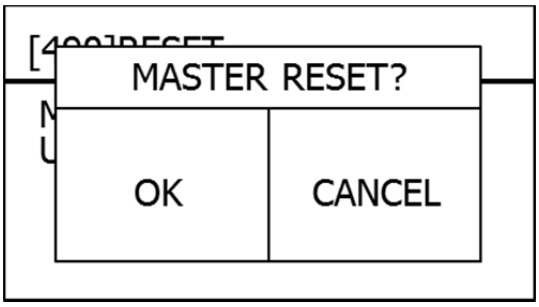


4.9 RESET



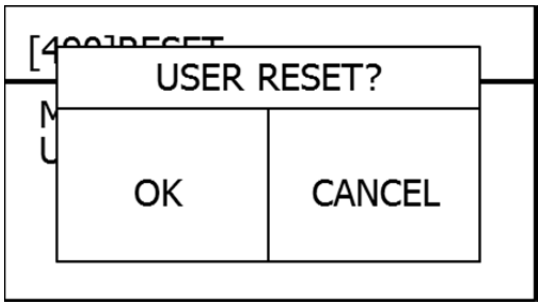
MASTER RESET

This menu is for resetting the device that is currently operating. If you select MASTER RESET function, the device will be initialized as default setting.



USER RESET

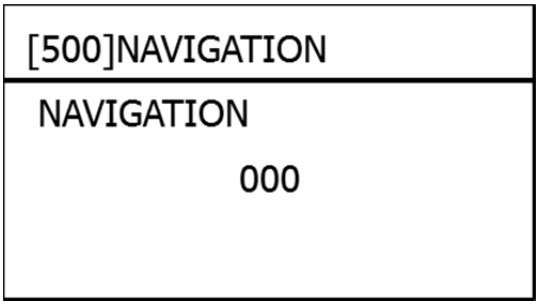
This menu is for resetting the device that is currently operating. If you select USER RESET, the device will be initialized as menu value that is stored at SETTING BACKUP.



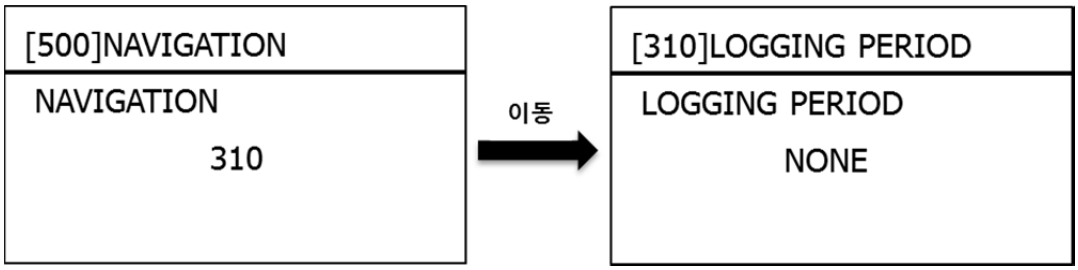
6.5 NAVIGATION

This menu allows for quick access to specific menus directly by entering the preset menu number. Refer to the menu list of SL-100S.

* The menu list is page95.



Ex) If you want to move to the menu of LOGGING PERIOD, please enter menu number [310] .
By entering menu number [310] , you can access LOGGING PERIOD menu immediately..



VII. Maintenance

Regular Inspection

- ✓ There are no contaminants on the surface of sensor.
- ✓ Current output is working in the normal range of 4-20mA.
- ✓ Value displayed at the screen is same as actual level value.
- ✓ Rating power supply is approved.

1. Battery

The battery which is equipped on the main board is CR-2032. The normal product life is around 10 years but it is subject to change by the environment and operating condition. The life can be shortened. Before the battery is out, check it regularly and change it.

- If the battery is out, the time data cannot back-up.
- The battery brand and specification will be subject to change without prior notice.

2. SENSOR

1) Check the sensor cable regularly.
2) Check the sensor bottom if there is contaminant and clean the bottom of the sensor.

3. Warranty Period

Warranty period is 2 years for the LM7000 but if the problem is caused by user's fault or misuse, the repair charge will be incurred.

4. Repair Service

If a problem occurs in this product, the error code displays on the screen to show what the problem is. The error code information can be found in this manual.

Contact the factory for an RMA before returning the product for repair. The repair request form has to be filled out and enclose with the product.

VIII. Trouble shooting

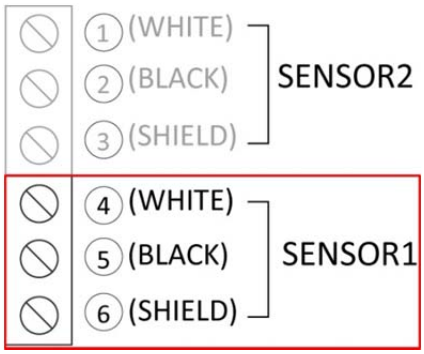
If a problem occurs in LM7000, the error code displays on the screen, it shows what the problem is. The error code information can be found by scanning the QR Code inside the controller door.

Error code list

ERROR CODE	CAUSE
E1101	Not connected SENSOR1
E2101	Not connected SENSOR2
E0101	Not connected SENSOR1 and SENSOR2
E1102	Temperature error of SENSOR1
E2102	Temperature error of SENSOR2
E0102	Temperature error of SENSOR1 and SENSOR2
E0401	External Temperature sensor Error
E0210	Flash memory error
E0202	EEPROM error
E0203	Real time clock error
E1204	The received signal of SENSOR1 is abnormal
E2204	The received signal of SENSOR2 is abnormal
E0204	The received signal of SENSOR1 and SENSOR2 is abnormal

E1101

This error appears when sensor1 is not connected to the terminal or if it is connected to the terminal incorrectly. Please proceed as follows to solve this problem.



When the sensor doesn't make sound radiation

(1) Please check that you can hear the sound emitted from the ultrasonic sensor. If you cannot hear the sound, please refer to (2). If you can hear the sound, please refer to (5).

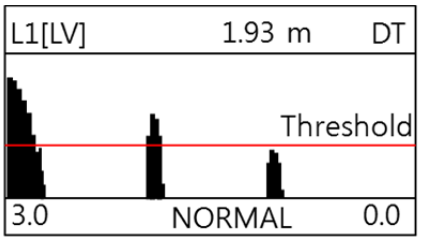
(2) Please check the sensor cable (white, black) visually or by using Multi-meter if it is cut or shorted. If you find a problem, please repair or replace the cable. If the problem has not been solved yet, please refer to (3)

(3) Please check that the sensor cable (white, black) is properly connected on the terminal at the exact position. If it is not, please connect the sensor cable properly.

(4) If the problem has not been solved yet even though you have confirmed the process above (2) and (3), please contact our service center or your local dealer.

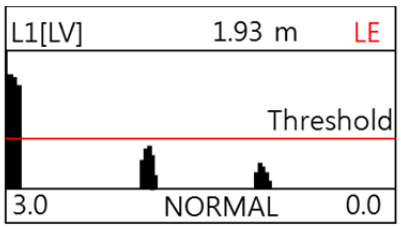
When the sensor makes sound radiation

(5) If you can hear the sound emitted from the ultrasonic sensor, please check the strength of the transmitted signal at the Echo Trend graph on the screen. You can suspect a faulty sensor if the transmitted signal is weak or received signal shows lower waveform than the Threshold value.



Transmitting Signal Receiving Signal

Normal condition



Transmitting Signal Receiving Signal

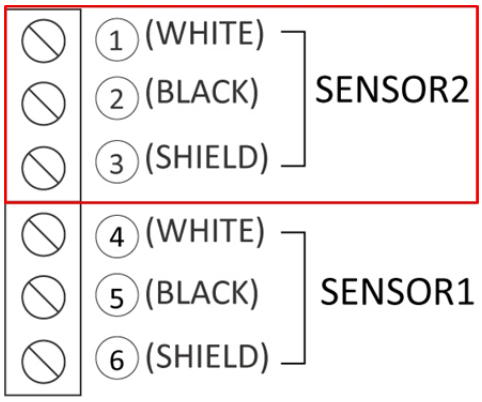
Abnormal condition

*** To see Echo Trend graph, press the [down] button on the Measuring Mode till the graph shows up on the screen.*

(6) If there is a spare sensor, please replace it with other sensors and test again. If the changed sensor operates properly, the sensor is defective. If it doesn't operate normally even if the other sensor has been replaced, you should check the controller.

(7) If you don't have a spare sensor, the faulty sensor needs repair or replacement. Please contact our service center or your local dealer.

E2101

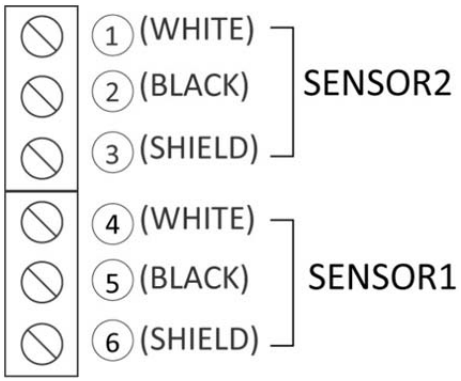


This error appears when sensor2 is not connected to the terminal or if it is connected to the terminal incorrectly. Please proceed as follows to solve this problem.

Processing method is the same as the E1101. (Please refer to Page _)

E0101

This error appears when sensor1 and sensor2 are not connected to the terminal or connected to the terminal incorrectly. Please proceed as follows to solve this problem.



Processing method is the same as the E1101. (Please refer to Page81)

E1102

This error appears when the built-in temperature sensor in sensor1 is not operating properly. The value of the temperature on the screen could be displayed abnormally. Please proceed as follows to solve this problem.

When the sensor doesn't make sound radiation

(1) Please check that you can hear the sound emitted from the ultrasonic sensor. If you cannot hear the sound, please refer to (2). If you can hear the sound, please refer to (5).

(2) Please check the sensor cable (white, black) visually or by using Multimeter if it is cut or shorted. If you find a problem, please repair or replace it. If the problem has not been solved yet, please refer to (3)

(3) Please check that the sensor cable (white, black) is properly connected on the terminal at the exact position. If it is not, please connect the sensor cable properly.

(4) If the problem has not been solved yet even though you have confirmed through the process (2) and (3), please contact our service center or your dealer.

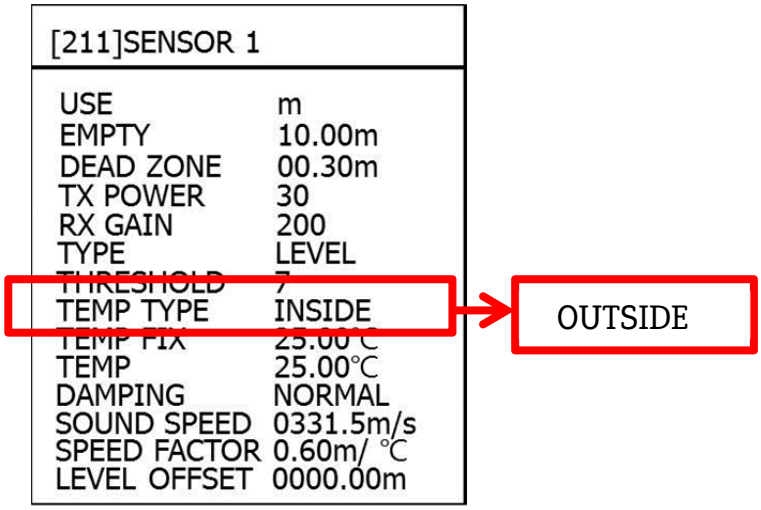
When the sensor makes sound radiation

(5) If you can hear the sound emitted from the ultrasonic sensor, please check the color of the sensor cable (black & shield) that connected to the terminal block. If it is not connected correctly, please re-assemble according to the color.

(6) Please check that the ultrasonic sensor is not connected to the sensor terminal block or the bolt is not tightened. If reconnection is needed, please reconnect it.

(7) If the problem has not been solved yet even though you have confirmed the process above (5) and (6) please check the resistance of cable (black & shield). At room temperature, it is normal if the resistance value is within about 9kΩ ~ 15kΩ. If the resistance value is over this range, the built-in temperature sensor is defective. A faulty sensor needs repair or replacement. Please contact our service center or your local dealer.

(8) If there is an external thermometer, you can use it instead of the built-in temperature sensor. When you change the temperature sensor, you have to change the menu option as well. The menu is as follows.



E2102

This error appears when the built-in temperature sensor in sensor2 is not operating properly. The value of the temperature on the screen could be displayed abnormally. Please proceed as follows to solve this problem.

Processing method is the same as the E1102. （Please refer to Page 83）

E0102

This error appears when the built-in temperature sensor in sensor1 and sensor2 are not operating properly. The value of the temperature on the screen could be displayed abnormally. Please proceed as follows to solve the problem.

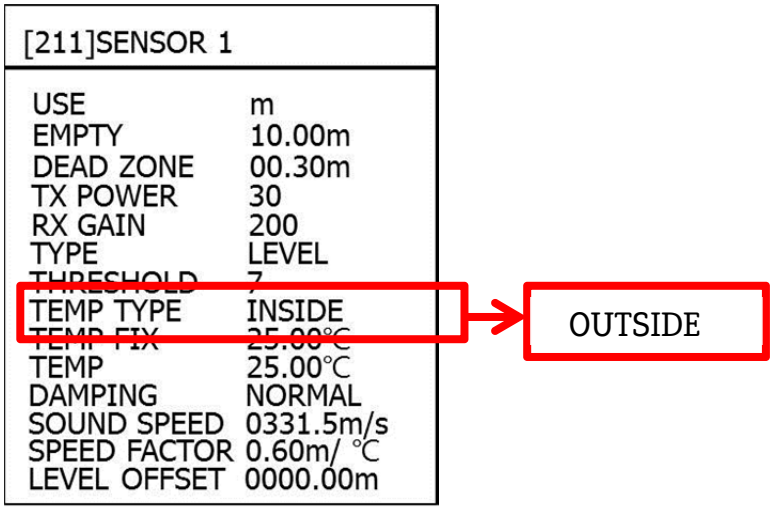
Processing method is the same as the E1102. （Please refer to Page 83）

E0401

This error appears when an external thermometer that connected to the controller is not operating properly. Please proceed as follows to solve this problem.

When the temperature type is selected incorrectly in the menu

(1) If you select “OUTSIDE” on the TEMP TYPE when setting the menu of the sensor, the value is measured based on the temperature value that measured by the external temperature sensor. Please check if you chose “OUTSIDE” instead of “INSIDE” on the TEMP TYPE menu even though an external temperature sensor is not connected.



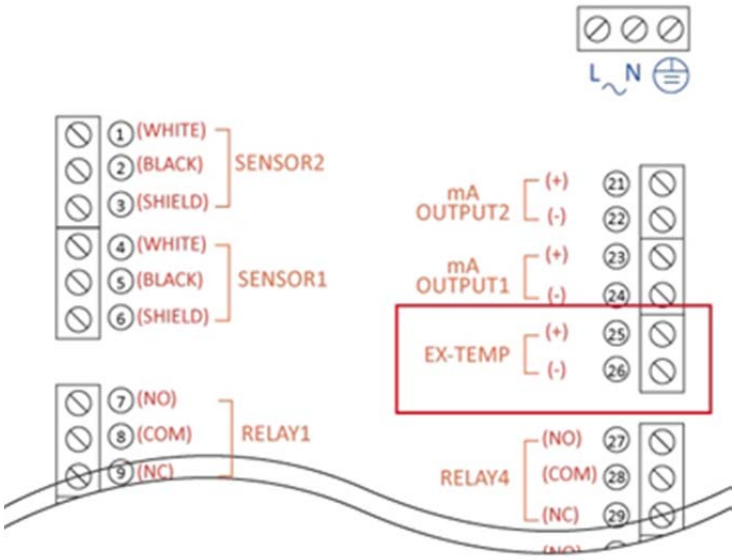
When the temperature sensor is connected incorrectly

(2) Please check the sensor cable visually or by using Multimeter if it is cut or shorted. If you find a problem, please repair or replace it. If the problem has not been solved yet, please refer to (3)

(3) Please check that the sensor cable is properly connected on the terminal at the exact position. If you find a problem, please connect the sensor cable properly.

(4) If the problem has not been solved yet even though you have confirmed the process above (2) and (3), please contact our service center or your local dealer.

SL-100S Terminal Block



E0201

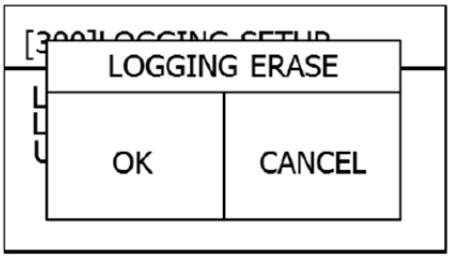
This error appears when the flash memory inside controller is not operating properly. Please proceed as follows to solve the problem.

Logging data Recovery

If the flash memory is defective, it is difficult to recover the stored data. For the recovery of the lost data, you will need to send the product to our service center for repair.

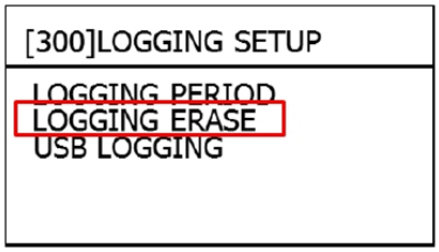
Memory Reset

(1) Please try to reset the flash memory at the menu.



(2) Please refer to the menu directory as follows. All data will be deleted and the memory will be rest.

(3) If the problem continues, please contact our service center or your local dealer.



E0202

(1) This error appears when the EEPROM memory inside controller is not operating properly. Please proceed as follows to solve the problem.

(2) Please contact our service center immediately. Do not attempt to fix it yourself

(EEPROM memory stores the important information about the product and cannot be handled by non-experts. If you need specific inspection and repair, please contact our service center or your local dealer.)

E0203

This error appears when the REAL TIME CLOCK inside of the controller is not operating properly. Please proceed as follows to solve the problem.

(1) Please contact our service center immediately. Do not attempt to fix it yourself

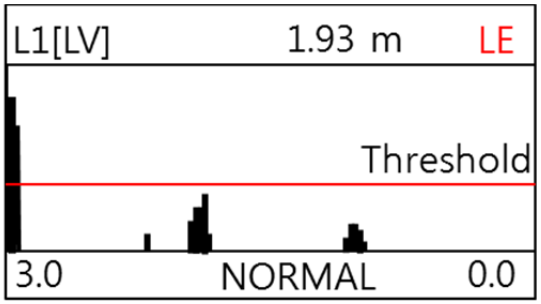
(2) REAL TIME CLOCK is sensitive and cannot be handled by non-experts. If you need specific inspection and repair, please contact our service center or your local dealer.

E1204

This error appears when the received signal from sensor1 is abnormal. “LE” will be flashing on the screen. Please proceed as follows to solve the problem.

(1) Check the installation position of the sensor

(2) Please check the strength of the received signal at the Echo Trend graph on the screen. If the received signal shows lower waveform than the default Threshold value, please check the installation location of the sensor.



Transmitting Signal Receiving Signal

*** To see Echo Trend graph, press the [down] button on the Measuring Mode till the graph shows up on the screen.*

(3) Please make sure that the sensor is installed perpendicularly to the object you’re measuring. If it is not, please reinstall it correctly.

(4) Check the contamination on the bottom of the sensor

(5) Please check if there is a contaminant adhering to the radiating surface. If the radiating surface is contaminated, please wipe it with a soft cloth.

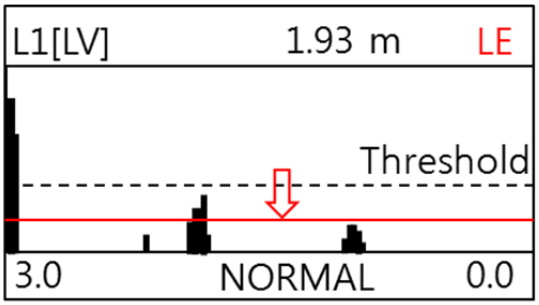
Adjust settings menu corresponding to the measurement object

(6) Please check if the measurement object is the ultrasonic absorber (foam, sludge). If it is, the received signal is attenuated than normal condition. Please adjust TX POWER, RX GAIN, and Threshold value at menu [211] to set an appropriate status for your environment.

TX POWER: Please change the default value from 30 to 50 ~ 70

RX GAIN: Please change the default value from 85 to 90 ~ 95

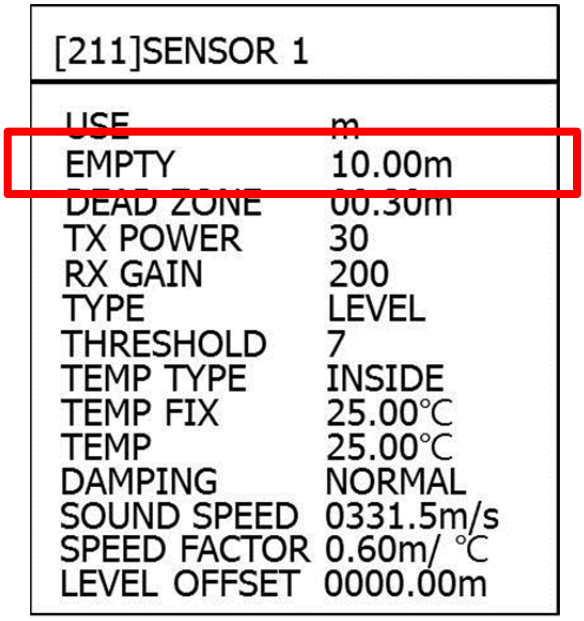
(7) If "LE" appears on the screen repeatedly and received value is lower than Threshold value, please change the default Threshold value from 4(0.8V) to 3(0.5V). if it is operating normally, "DT" will be displayed on the screen during normal operation.



Transmitting Signal Receiving Signal

*** To see Echo Trend graph, press the [down] button on the Measuring Mode till the graph shows up on the screen.*

(８) Check the bottom distance setting
(９)Please check that the value of the EMPTY has been set within the range.



(１０) If the problem keeps occurring, please contact our service center or your local dealer.

E2204

This error appears when the signal from sensor2 is not received normally. “LE” will be flashing on the screen. Please proceed as follows to solve the problem.

Processing method is the same as the E1204. (Please refer to Page90.)

E0204

This error appears when the signals from sensor1 and sensor2 are abnormal. “LE” will be flashing on the screen. Please proceed as follows to solve the problem.

Processing method is the same as the E1204. (Please refer to Page 90)

APENDIX A. MENU LIST

QUICK SETUP

QUICK SETUP(100)			
1st MENU	**2nd MENU**	Range	**Default**
SENSOR 1 (110)	UNIT	mm/ cm/ m/ in/ yd/ ft	m
	BOTTOM	0.3 ~ 99.99m	10m
	DEAD ZONE	0.3 ~ 99.99m	0.3m
	4mA OUT	-99.99 ~ 99.99m	0m
	20mA OUT	-99.99 ~ 99.99m	10m
SENSOR 2 (120)	UNIT	mm/ cm/ m/ in/ yd/ ft	m
	BOTTOM	0.3 ~ 99.99m	10m
	DEAD ZONE	0.3 ~ 99.99m	0.3m
	4mA OUT	-99.99 ~ 99.99m	0m
	20mA OUT	-99.99 ~ 99.99m	10m
CURRENT SIMULATION (130)	OUTPUT 1	MEASURE/3.8mA/ 4mA/ 12mA/ 20mA/ 22mA	MEASURE
	OUTPUT 2	MEASURE/3.8mA/ 4mA/ 12mA/ 20mA/ 22mA	MEASURE

DETAIL MENU

1st MENU	2nd MENU	3rd MENU	4th MENU	Input Range	Default
LEVEL METER SETUP (200)	LEVEL (210)	SENSOR 1 (211)	USE	ENABLE/DISABLE	ENABLE
			SENSOR TYPE	LXD-10 / LXD-15	LXD-10
			BOTTOM	0.3 ~ 99.99m	10m
			DEAD ZONE	0.3 ~ 99.99m	0.3m
			TX POWER	1~100	50
			RX GAIN	0~100	93
			TYPE	DISTANCE/ LEVEL/ SPACE/ VOLUME	LEVEL
			N.THRES-HOLD	1~10	4(0.8V)
			F.THRES-HOLD	1~10	4(0.8V)
			TEMP TYPE	INSIDE/ OUTSIDE/ FIX	INSIDE
			TEMP FIX	0~60℃	25℃
			TEMP	0~60℃	
			DAMPING	SLOW/ NORMAL/ FAST/ VERY FAST	NORMAL
			SOUND SPEED	1~9999 m/s	331.5m/s
			SOUND SPEED FACTOR	-2.0~2.0 m/℃	0.60m/℃
			LEVEL OFFSET	-99m~999.9m	0m
		SENSOR 2 (212)	USE	ENABLE/ DISABLE	DISABLE
			SENSOR TYPE	LXD-10 / LXD-15	LXD-10
			BOTTOM	0.3 ~ 99.99m	10m
			DEAD ZONE	0.3 ~ 99.99m	0.3m
			TX POWER	1~100	30
			RX GAIN	0~100	85
			TYPE	DISTANCE/ LEVEL/ SPACE/ VOLUME	LEVEL
			THRES-HOLD	0.324 / 0.664 / 0.813 / 1.075 / 1.402 / 1.648 / 1.927 / 2.19 / 2.517 / 2.665	1.927V

1st MENU	2nd MENU	3rd MENU	4th MENU	Input Range	Default
LEVEL METER SETUP (200)	LEVEL (210)	SENSOR 2 (212)	TEMP TYPE	INSIDE/ OUTSIDE/ FIX	INSIDE
			TEMP FIX	0~60℃	25℃
			TEMP	-30 ~80℃	
			DAMPING	SLOW/ NORMAL/ FAST/ VERY FAST	NORMAL
			SOUND SPEED	1~9999 m/s	331.5m/s
			SOUND SPEED FACTOR	-2.0~2.0 m/℃	0.61m/℃
			LEVEL OFFSET	-99m~999.9m	0m
		UNIT (213)	UNIT	mm/ cm/ m/ in/ yd/ ft	meter
			TEMP UNIT	℃ or ℉	℃
	VOLUME (220)	TYPE (221)	TANK TYPE	HORIZONTAL CYLINDER/ VERTICAL CYLINDER/ SPHERE/ USER DEFINE	VERTICAL CYLINDER
			HEAD TYPE	CONICAL HEAD/ ELLIPSOIDAL HEAD/ GUPPY HEAD/ SPHERICAL HEAD/ FLAT HEAD	FLAT HEAD
			BOTTOM TYPE	CONICAL BOTTOM/ ELLIPSOIDAL BOTTOM/ SPHERICAL BOTTOM/ FLAT BOTTOM	FLAT BOTTOM
		VARIABLE (222)	D	0~50M (Tank diameter)	5M
			L	0~15M (Tank width/height)	10M
			A	Head/bottom width(-15M~15M) (+ : convex / - concave)	0.5M
		LEVEL TABLE (223)	INDEX1~30	Measured level value by user's tank It has to be matched with the volume table below.	0
		VOLUME TABLE (224)	INDEX1~30	Measured volume value by user's tank. It has to be matched with the level table below.	0
		SIMULATION (225)	LEVEL	Simulation level input	0
			VOLUME	Volume	0
			MAX VOLUME	Total volume value display by setting tank condition	0
			RATIO	Ratio of Volume and max volume	0

1st MENU	2nd MENU	3rd MENU	4th MENU	Input Range	Default
LEVEL METER SETUP (200)	RELAY (230)	RELAY 1 (231)	FUNCTION	NONE/ LIMIT/ ALTERNATE/ ALARM	NONE
			OPERATE	SENSOR 1 / SENSOR 2	SENSOR 1
			GROUP	1~3	1
			ON POINT	0~15.5m	0
			OFF POINT	0~15.5m	0
		RELAY 2 (232)	FUNCTION	NONE/ LIMIT/ ALTERNATE/ ALARM	NONE
			OPERATE	SENSOR 1 / SENSOR 2	SENSOR 1
			GROUP	1~3	1
			ON POINT	-99.99 ~ 99.99m	0
			OFF POINT	-99.99 ~ 99.99m	0
		RELAY 3 (233)	FUNCTION	NONE/ LIMIT/ ALTERNATE/ ALARM	NONE
			OPERATE	SENSOR 1 / SENSOR 2	SENSOR 1
			GROUP	1~3	1
			ON POINT	-99.99 ~ 99.99m	0
			OFF POINT	-99.99 ~ 99.99m	0
		RELAY 4 (234)	FUNCTION	NONE/ LIMIT/ ALTERNATE/ ALARM	NONE
			OPERATE	SENSOR 1 / SENSOR 2	SENSOR 1
			GROUP	1~3	1
			ON POINT	-99.99 ~ 99.99m	0
			OFF POINT	-99.99 ~ 99.99m	0
		RELAY 5 (235)	FUNCTION	NONE/ LIMIT/ ALTERNATE/ ALARM	NONE
			OPERATE	SENSOR 1 / SENSOR 2	SENSOR 1
			GROUP	1~3	1
			ON POINT	-99.99 ~ 99.99m	0
			OFF POINT	-99.99 ~ 99.99m	0
		RELAY 6 (236)	FUNCTION	NONE/ LIMIT/ ALTERNATE/ ALARM	NONE
			OPERATE	SENSOR 1 / SENSOR 2	SENSOR 1
			GROUP	1~3	1
			ON POINT	-99.99 ~ 99.99m	0
			OFF POINT	-99.99 ~ 99.99m	0

1st MENU	2nd MENU	3rd MENU	4th MENU	Input Range	Default
LEVEL METER SETUP (200)	RELAY (230)	RELAY SIMULATION (237)	RELAY 1	ON/ OFF	OFF
			RELAY 2	ON/ OFF	OFF
			RELAY 3	ON/ OFF	OFF
			RELAY 4	ON/ OFF	OFF
			RELAY 5	ON/ OFF	OFF
			RELAY 6	ON/ OFF	OFF
	CURRENT OUTPUT (240)	CURRENT OUTPUT 1 (241)	4mA	-99.99 ~ 99.99m	0m
			20mA	-99.99 ~ 99.99m	10m
			ERROR	HOLD/ 3.8mA/ 22mA	22mA
		CURRENT OUTPUT 2 (242)	4mA	-99.99 ~ 99.99m	0m
			20mA	-99.99 ~ 99.99m	10m
			ERROR	HOLD/ 3.8mA/ 22mA	22mA
		CURRENT SIMULATION (243)	OUTPUT 1	MEASURE/ 3.8mA/ 4mA/ 12mA/ 20mA/ 22mA	MEASURE
			OUTPUT 2	MEASURE/ 3.8mA/ 4mA/ 12mA/ 20mA/ 22mA	MEASURE
	COMMUNICATION SETUP (250)	RS-232 SETUP (251)	USE	ENABLE/ DISABLE	ENABLE
			BAUDRATE	4800, 9600, 14400, 19200, 38400, 57600, 115200	9600
			PARITY	NONE/ ODD/ EVEN	NONE
			STOP BIT	1 or 2	1
			DATA BIT	8 or 9	8
			PROTOCOL	FLOMOTION/ BKCM/ Modbus-RTU/ Modbus-ASCII	FLOMOTION
		RS-485 SETUP (252)	USE	ENABLE/ DISABLE	DISABLE
			BAUDRATE	4800, 9600, 14400, 19200, 38400, 57600, 115200	9600
			PARITY	NONE/ ODD/ EVEN	NONE
			STOP BIT	1 or 2	1
			DATA BIT	8 or 9	8
			PROTOCOL	FLOMOTION/ BKCM/ Modbus-RTU/ Modbus-ASCII	FLOMOTION

1st MENU	2nd MENU	3rd MENU	4th MENU	Input Range	Default
LOGGING SETUP (300)	LOGGING PERIOD (310)	LOGGING PERIOD		NONE/ 10 SEC/ 1 MINUTE/ 5 MINUTE/ 10 MINUTE/ 15 MINUTE/ 30 MINUTE/ 60 MINUTE	NONE
	LOGGING ERASE (320)				
	USB LOGGING (330)				
SYSTEM SETUP (400)	SYSTEM INFO (410)				
	SYSTEM ID (420)	SYSTEM ID		0~99	0
		MODBUS ID		1~247	1
	SYSTEM TIME (430)	SYSTEM TIME		2000/00/00/ 00:00 ~ 2099/12/31 23:59	2013/1/1/00:00
	PASSWORD (440)	PASSWORD		0~9999	0
	LANGUAGE (450)	LANGUAGE		ENGLISH	ENGLISH
	FAIL SAFE TIME (460)			20~999 sec	300 sec
	DISPLAY TYPE (470)			TEMP/ CURRENT	TEMP
	SETTING BACKUP (480)				
	RESET (490)	MASTER RESET (491)			
		USER RESET (492)			
NAVIGATION (500)					

APPENDIX B. RS-232/RS-485 Protocol

PROTOCOL

Data Field	DATA START						System ID			YEAR					MONTH			DAY				HOUR			MIN.	
Byte Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Data	:	D	A	T	A		0	0		2	0	1	3		0	1		0	1		0	0		0	0	
Data Field	SECOND			UNIT		SENSOR1 Level							SENSOR2 Level							SENSOR1-SENSOR2 Level							
Byte Number	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Data	0	0		M		0	0	0	0	0	0		0	0	0	0	0	0		0	0	0	0	0	0	
Data Field	SENSOR1-SENSOR2 Level						SENSOR1 Volume												SENSOR2 Volume							
Byte Number	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
Data	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
Data Field	TEMP. UNIT			SENSOR1 TEMPERATURE								SENSOR2 TEMPERATURE							DATA END							
Byte Number	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99					
Data		C		+/-	0	0	0	0	.	0		+/-	0	0	0	0	.	0		₩n	₩r					

2. DATA FORMAT

- System ID: System ID
- YEAR/MONTH/DAY/HOUR/MINUTE/SECOND : DATA LOGGING TIME
- UNIT: MEASUREMENT UNIT

UNIT					
mm	cm	m	ft	in	yd

- SENSOR1 Level: Measurement value of SENSOR1.
- SENSOR2 Level: Measurement value of SENSOR2.
- SENSOR1-SENSOR2 Level: Differentiation subtracted SENSOR2 from SENSOR1
- SENSOR2-SENSOR1 Level: Differentiation subtracted SENSOR1 from SENSOR2.
- SENSOR1 Volume: Measurement value of SENSOR1 Volume.
- SENSOR2 Volume: Measurement value of SENSOR2 Volume.
- Temp. unit : the unit of temperature

Temperature unit	
C	℃
F	℉

- SENSOR1 Temperature: Temperature of SENSOR1
- SENSOR2 Temperature: Temperature of SENSOR1
- DATA END: The sign of DATA end. “\n\r(Line feed(0x12),carrage return(0x15))”

2. BKCM PROTOCOL

"This protocol is designed for a company. It isn't printed in this manual."

3. Modbus

SL-100S provides Modbus RTU and Modbus ASCII. It is Read Holding Registers only, Modbus ID is available between 1~ 247. Modbus ID setting menu locates as below.

- SYSTEM SETUP->SYSTEM ID->Modbus ID

Type	Description	Start Register		Register Offset		Registers	Data Description
		Hex	Decimal	Hex	Decimal		
ID	Product code	8001	32769	8000	32768	1	0 = Level(SL-100S)
							10 = Flow(SF-500S)
							20 = Sludge(SL-300S)
Unit	Measurement Unit (Level)	8002	32770	8001	32769	1	1 = Meter
							2 = Millimeter
							3 = Centimeter
							4 = feet
							5 = inch
							6 = yard
	Temperature Unit	8004	32772	8003	32771	1	0 = ℃
							1 = ℉

Type	Description	Start Register		Register Offset		Registers	Data Description	
		Hex	Decimal	Hex	Decimal			
Data	Distance1	8011	32785	8010	32784	2	SENSOR1 Distance	float
	Level1	8013	32787	8012	32786	2	SENSOR1 level	float
	Space1	8015	32789	8014	32788	2	SENSOR1 space	float
	Volume1	8017	32791	8016	32790	2	SENSOR1 volume	float
	Distance2	8019	32793	8018	32792	2	SENSOR2 Distance	float
	Level2	801B	32795	801A	32794	2	SENSOR2 level	float
Data	Space2	801D	32797	801C	32796	2	SENSOR2 space	float
	Volume2	801F	32799	801E	32798	2	SENSOR2 volume	float
	Temp 1(inside)	802B	32811	802A	32810	2	SENSOR1 temperature	float
	Temp 2(inside)	802D	32813	802C	32812	2	SENSOR2 temperature	float
	Temp (outside)	802F	32815	802E	32814	2	Outside temperature	float
Relay	Relay control status	8031	32817	8030	32816	1	Bit Mapped	
							0bxxxx xxx0 / (0x00)	Relay 1 Off
							0bxxxx xxx1 / (0x01)	Relay 1 On
							0bxxxx xx0x / (0x00)	Relay 2 Off
							0bxxxx xx1x / (0x02)	Relay 2 On
							0bxxxx x0xx / (0x00)	Relay 3 Off
							0bxxxx x1xx / (0x04)	Relay 3 On
							0bxxxx 0xxx / (0x00)	Relay 4 Off
							0bxxxx 1xxx / (0x08)	Relay 4 On
							0bxxx0 xxxx / (0x00)	Relay 5 Off
							0bxxx1 xxxx / (0x10)	Relay 5 On
							0bxx0x xxxx / (0x00)	Relay 6 Off
							0bxx1x xxxx / (0x20)	Relay 6 On

Request PDU Example

- Product code Request

Function Code	Data Request	
	Register Offset	Quantity
0 X 03	0 X 8000	0 X 0001

- Distance, Level, Space, Volume Request

Function Code	Data Request	
	Register Offset	Quantity
0 X 03	0 X 8000	0 X 0002
0 X 03	0 X 8012	0 X 0002
0 X 03	0 X 8014	0 X 0002
0 X 03	0 X 8016	0 X 0002

Modbus Register Data type

- Data field: 4byte float type
- ID, UNIT, Relay field: Unsigned short(2byte) type

APPENDIX C. Volume Table

VERTICAL CYLINDER - CONICAL BOTTOM

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
A[m]		0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
h[m]	0.5	0.13	0.03	0.01	1.18	0.29	0.07	3.27	0.82	0.20	6.41	1.60	0.40	10.60	2.65	0.66
	1.0	0.52	0.26	0.07	4.71	2.36	0.59	13.09	6.54	1.64	25.66	12.83	3.21	42.41	21.21	5.30
	1.5	0.92	0.65	0.22	8.25	5.89	1.99	22.91	16.36	5.52	44.90	32.07	10.82	74.22	53.01	17.89
	2.0	1.31	1.05	0.52	11.78	9.42	4.71	32.72	26.18	13.09	64.14	51.31	25.66	106.03	84.82	42.41
	2.5	1.70	1.44	0.92	15.32	12.96	8.25	42.54	36.00	22.91	83.38	70.55	44.90	137.84	116.63	74.22
	3.0	2.09	1.83	1.31	18.85	16.49	11.78	52.36	45.81	32.72	102.63	89.80	64.14	169.65	148.44	106.03
	3.5	2.49	2.23	1.70	22.38	20.03	15.32	62.18	55.63	42.54	121.87	109.04	83.38	201.45	180.25	137.84
	4.0	2.88	2.62	2.09	25.92	23.56	18.85	71.99	65.45	52.36	141.11	128.28	102.63	233.26	212.06	169.65
	4.5	3.27	3.01	2.49	29.45	27.10	22.38	81.81	75.27	62.18	160.35	147.52	121.87	265.07	243.87	201.45
	5.0	3.67	3.40	2.88	32.99	30.63	25.92	91.63	85.08	71.99	179.59	166.77	141.11	296.88	275.67	233.26
	5.5	4.06	3.80	3.27	36.52	34.16	29.45	101.45	94.90	81.81	198.84	186.01	160.35	328.69	307.48	265.07
	6.0	4.45	4.19	3.67	40.06	37.70	32.99	111.26	104.72	91.63	218.08	205.25	179.59	360.50	339.29	296.88
	6.5	4.84	4.58	4.06	43.59	41.23	36.52	121.08	114.54	101.45	237.32	224.49	198.84	392.31	371.10	328.69
	7.0	5.24	4.97	4.45	47.12	44.77	40.06	130.90	124.35	111.26	256.56	243.74	218.08	424.12	402.91	360.50
	7.5	5.63	5.37	4.84	50.66	48.30	43.59	140.72	134.17	121.08	275.81	262.98	237.32	455.92	434.72	392.31
	8.0	6.02	5.76	5.24	54.19	51.84	47.12	150.53	143.99	130.90	295.05	282.22	256.56	487.73	466.53	424.12
	8.5	6.41	6.15	5.63	57.73	55.37	50.66	160.35	153.81	140.72	314.29	301.46	275.81	519.54	498.34	455.92
	9.0	6.81	6.54	6.02	61.26	58.90	54.19	170.17	163.62	150.53	333.53	320.70	295.05	551.35	530.14	487.73
	9.5	7.20	6.94	6.41	64.80	62.44	57.73	179.99	173.44	160.35	352.77	339.95	314.29	583.16	561.95	519.54
	10.0	7.59	7.33	6.81	68.33	65.97	61.26	189.80	183.26	170.17	372.02	359.19	333.53	614.97	593.76	551.35
	10.5	7.98	7.72	7.20	71.86	69.51	64.80	199.62	193.08	179.99	391.26	378.43	352.77	646.78	625.57	583.16

- D: Tank diameter
- A: Bottom length
- h: Level height
- unit: m3

VERTICAL CYLINDER - CONICAL BOTTOM

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
A[m]		0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
h[m]	11.0	8.38	8.12	7.59	75.40	73.04	68.33	209.44	202.89	189.80	410.50	397.67	372.02	678.58	657.38	614.97
	11.5	8.77	8.51	7.98	78.93	76.58	71.86	219.26	212.71	199.62	429.74	416.92	391.26	710.39	689.19	646.78
	12.0	9.16	8.90	8.38	82.47	80.11	75.40	229.07	222.53	209.44	448.99	436.16	410.50	742.20	721.00	678.58
	12.5	9.56	9.29	8.77	86.00	83.64	78.93	238.89	232.35	219.26	468.23	455.40	429.74	774.01	752.80	710.39
	13.0	9.95	9.69	9.16	89.54	87.18	82.47	248.71	242.16	229.07	487.47	474.64	448.99	805.82	784.61	742.20
	13.5	10.34	10.08	9.56	93.07	90.71	86.00	258.53	251.98	238.89	506.71	493.88	468.23	837.63	816.42	774.01
	14.0	10.73	10.47	9.95	96.60	94.25	89.54	268.34	261.80	248.71	525.95	513.13	487.47	869.44	848.23	805.82
	14.5	11.13	10.86	10.34	100.14	97.78	93.07	278.16	271.62	258.53	545.20	532.37	506.71	901.24	880.04	837.63
	15.0	11.52	11.26	10.73	103.67	101.32	96.60	287.98	281.43	268.34	564.44	551.61	525.95	933.05	911.85	869.44

- D: Tank diameter
- A: Bottom length
- h: Level height
- unit: m3

	11.5	8.90	8.77	8.51	80.11	78.93	76.58	222.53	219.26	212.71	436.16	429.74	416.92	721.00	710.39	689.19
	12.0	9.29	9.16	8.90	83.64	82.47	80.11	232.35	229.07	222.53	455.40	448.99	436.16	752.80	742.20	721.00
	12.5	9.69	9.56	9.29	87.18	86.00	83.64	242.16	238.89	232.35	474.64	468.23	455.40	784.61	774.01	752.80

- D: Tank diameter
- A: Bottom length
- h: Level height
- unit: m3

VERTICAL CYLINDER - ELLIPSOIDAL BOTTOM

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
A[m]		0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
h[m]	13.0	10.08	9.95	9.69	90.71	89.54	87.18	251.98	248.71	242.16	493.88	487.47	474.64	816.42	805.82	784.61
	13.5	10.47	10.34	10.08	94.25	93.07	90.71	261.80	258.53	251.98	513.13	506.71	493.88	848.23	837.63	816.42
	14.0	10.86	10.73	10.47	97.78	96.60	94.25	271.62	268.34	261.80	532.37	525.95	513.13	880.04	869.44	848.23
	14.5	11.26	11.13	10.86	101.32	100.14	97.78	281.43	278.16	271.62	551.61	545.20	532.37	911.85	901.24	880.04
	15.0	11.65	11.52	11.26	104.85	103.67	101.32	291.25	287.98	281.43	570.85	564.44	551.61	943.66	933.05	911.85

VERTICAL CYLINDER - SPHERICAL BOTTOM

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
A[m]		0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
h[m]	0.5	0.26	0.36	0.70	1.83	1.15	1.10	4.97	2.72	1.88	9.69	5.07	3.06	15.97	8.21	4.63
	1.0	0.65	0.92	2.29	5.37	4.06	3.86	14.79	10.34	7.00	28.93	19.77	11.72	47.78	32.33	18.00
	1.5	1.05	1.31	3.98	8.90	7.59	7.51	24.61	20.16	14.58	48.17	39.01	25.18	79.59	64.14	39.32
	2.0	1.44	1.70	4.97	12.44	11.13	11.26	34.43	29.98	23.82	67.41	58.25	42.67	111.40	95.95	67.81
	2.5	1.83	2.09	5.37	15.97	14.66	14.79	44.24	39.79	33.64	86.66	77.49	61.92	143.20	127.76	99.61
	3.0	2.23	2.49	5.76	19.50	18.20	18.33	54.06	49.61	43.46	105.90	96.73	81.16	175.01	159.57	131.42
	3.5	2.62	2.88	6.15	23.04	21.73	21.86	63.88	59.43	53.28	125.14	115.98	100.40	206.82	191.38	163.23
	4.0	3.01	3.27	6.54	26.57	25.26	25.39	73.70	69.25	63.09	144.38	135.22	119.64	238.63	223.18	195.04
	4.5	3.40	3.67	6.94	30.11	28.80	28.93	83.51	79.06	72.91	163.62	154.46	138.88	270.44	254.99	226.85
	5.0	3.80	4.06	7.33	33.64	32.33	32.46	93.33	88.88	82.73	182.87	173.70	158.13	302.25	286.80	258.66
	5.5	4.19	4.45	7.72	37.18	35.87	36.00	103.15	98.70	92.55	202.11	192.95	177.37	334.06	318.61	290.47
	6.0	4.58	4.84	8.12	40.71	39.40	39.53	112.97	108.52	102.36	221.35	212.19	196.61	365.86	350.42	322.28
	6.5	4.97	5.24	8.51	44.24	42.94	43.07	122.78	118.33	112.18	240.59	231.43	215.85	397.67	382.23	354.08
	7.0	5.37	5.63	8.90	47.78	46.47	46.60	132.60	128.15	122.00	259.84	250.67	235.10	429.48	414.04	385.89
	7.5	5.76	6.02	9.29	51.31	50.00	50.13	142.42	137.97	131.82	279.08	269.92	254.34	461.29	445.84	417.70
	8.0	6.15	6.41	9.69	54.85	53.54	53.67	152.24	147.79	141.63	298.32	289.16	273.58	493.10	477.65	449.51
	8.5	6.54	6.81	10.08	58.38	57.07	57.20	162.05	157.60	151.45	317.56	308.40	292.82	524.91	509.46	481.32
	9.0	6.94	7.20	10.47	61.92	60.61	60.74	171.87	167.42	161.27	336.80	327.64	312.06	556.72	541.27	513.13
	9.5	7.33	7.59	10.86	65.45	64.14	64.27	181.69	177.24	171.09	356.05	346.88	331.31	588.53	573.08	544.94
	10.0	7.72	7.98	11.26	68.98	67.68	67.81	191.51	187.06	180.90	375.29	366.13	350.55	620.33	604.89	576.74
	10.5	8.12	8.38	11.65	72.52	71.21	71.34	201.32	196.87	190.72	394.53	385.37	369.79	652.14	636.70	608.55
	11.0	8.51	8.77	12.04	76.05	74.74	74.87	211.14	206.69	200.54	413.77	404.61	389.03	683.95	668.50	640.36
	11.5	8.90	9.16	12.44	79.59	78.28	78.41	220.96	216.51	210.36	433.02	423.85	408.28	715.76	700.31	672.17
	12.0	9.29	9.56	12.83	83.12	81.81	81.94	230.78	226.33	220.17	452.26	443.10	427.52	747.57	732.12	703.98
	12.5	9.69	9.95	13.22	86.66	85.35	85.48	240.59	236.14	229.99	471.50	462.34	446.76	779.38	763.93	735.79

VERTICAL CYLINDER - SPHERICAL BOTTOM

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
A[m]		0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
h[m]	13.0	10.08	10.34	13.61	90.19	88.88	89.01	250.41	245.96	239.81	490.74	481.58	466.00	811.19	795.74	767.60
	13.5	10.47	10.73	14.01	93.72	92.42	92.55	260.23	255.78	249.63	509.99	500.82	485.25	842.99	827.55	799.40
	14.0	10.86	11.13	14.40	97.26	95.95	96.08	270.05	265.60	259.44	529.23	520.06	504.49	874.80	859.36	831.21
	14.5	11.26	11.52	14.79	100.79	99.48	99.61	279.86	275.41	269.26	548.47	539.31	523.73	906.61	891.17	863.02
	15.0	11.65	11.91	15.18	104.33	103.02	103.15	289.68	285.23	279.08	567.71	558.55	542.97	938.42	922.97	894.83

- D: Tank diameter
- A: Bottom length
- h: Level height
- unit: m^3

VERTICAL CYLINDER - FLAT BOTTOM

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
h[m]	0.5	0.39	0.39	0.39	3.53	3.53	3.53	9.82	9.82	9.82	19.24	19.24	19.24	31.81	31.81	31.81
	1.0	0.79	0.79	0.79	7.07	7.07	7.07	19.63	19.63	19.63	38.48	38.48	38.48	63.62	63.62	63.62
	1.5	1.18	1.18	1.18	10.60	10.60	10.60	29.45	29.45	29.45	57.73	57.73	57.73	95.43	95.43	95.43
	2.0	1.57	1.57	1.57	14.14	14.14	14.14	39.27	39.27	39.27	76.97	76.97	76.97	127.23	127.23	127.23
	2.5	1.96	1.96	1.96	17.67	17.67	17.67	49.09	49.09	49.09	96.21	96.21	96.21	159.04	159.04	159.04
	3.0	2.36	2.36	2.36	21.21	21.21	21.21	58.90	58.90	58.90	115.45	115.45	115.45	190.85	190.85	190.85
	3.5	2.75	2.75	2.75	24.74	24.74	24.74	68.72	68.72	68.72	134.70	134.70	134.70	222.66	222.66	222.66
	4.0	3.14	3.14	3.14	28.27	28.27	28.27	78.54	78.54	78.54	153.94	153.94	153.94	254.47	254.47	254.47
	4.5	3.53	3.53	3.53	31.81	31.81	31.81	88.36	88.36	88.36	173.18	173.18	173.18	286.28	286.28	286.28
	5.0	3.93	3.93	3.93	35.34	35.34	35.34	98.17	98.17	98.17	192.42	192.42	192.42	318.09	318.09	318.09
	5.5	4.32	4.32	4.32	38.88	38.88	38.88	107.99	107.99	107.99	211.66	211.66	211.66	349.89	349.89	349.89
	6.0	4.71	4.71	4.71	42.41	42.41	42.41	117.81	117.81	117.81	230.91	230.91	230.91	381.70	381.70	381.70
	6.5	5.11	5.11	5.11	45.95	45.95	45.95	127.63	127.63	127.63	250.15	250.15	250.15	413.51	413.51	413.51
	7.0	5.50	5.50	5.50	49.48	49.48	49.48	137.44	137.44	137.44	269.39	269.39	269.39	445.32	445.32	445.32
	7.5	5.89	5.89	5.89	53.01	53.01	53.01	147.26	147.26	147.26	288.63	288.63	288.63	477.13	477.13	477.13
	8.0	6.28	6.28	6.28	56.55	56.55	56.55	157.08	157.08	157.08	307.88	307.88	307.88	508.94	508.94	508.94
	8.5	6.68	6.68	6.68	60.08	60.08	60.08	166.90	166.90	166.90	327.12	327.12	327.12	540.75	540.75	540.75
	9.0	7.07	7.07	7.07	63.62	63.62	63.62	176.71	176.71	176.71	346.36	346.36	346.36	572.56	572.56	572.56
	9.5	7.46	7.46	7.46	67.15	67.15	67.15	186.53	186.53	186.53	365.60	365.60	365.60	604.36	604.36	604.36
	10.0	7.85	7.85	7.85	70.69	70.69	70.69	196.35	196.35	196.35	384.85	384.85	384.85	636.17	636.17	636.17
	10.5	8.25	8.25	8.25	74.22	74.22	74.22	206.17	206.17	206.17	404.09	404.09	404.09	667.98	667.98	667.98
	11.0	8.64	8.64	8.64	77.75	77.75	77.75	215.98	215.98	215.98	423.33	423.33	423.33	699.79	699.79	699.79
	11.5	9.03	9.03	9.03	81.29	81.29	81.29	225.80	225.80	225.80	442.57	442.57	442.57	731.60	731.60	731.60
	12.0	9.42	9.42	9.42	84.82	84.82	84.82	235.62	235.62	235.62	461.81	461.81	461.81	763.41	763.41	763.41
	12.5	9.82	9.82	9.82	88.36	88.36	88.36	245.44	245.44	245.44	481.06	481.06	481.06	795.22	795.22	795.22
	13.0	10.21	10.21	10.21	91.89	91.89	91.89	255.25	255.25	255.25	500.30	500.30	500.30	827.02	827.02	827.02

VERTICAL CYLINDER - FLAT BOTTOM

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
h[m]	13.5	10.60	10.60	10.60	95.43	95.43	95.43	265.07	265.07	265.07	519.54	519.54	519.54	858.83	858.83	858.83
	14.0	11.00	11.00	11.00	98.96	98.96	98.96	274.89	274.89	274.89	538.78	538.78	538.78	890.64	890.64	890.64
	14.5	11.39	11.39	11.39	102.49	102.49	102.49	284.71	284.71	284.71	558.03	558.03	558.03	922.45	922.45	922.45
	15.0	11.78	11.78	11.78	106.03	106.03	106.03	294.52	294.52	294.52	577.27	577.27	577.27	954.26	954.26	954.26

- D: Tank diameter
- A: Bottom length
- h: Level height
- unit: m^3

HORIZONTAL CYLINDER - CONICAL HEAD

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
A[m]		0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
h[m]	0.5	2.09	2.23	2.49	3.97	4.07	4.27	5.19	5.27	5.43	6.17	6.24	6.38	7.01	7.07	7.20
	1.0	4.19	4.45	4.97	10.81	11.31	12.32	14.40	14.83	15.68	17.24	17.61	18.35	19.65	19.99	20.66
	1.5				18.85	20.03	22.38	25.87	26.96	29.16	31.22	32.20	34.17	35.74	36.63	38.42
	2.0				26.89	28.74	32.45	38.75	40.82	44.97	47.29	49.21	53.06	54.40	56.18	59.72
	2.5				33.73	35.98	40.50	52.36	55.63	62.18	64.87	68.05	74.41	75.08	78.06	84.02
	3.0				37.70	40.06	44.77	65.97	70.44	79.38	83.48	88.18	97.59	97.32	101.83	110.84
	3.5							78.85	84.30	95.20	102.63	109.04	121.87	120.74	127.07	139.72
	4.0							90.32	96.43	108.67	121.77	129.90	146.14	144.98	153.36	170.14
	4.5							99.53	106.00	118.93	140.38	150.03	169.33	169.65	180.25	201.45
	5.0							104.72	111.26	124.35	157.96	168.87	190.68	194.32	207.13	232.77
	5.5										174.03	185.88	209.57	218.55	233.43	263.18
	6.0										188.02	200.47	225.38	241.97	258.67	292.07
	6.5										199.08	211.84	237.36	264.21	282.44	318.89
	7.0										205.25	218.08	243.74	284.89	304.32	343.19
	7.5													303.55	323.86	364.49
	8.0													319.64	340.51	382.25
	8.5													332.28	353.42	395.71

- D: Tank diameter
- A: Bottom length
- h: Level height
- unit: m^3

HORIZONTAL CYLINDER - ELLIPSOIDAL HEAD

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
A[m]		0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
h[m]	0.5	2.23	2.49	3.01	4.22	4.57	5.27	5.48	5.84	6.58	6.47	6.85	7.60	7.33	7.71	8.46
	1.0	4.45	4.97	6.02	11.53	12.76	15.20	15.34	16.70	19.42	18.28	19.70	22.55	20.77	22.23	25.14
	1.5				20.03	22.38	27.10	27.60	30.43	36.08	33.26	36.29	42.35	37.99	41.13	47.41
	2.0				28.52	32.01	38.99	41.28	45.89	55.10	50.45	55.54	65.71	57.99	63.34	74.04
	2.5				35.83	40.20	48.92	55.63	62.18	75.27	69.17	76.65	91.61	80.10	88.10	104.10
	3.0				40.06	44.77	54.19	69.99	78.47	95.43	88.87	98.97	119.16	103.81	114.81	136.80
	3.5							83.67	93.93	114.45	109.04	121.87	147.52	128.67	142.92	171.43
	4.0							95.93	107.65	131.11	129.21	144.77	175.89	154.28	171.96	207.33
	4.5							105.79	118.51	143.96	148.91	167.08	203.43	180.25	201.45	243.87
	5.0							111.26	124.35	150.53	167.63	188.20	229.34	206.22	230.95	280.40
	5.5										184.82	207.44	252.70	231.83	259.99	316.30
	6.0										199.80	224.03	272.50	256.69	288.10	350.94
	6.5										211.60	236.89	287.45	280.40	314.81	383.63
	7.0										218.08	243.74	295.05	302.51	339.57	413.69
	7.5													322.51	361.78	440.32
	8.0													339.72	380.68	462.59
	8.5													353.17	395.20	479.27
	9.0													360.50	402.91	487.73

HORIZONTAL CYLINDER - GUPPY HEAD

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
A[m]		0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
h[m]	0.5	2.04	2.11	2.26	3.92	3.97	4.08	5.15	5.19	5.27	6.14	6.17	6.24	6.98	7.01	7.08
	1.0	4.19	4.45	4.97	10.58	10.85	11.39	14.20	14.42	14.86	17.05	17.24	17.63	19.49	19.66	20.00
	1.5				18.35	19.03	20.38	25.35	25.94	27.10	30.74	31.26	32.28	35.31	35.77	36.69
	2.0				26.28	27.53	30.03	37.81	38.95	41.22	46.38	47.40	49.43	53.56	54.48	56.32
	2.5				33.36	35.25	39.04	50.97	52.85	56.62	63.41	65.13	68.56	73.67	75.24	78.39
	3.0				37.70	40.06	44.77	64.30	67.09	72.68	81.38	84.00	89.22	95.23	97.65	102.48
	3.5							77.23	81.05	88.70	99.90	103.60	110.98	117.87	121.33	128.24
	4.0							89.10	94.00	103.80	118.59	123.53	133.40	141.28	145.97	155.35
	4.5							98.97	104.87	116.68	137.05	143.37	156.01	165.15	171.25	183.45
	5.0							104.72	111.26	124.35	154.85	162.65	178.24	189.18	196.86	212.23
	5.5										171.50	180.81	199.42	213.08	222.48	241.30
	6.0										186.33	197.10	218.64	236.52	247.77	270.26
	6.5										198.37	210.42	234.52	259.15	272.31	298.64
	7.0										205.25	218.08	243.74	280.56	295.67	325.89
	7.5													300.26	317.28	351.32
	8.0													317.57	336.37	373.97
	8.5													331.44	351.75	392.37
	9.0													339.29	360.50	402.91

HORIZONTAL CYLINDER - SPHERICAL HEAD

D[m]		1	1	1	3	3	3	5	5	5	7	7	7	9	9	9
A[m]		0.2	0.3	0.5	0.5	1.0	1.5	1.0	2.0	2.5	1.0	3.5	5.0	1.0	3.0	4.5
h[m]	0.5	3.62	3.67	3.80	7.16	7.46	8.02	9.54	10.25	11.03	11.26	12.64	12.02	13.45	13.74	17.01
	1.0	7.23	7.33	7.59	19.43	20.55	22.23	26.83	29.63	31.97	31.81	37.42	35.18	38.03	39.54	51.45
	1.5				33.64	35.87	38.88	48.55	54.40	58.73	58.06	70.27	65.74	69.72	73.52	98.30
	2.0				47.86	51.18	55.53	72.97	82.49	89.05	88.42	109.06	101.77	106.86	114.03	155.10
	2.5				60.12	64.28	69.74	98.70	112.18	121.08	121.70	152.09	141.73	148.35	159.89	220.00
	3.0				67.28	71.73	77.75	124.42	141.87	153.12	156.86	197.89	184.25	193.33	210.07	291.45
	3.5							148.84	169.96	183.44	192.95	245.04	228.02	240.99	263.66	368.01
	4.0							170.56	194.74	210.20	229.03	292.20	271.80	290.65	319.77	448.34
	4.5							187.86	214.11	231.13	264.19	338.00	314.32	341.61	377.55	531.16
	5.0							197.40	224.36	242.16	297.47	381.03	354.28	393.22	436.16	615.23
	5.5										327.83	419.82	390.31	444.83	494.77	699.29
	6.0										354.08	452.67	420.87	495.80	552.55	782.12
	6.5										374.63	477.45	444.03	545.45	608.66	862.45
	7.0										385.89	490.09		593.12	662.25	939.01
	7.5													638.09	712.43	1010.45
	8.0													679.59	758.28	1075.36
	8.5													716.73	798.80	1132.16
	9.0													748.41	832.78	1179.01
	9.5													773.00	858.58	1213.45
	10.0													786.45	872.32	1230.46

HORIZONTAL CYLINDER - FLAT HEAD

D[m]		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
h[m]	0.5	0.39	0.61	0.77	0.91	1.02	1.13	1.22	1.31	1.39	1.47	1.54	1.61	1.68	1.74	1.81
	1.0	0.79	1.57	2.06	2.46	2.80	3.10	3.37	3.63	3.86	4.09	4.30	4.50	4.69	4.88	5.06
	1.5		2.53	3.53	4.30	4.95	5.53	6.05	6.52	6.97	7.39	7.78	8.16	8.52	8.86	9.20
	2.0		3.14	5.01	6.28	7.33	8.25	9.07	9.83	10.53	11.18	11.80	12.39	12.95	13.49	14.01
	2.5			6.29	8.26	9.82	11.15	12.34	13.42	14.42	15.35	16.24	17.07	17.87	18.63	19.36
	3.0			7.07	10.11	12.30	14.14	15.75	17.22	18.56	19.82	21.00	22.11	23.17	24.19	25.16
	3.5				11.66	14.68	17.12	19.24	21.14	22.88	24.50	26.01	27.44	28.80	30.10	31.34
	4.0				12.57	16.84	20.02	22.73	25.13	27.32	29.34	31.22	33.00	34.69	36.29	37.83
	4.5					18.61	22.75	26.15	29.12	31.81	34.28	36.58	38.74	40.78	42.73	44.59
	5.0					19.63	25.18	29.41	33.05	36.30	39.27	42.02	44.60	47.04	49.35	51.56
	5.5						27.15	32.44	36.85	40.73	44.26	47.52	50.56	53.42	56.13	58.72
	6.0						28.27	35.11	40.44	45.05	49.20	53.01	56.55	59.87	63.02	66.01
	6.5							37.26	43.74	49.20	54.04	58.46	62.54	66.37	69.97	73.40
	7.0							38.48	46.64	53.09	58.72	63.81	68.49	72.86	76.97	80.86
	7.5								48.96	56.65	63.19	69.02	74.36	79.31	83.96	88.36
	8.0								50.27	59.75	67.36	74.04	80.10	85.69	90.92	95.85
	8.5									62.23	71.15	78.80	85.66	91.95	97.81	103.31
	9.0									63.62	74.45	83.23	90.99	98.05	104.58	110.71
	9.5										77.07	87.25	96.03	103.93	111.21	118.00
	10.0										78.54	90.73	100.71	109.56	117.65	125.15
	10.5											93.49	104.94	114.87	123.84	132.13
	11.0											95.03	108.60	119.78	129.75	138.88
	11.5												111.48	124.21	135.31	145.38
	12.0												113.10	128.04	140.45	151.55
	12.5													131.05	145.07	157.36
h[m]	13.0													132.73	149.06	162.71
	13.5														152.19	167.52
	14.0														153.94	171.66
	14.5															174.91
	15.0															176.71

VERTICAL CYLINDER - SPHERICAL BOTTOM

D[m]		1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
h[m]	0.5	0.26	1.05	1.83	2.62	3.40	4.19	4.97	5.76	6.54	7.33	8.12	8.90	9.69	10.47	11.65
	1.0		3.67	6.81	9.95	13.09	16.23	19.37	22.51	25.66	28.80	31.94	35.08	38.22	41.36	46.08
	1.5		7.07	14.14	21.21	28.27	35.34	42.41	49.48	56.55	63.62	70.69	77.75	84.82	91.89	102.49
	2.0			23.04	35.60	48.17	60.74	73.30	85.87	98.44	111.00	123.57	136.14	148.70	161.27	180.12
	2.5			32.72	52.36	71.99	91.63	111.26	130.90	150.53	170.17	189.80	209.44	229.07	248.71	278.16
	3.0				70.69	98.96	127.23	155.51	183.78	212.06	240.33	268.61	296.88	325.15	353.43	395.84
	3.5				89.80	128.28	166.77	205.25	243.74	282.22	320.70	359.19	397.67	436.16	474.64	532.37
	4.0					159.17	209.44	259.70	309.97	360.24	410.50	460.77	511.03	561.30	611.56	686.96
	4.5					190.85	254.47	318.09	381.70	445.32	508.94	572.56	636.17	699.79	763.41	858.83
	5.0						301.07	379.61	458.15	536.69	615.23	693.77	772.31	850.85	929.39	1047.20
	5.5						348.45	443.49	538.52	633.55	728.59	823.62	918.65	1013.69	1108.72	1251.27
	6.0							508.94	622.04	735.13	848.23	961.33	1074.42	1187.52	1300.62	1470.27
	6.5							575.17	707.91	840.64	973.37	1106.10	1238.83	1371.57	1504.30	1703.40
	7.0								795.35	949.28	1103.22	1257.16	1411.10	1565.04	1718.97	1949.88
	7.5								883.57	1060.29	1237.00	1413.72	1590.43	1767.15	1943.86	2208.93
	8.0									1172.86	1373.92	1574.99	1776.05	1977.11	2178.17	2479.76
	8.5									1286.22	1513.20	1740.18	1967.16	2194.14	2421.12	2761.59
	9.0										1654.05	1908.52	2162.99	2417.46	2671.92	3053.63
	9.5										1795.68	2079.21	2362.74	2646.27	2929.80	3355.09
	10.0											2251.47	2565.63	2879.79	3193.95	3665.19
	10.5											2424.52	2770.88	3117.25	3463.61	3983.15

VERTICAL CYLINDER - SPHERICAL BOTTOM

D[m]		1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
h[m]	11.0												2977.71	3357.84	3737.97	4308.17
	11.5												3185.31	3600.79	4016.26	4639.48
	12.0													3845.31	4297.70	4976.28
	12.5													4090.62	4581.49	5317.80
	13.0														4866.85	5663.24
	13.5														5153.00	6011.83
	14.0															6362.77
	14.5															6715.29
	15.0															7068.58

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