ULTRASONIC OPEN CHANNEL FLOW METER

SF-500S

USER'S MANUAL

Please read this manual attentively before installation

SONDAR

Contents

About this Manual

This manual provides important information about the installation, wiring, operation, and control of SF-500S and its sensors; LXD-04. 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.

This manual is provided an electronic version only. The electric version is provided with the product package or it can be downloaded through our website (www.sondar.com).

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.

Safety Guide Instruction

I. Safety Guide Instruction

1. Authorized Personnel

The installation and operation of the product must be carried out by licensed experts or qualified personnel. Please always wear protective equipment when operating the products.

2. Operation

Before operating the unit, please read this manual thoroughly. The manufacturer isn't responsible accidents caused by user's misuse or modification of the product without manufacture's permission. Conduct periodic inspection of the product.

3. Cautions

This manual provides all information you need to operate SF-500S, maintain and trouble shoot. Please follow the instructions. The manufacturer is not responsible in any way for the risk of an accident when user doesn't follow the instructions.

4. Product Inspection

When opening the product package box, look carefully to determine if the products or accessories have been damaged or contaminated. If the product has been damaged, it may not function properly.

5. Symbols

Caution:

If it is ignored, faults or malfunctions could be result.

Warning:

If it is ignored, injury to people and serious damage to the instrument could be result.

Electric Shock

If it is ignored, the product could be damaged by electric shock

Information:

It provides additional information.

Product Description

SF-500S | LXD-04

II. PRODUCT

SF-500S is an ultrasonic non-contacting flow meter for open channels. The measured level value is converted into the rate of flow in specific weirs or flumes therefore the accurate level value is very important. LXD-04 is an exclusive sensor for open channel flow, it provides accurate level reading.

SF-500S provides a variety of weirs and flumes formulations so it can be used in different applications. The measured flow information is saved in the memory of SF-500S and it can be downloaded by USB or transmitted by the digital communication such as RS232, RS485 or Modbus.

Application:

LXD-Series sensors are suitable for liquids level monitoring in all industries, particularly in the water and wastewater industry.

Weirs & Flumes

- ✓ Parshall Flume
- ✓ Suppressed Rectangular Weir
- ✓ Contracted Rectangular Weir
- ✓ V-Notch[Triangular] Weir
- ✓ Cipolletti Weir
- ✓ Leopold Lagco Flume
- ✓ Palmer Bowlus Flume
- ✓ H Flume
- ✓ Trapezoidal Flume

- Compatible sensors only LXD-04.
- XDS-300 sensor is not compatible with the SF-500S controller.

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

1. Principle of operation

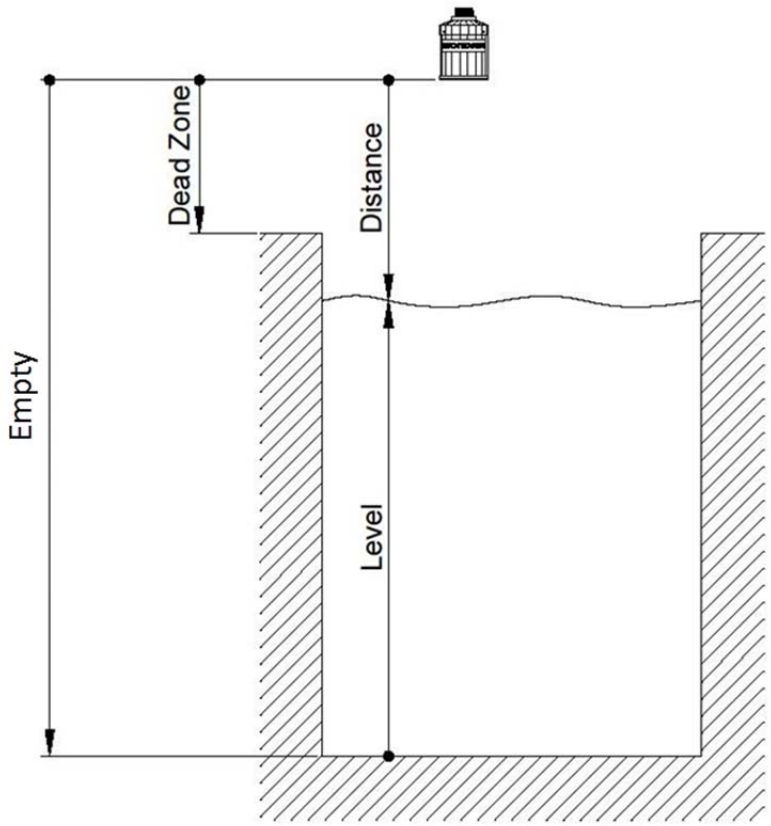
LXD-Series, the sensor transmits ultrasonic pulses to the measurement target. The pulses are reflected from the surface of the target and received back by the sensor. The running time is converted into the distance and it is converted the level. The measured level is also converted into flow rate according to the selected primary measurement device of SF-500S.

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

SF-500S (Controller)	
Measurement Method	Ultrasonic non-contacting
Measurement Range	0.00m^3 /h~ 200,000.00m^3 /h
Accuracy	0.2% of F.S
Resolution	1mm
Damping Rate	0.1m/min - 100m/min adjustable
Data Logging Period	Maximum 672 days (1hr interval)
Output Analog	Two Analog 4~20mA, max 750Ω isolated
	3 Relays
	Digital RS232, RS485, Modbus
Display	Illuminated Graphic LCD
IP Rating	IP65
Temperature	-20℃~60℃(-4℉~140℉), 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

LXD-04 (Sensor)	
Range	0.3~4m (0.98- 13ft)
Bean Angle	8˚at -3dB
Process Connection	1" PF
Weight	ca. 1.0kg
Material	PVDF
Temperature	-30℃~70℃ (-22℉~158℉), 80% relative humidity
Temperature Compensation by a built-in temperature sensor	
IP Rating	IP68
Cable	2 Core Shield (AWG18)
Cable Extension	up to 450m (1,476.3ft)

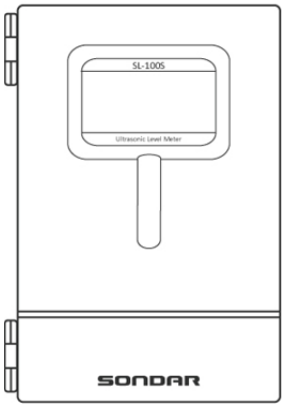
External Temperature Sensor	
Type	NTC, 10 kΩ
Temperature	-30℃~70℃ (-22℉~158℉)
Process Connection	1/8” PT
IP Rating	IP68
Cable	RG174

* The Specification is subject to change without prior notice.

3. Product Package

SF-500S is a controller is operated with the sensor, LXD-04. SF-500S and sensors are packed respectively.

3.1 Controller Box Package



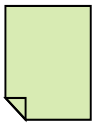
Controller

Manual CD

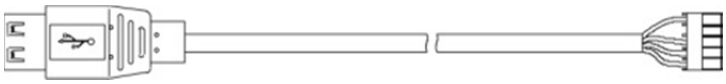
(PG13.5 1EA)

(PG11.0 2EA)

Cable Grand X3



Test Report



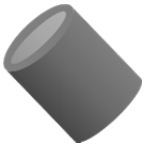
USB Connector Cable

External Temperature Sensor (Option)

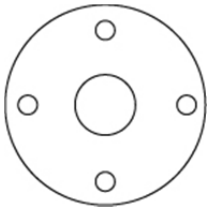
- The protection grade of SF-500S is IP65. It is valid before the cable grand whole is made. When the product is delivered to the customers, the cable grand wholes are made for user's convenience.

3.2 Sensor Box Package

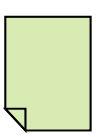
Sensor



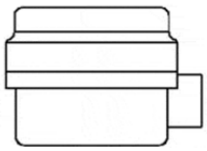
1” Adapter
(option)



Flange(option)



Test Report



Junction Box
(option)

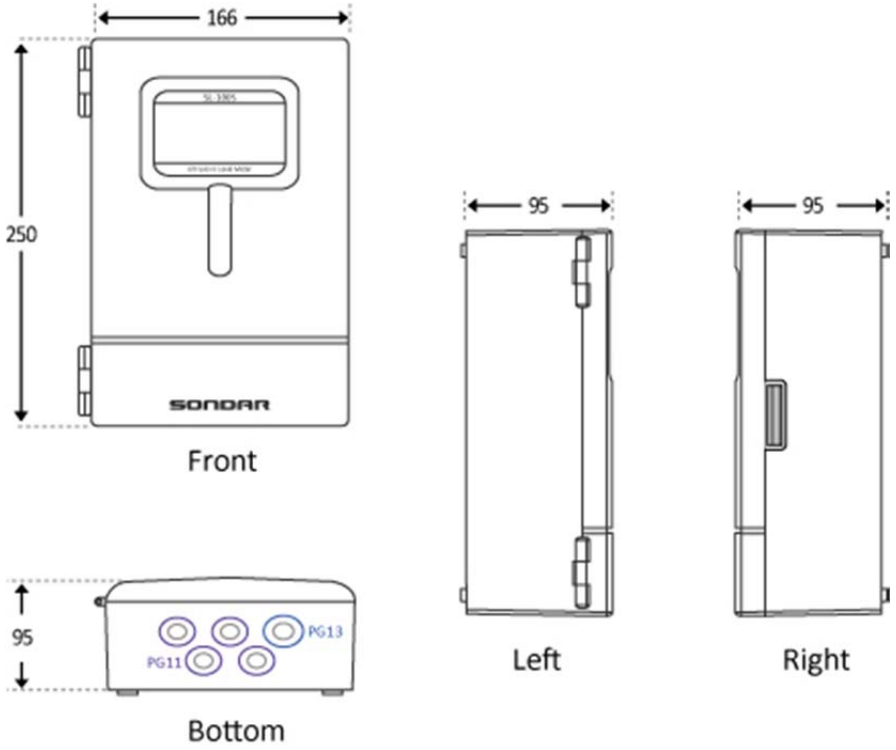
Pipe (option)

- The basic length of the sensor is 1 meter. The cable length is subject to change as an option if requested when ordering.

4. Dimension

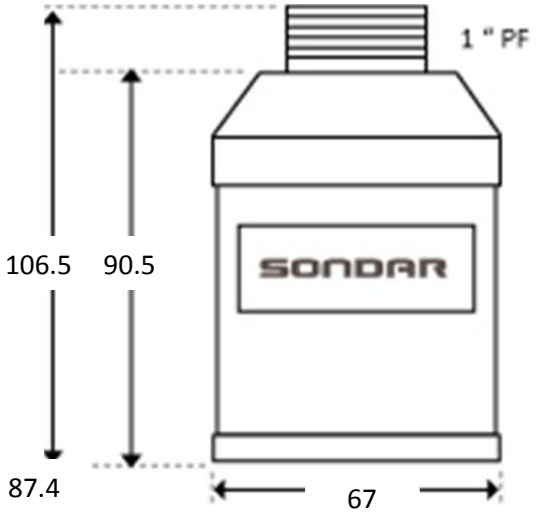
4.1 Controller

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.



4.2 Sensor

LXD-04 Sensor is an exclusive level sensor for SF-500S.its range is 4meter (13ft). The temperature is compensated by a built-in temperature sensor. The sensor materials are PP or PVDF. According to the application, the sensor housing material must be selected. Before mounting the sensor, check the chemical compatibility chart.



LXD-04

INSTALLATION

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.

This is general guide for installing SONDAR products.

- ✓ 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

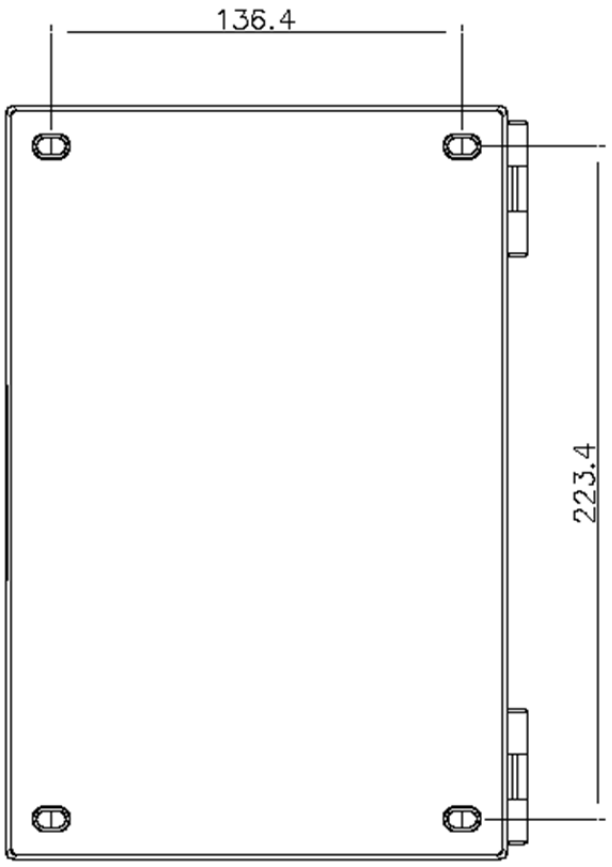
2.1 Environment condition

- ✓ 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

Dead zone is the area which the ultrasonic sensor can't measure. The maximum level shouldn't be reached into the Dead Zone. The echo signal isn't calculated within Dead zone area. Thus the measurement value may not correct.

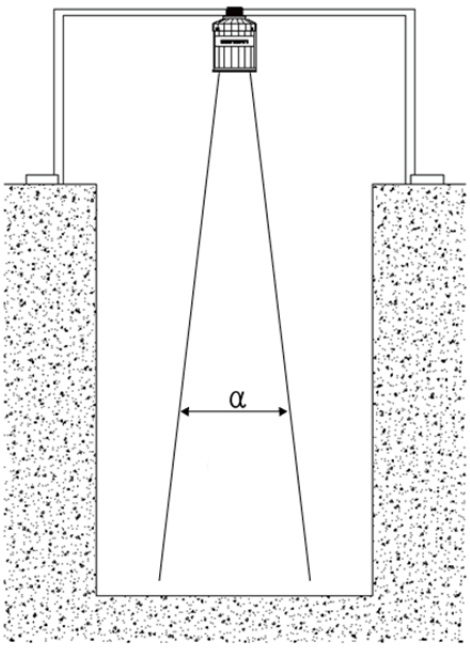
Sensor Model	Dead zone
LXD-04	0.3 m (11.81in)

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

3.3 Beam Space

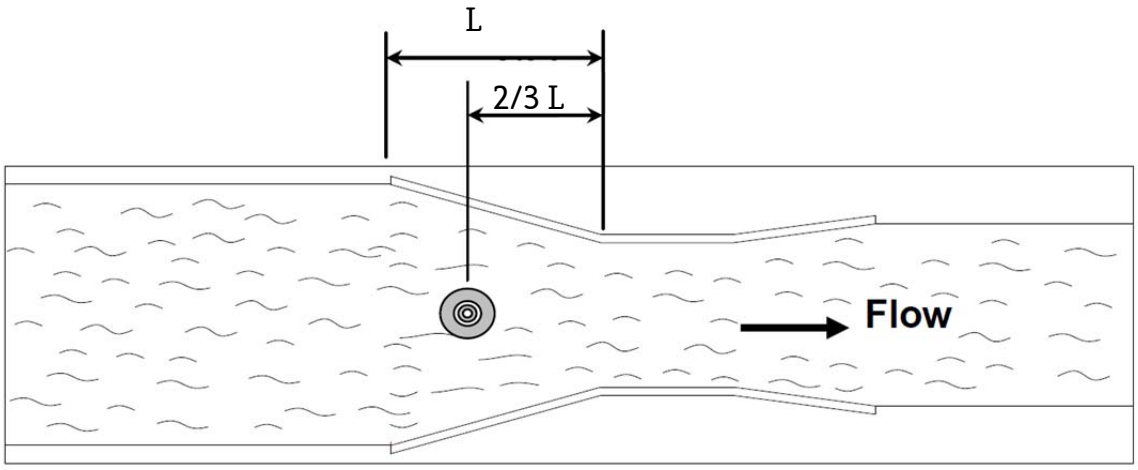
Make sure there is no interference on the emitted beam space area such as a limit switch, temperature sensors, and ladders. .

Measurement distance	Beam Space(α)
1m	0.09m
2m	0.18m
3m	0.27m
4m	0.36m
5m	0.47m



3.4 Installation

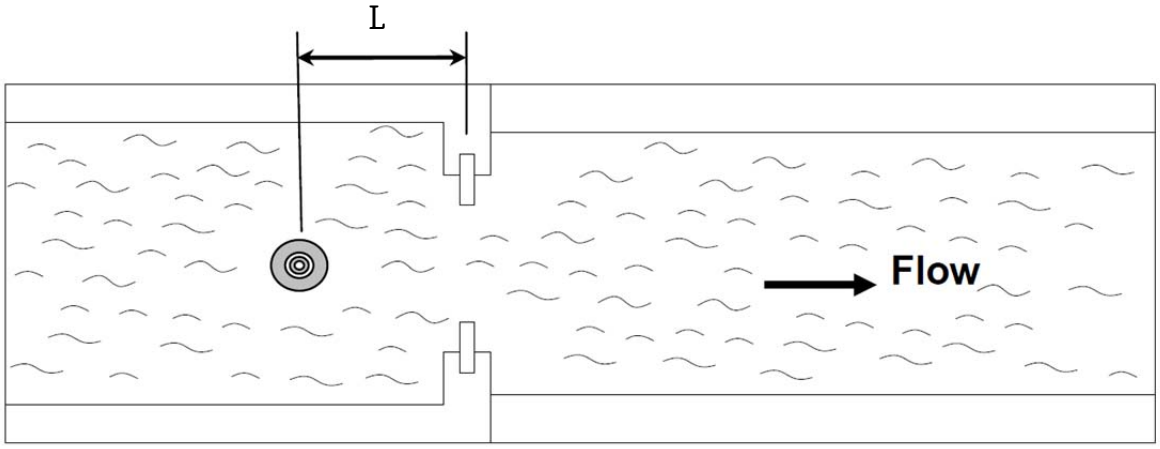
3.4.1 Parshall Flume



The sensor must be installed at 2/3 the length (L) of the converging section upstream of the beginning of the throat section.

3.4.2 Weir

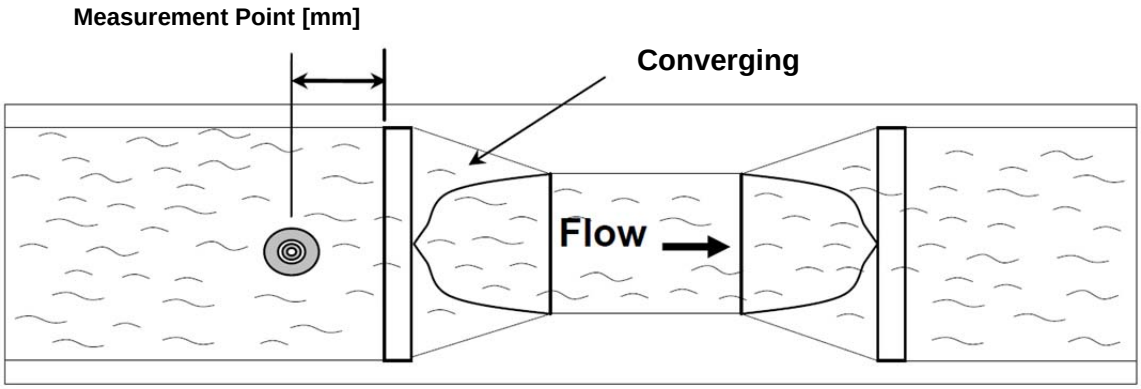
In the rectangular, triangular, and Cipolletti channels, the sensor should be installed at the top of the channel (Max. height x 4 ~ 5 times recommended).



3.4.2 Leopold Lagco Flume

In the Leopold-Largco Flume, the sensor should be installed at a position distant from Converging Section (corresponding to the distance of measurement point according to Flumes size)

Flume Size		Measurement Point	
mm	inches	mm	inches
100 ~	4~12	25	1.0
380	15	32	1.3
455	18	38	1.5
530	21	44	1.8
610	24	51	2.1
760	30	64	2.5



- The sensor must be installed above maximum level including the dead zone.

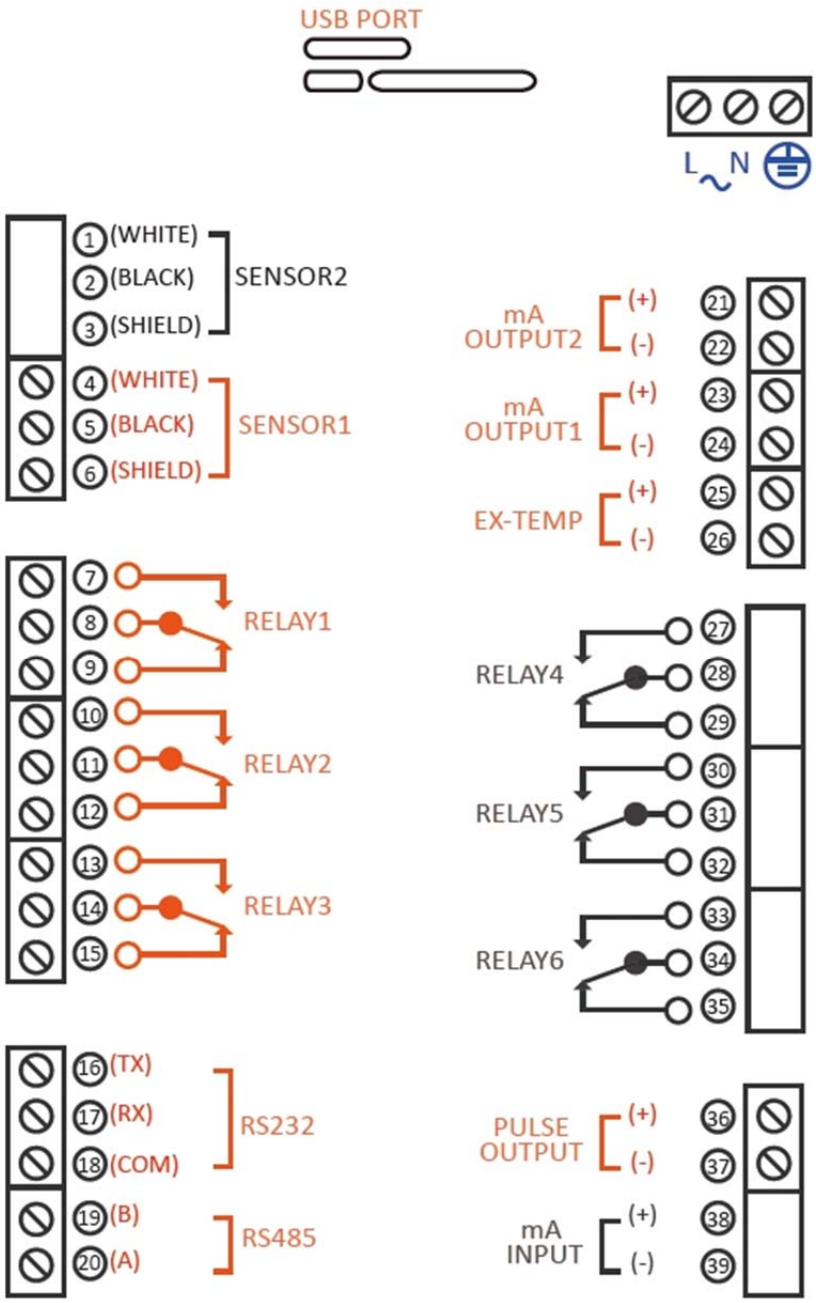
Wiring

IV. Wiring

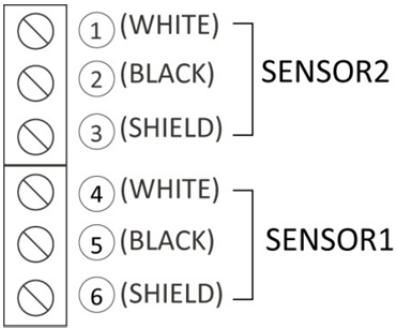
1. Wiring

CONTROL TERMINAL BOARD

There are 39 terminal blocks inside SF-500S. Make sure that all related equipment is connected with each correct terminal block.



TRASDUCER



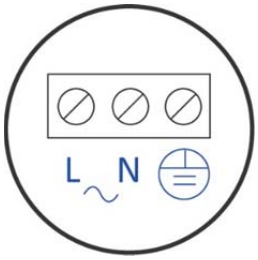
Sensor Channel 1 is selected when ordering SF-500S, SENSOR2 Terminal block is eliminated.

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

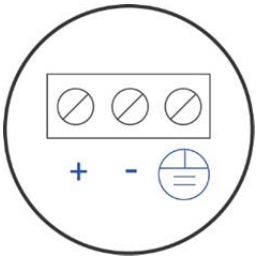
- Do not use old version sensors. Connect only the sensors stated in this manual.

Power

The standard power type is AC power. DC power can be selected as an option if requested when ordering. The thickness of the power cable should be more than 0.755SQmm.



AC Power Terminal



DC Power Terminal

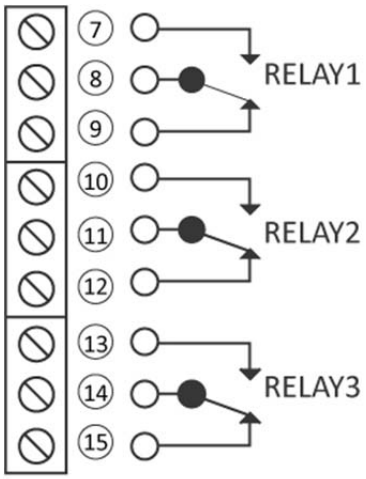
- When turning on the power of SF-500S for the first time, make sure any connected devices are disabled until all system functions are confirmed and to be operating properly.
- The system must be protected by a 10A fuse, otherwise it should be installed in a place where there is a circuit breaker or 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.

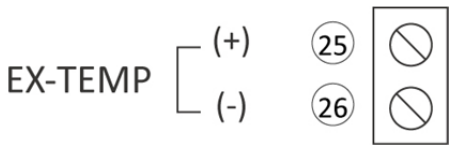
Two Form C, NO or NC relays

- ✓ 4A at 250Vac



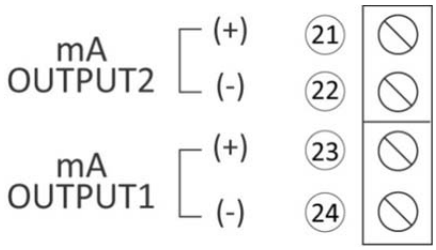
Temperature Sensor

The temperature information is a critical factor for measurement. LXD-05 sensor has built-in temperature sensor inside the sensor to compensate. If the ambient temperature is changed rapidly, an external temperature sensor is recommendable. The external temperature sensor for SF-500S can be purchased if requested when ordering.



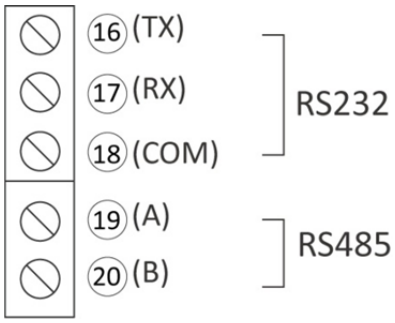
Analog output

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

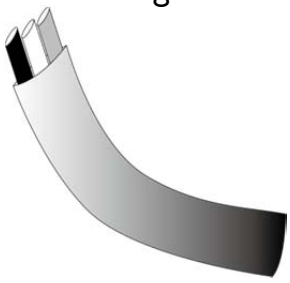
The standard communication type is RS232. RS485, Modbus can be selected as an option if requested when ordering.



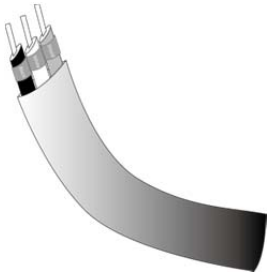
2. Sensor Cable

LXD transducer cable is a shielded two-wire cable. The standard cable length is 1meter (3.28ft). The cable can be extended by an option when placing the order. When the cable needs to extend with other cable, the cable has to be a shielded two-wire cable, same type.

Recommend to use a grounded conduit and a junction box for cable protection.



If the standard model is ordered, the end of cable is provided as the picture above.



If the cable is ordered more than 1meter, the end of cable is provided as the picture above.

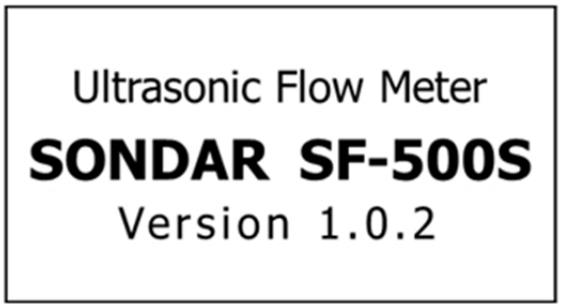
- Do not use a coaxial cable for extension with SF-500S. The extension cable must be used same specification as LXD Series sensor cable

Operation

V. Operation

1. Start-up Display

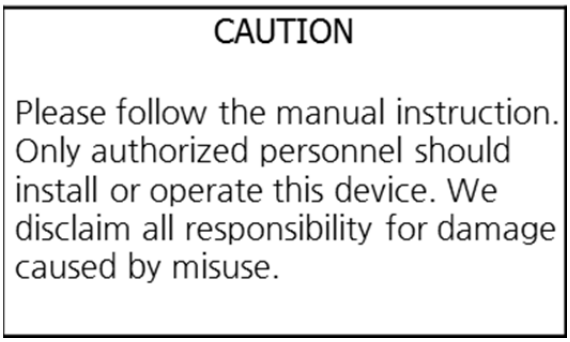
When SF-500S is powered on, the screen shows as bellow picture.



Item

Model Name

Firmware Version

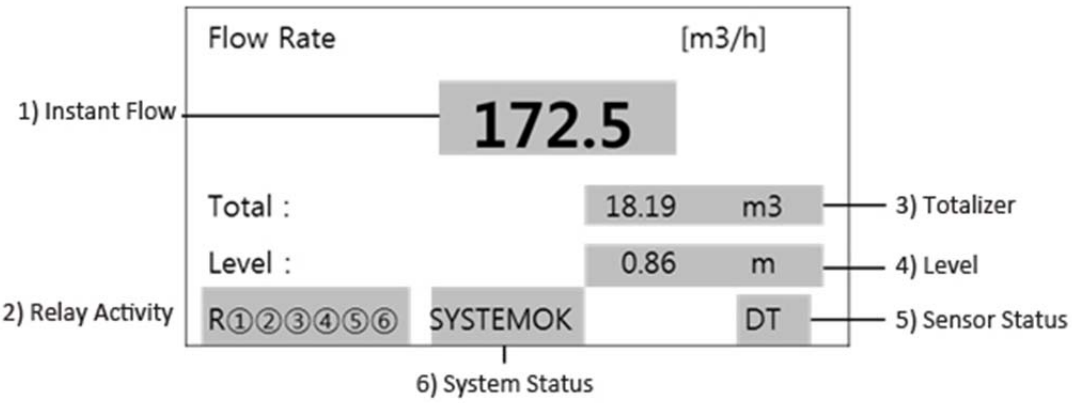


2. Display

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



3) It shows the current flow measurement value

4) It shows the relay currently wired.

5) It shows total flow.

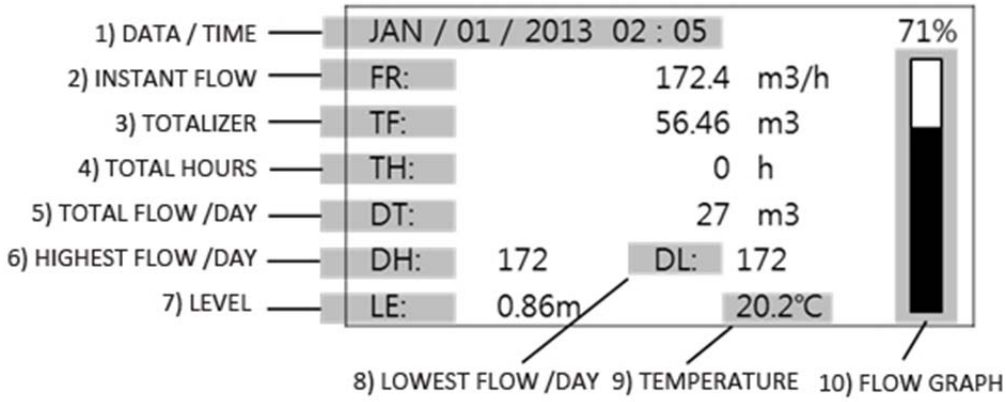
6) It shows current level measurement value.

7) 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

8) It shows a system status.
   - SYSTEM OK : normal status
   - SYSTEM OPEN: when the sensor is not wired or some cables are cut.
   - FAIL: when it can't measure.

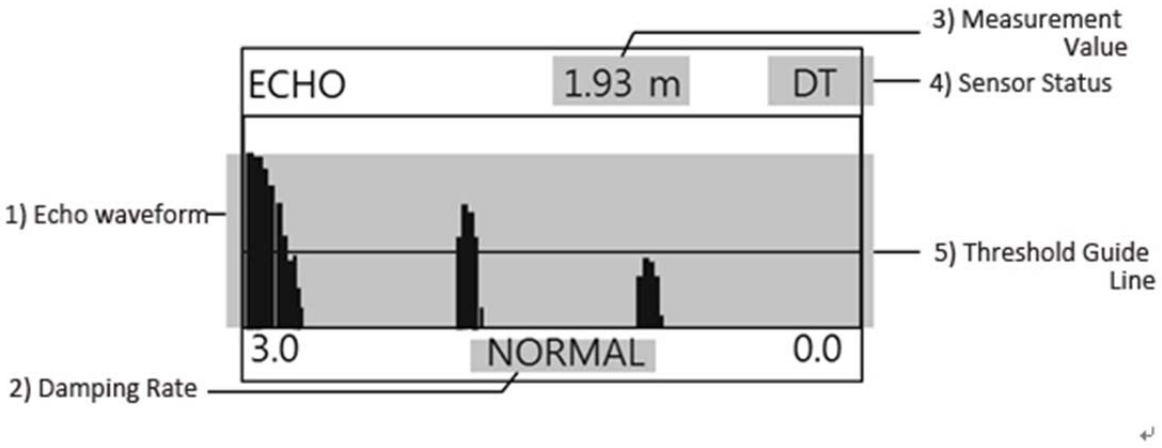
DISPALY B

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.



1) It shows today's date and current time
2) It shows instant flow value.
3) It shows total flow.
4) It shows the total hours measured
5) It shows total flow in a day.
6) It shows highest flow in a day
7) It shows level value currently being measured.
8) It shows lowest flow in a day
9) It shows the ambient temperature currently being measured.
10) It shows the flow graph.

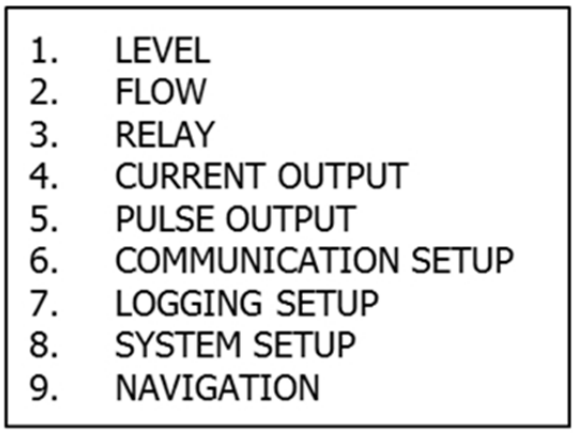
Echo Trend DISPLAY



1) It shows the echo waveform received by sensor.
2) It shows the damping rate. The Setting Level is as below.
   - SLOW
   - NORMAL
   - FAST
   - VERY FAST
3) It shows the measurement value currently measured.
4) 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
5) It shows the threshold guide line.

2.2 Programming Mode

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



LEVEL

This menu is for detail parameter setup of level measurement.

FLOW

This menu is for detail parameter setup of flow measurement.

RELAY

This menu is for detail parameter setup of relay activity.

CURRENT OUTPUT

This menu is for detail parameter setup of current output.

PULSE OUTPUT

This menu is for detail parameter setup of pulse output.

COMMUNICATION SETUP

This menu is for detail parameter setup of communication.

LOGGING SETUP

This menu is for logging data management.

SYSTEM SETUP

This menu is for system setting

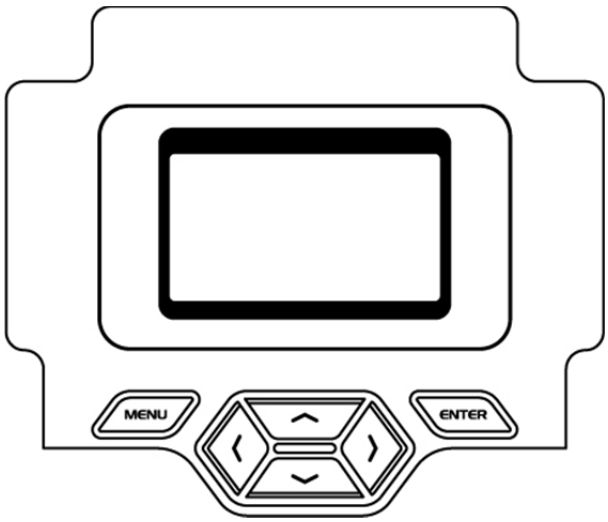
NAVIGATION

This menu allows for quick access to specific menus directly by entering the preset menu number. Refer to the menu list of SF-500S.

* The menu list is page95.

3. Buttons

SF-500S has 6 buttons to operate the system and to setup the menus.



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

- Select a menu in Programming 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.

Programming

VI. Programming

1. LEVEL

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

[1000] LEVEL	
UNIT	m
TEMP UNIT	℃
EMPTY	01.20m
DEAD ZONE	00.25m
TX POWER	030
RX GAIN	085
THRESHOLD	4 [0.8V]
TEMP TYPE	INSIDE
TEMP FIX	25.00℃
TEMP	21.04℃
DAMPING	NORMAL
SOUND SPEED	0331.5m/s
SPEED FACTOR	+0.60m/℃

1) UNIT

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

- Unit Selection: mm, cm, m, in, yd, 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) TEMP UNIT

This menu is to select the unit of ambient temperature being measured.

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

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
LXD-04	0. 30~4.50m	1.2m

- The setting value of EMPTY 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.

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
LXD-04	0. 25~4.50m	0.25m

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: 80 , Maximum setting range: 1~ 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.)

7) 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: 4(0.8V), Maximum setting range: 1~10]

8) 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.

9) TEMP FIX

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

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

10) TEMP

This menu is for checking the temperature value measured currently.

11) DAMPING

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

Select Item	Slow	Normal	Fast	Very Fast
Speed	0.1m/min	1m/min	10m/min	100m/min

12) 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 (m/sec)
Chlorine	206
Carbon dioxide	259
Argon	308
Oxygen	316
Air	331.5
Ammonia	415
Ethane	430
Neon	435
Helium	965

13) 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.

2. FOW

Set the detail menu for flow parameters.

[2000] FLOW
FLOW UNIT
DEVICE SELECTION
LOW CUT VALUE
HIGH CUT VALUE
TOTALIZER
FLOW RATE
FLOW INDEX

1) FLOW UNIT

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

- Unit selection: m3/h, m3/d, l/min, ft3/s, GPM[UK] , GPM[US] , MGD[UK] , MGD[US]

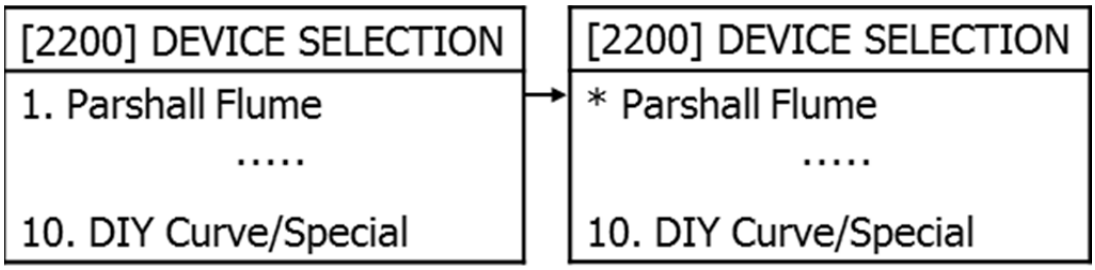
2) DEVICE SELECTION

This menu is for channel selection and detailed parameter setting. Select the channel first and then, set parameters for the channel.

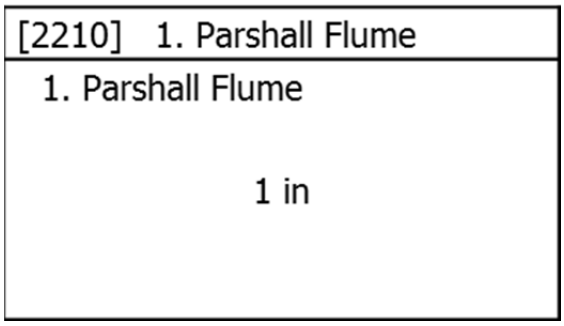
[2200] DEVICE SELECTION
1. Parshall Flume
2. Rect. Suppressed
3. Rect. Contracted
4. V-Notch Weir
5. Cipoletti Weir
6. Leopold Lagco Flume
7. Palmer Bowlus Flume
8. H Flume
9. TRAPEZOIDAL Flume
10. DIY Curve/Special

- When the weir or flume is selected, the current value and relay are changed according to the selected weir or flume.

Selected device is marked by "*"

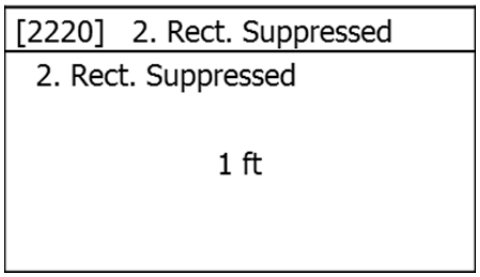


Parshall Flume



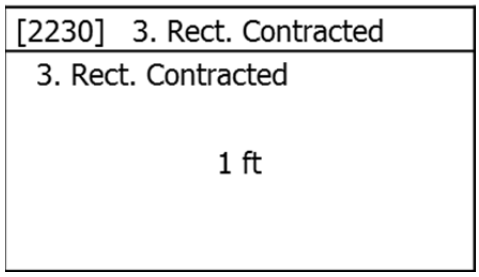
Parshall Flume	Maximum height [mm]	Parshall Flume	Maximum height [mm]
1 in	180	1 ft	760
2 in	180	1.5 ft	760
3 in	450	2ft	760
6 in	450	3 ft	760
9 in	600	4 ft	760
		5 ft	760
		6 ft	760
		8 ft	760
		10 ft	1060
		12 ft	1370

Rect.Suppressed



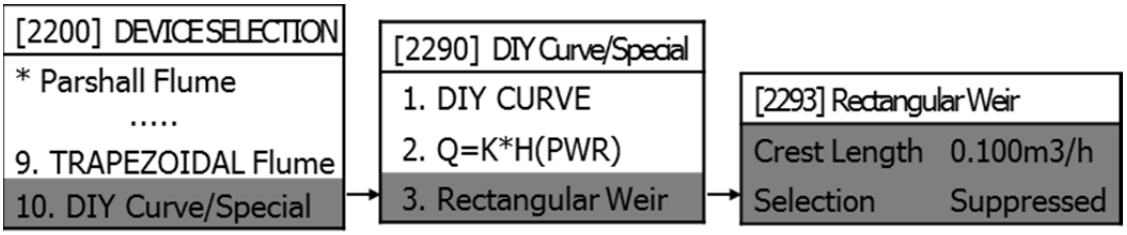
Rect. Suppressed	Maximum height [mm]	Rect. Suppressed	Maximum height [mm]
1 ft	150	4 ft	600
1.5 ft	220	5 ft	750
2 ft	300	6 ft	900
2.5 ft	370	8 ft	1200
3 ft	450	10 ft	1500

Rect. Contracted



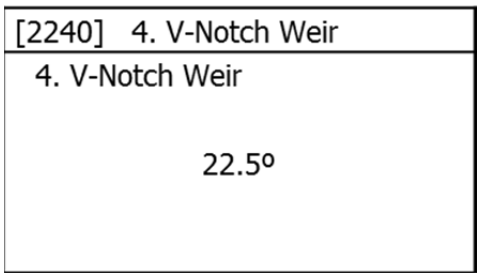
Rect. Contracted	Maximum height [mm]	Rect. Contracted	Maximum height [mm]
1 ft	150	4 ft	600
1.5 ft	220	5 ft	750
2 ft	300	6 ft	900
2.5 ft	370	8 ft	1200
3 ft	450	10 ft	1500

If there is no channel that installed on the menu, please complete the following steps. At [2293] Rectangular Weir menu, Please select Suppressed Weir and enter the conrresponding Crest Length.

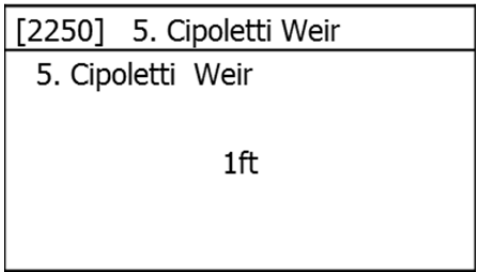


V-Notch Weir

[Type: 22.5°/ 30°/ 45°/ 60°/ 90°/ 120°]

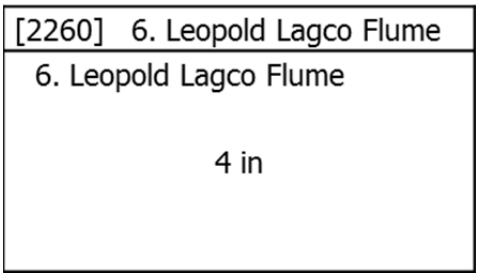


Cipoletti Weir



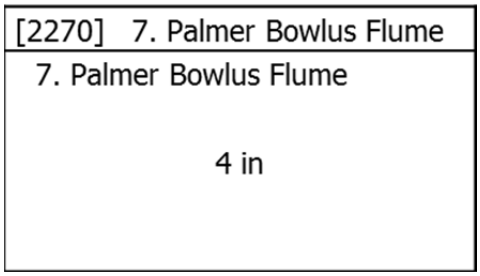
Cipoletti Weir	Maximum height [mm]	Cipoletti Weir	Maximum height [mm]
1 ft	150	4 ft	600
1.5 ft	220	5 ft	750
2 ft	300	6 ft	900
2.5 ft	370	8 ft	1200
3 ft	450	10 ft	1500

Leopold Lagco Flume



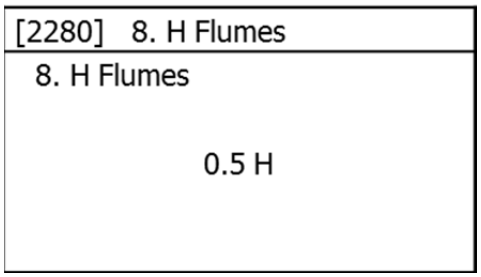
Leopold Lagco Flume	Maximum height [mm]	Leopold Lagco Flume	Maximum height [mm]
4"	70	15"	270
6"	100	18"	320
8"	130	21"	380
10"	180	24"	420
12"	210	30"	530

Palmer Bowlus Flume



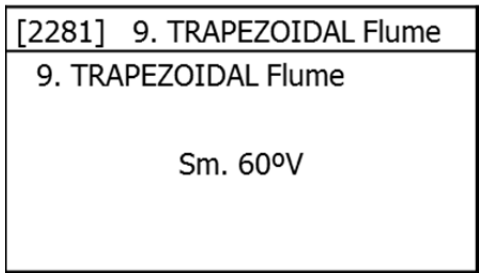
Palmer Bowlus Flume	Maximum Hight [mm]	Palmer Bowlus Flume	Maximum Heght [mm]
4"	75	15"	270
6"	105	18"	320
8"	150	21"	380
10"	180	24"	420
12"	210	30"	485

H Flume



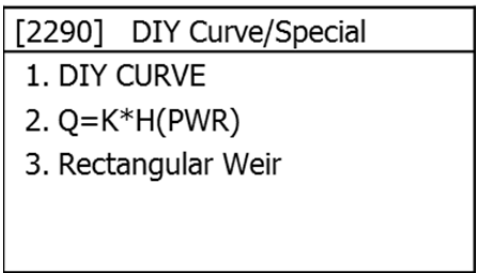
H Flume	Maximum Height [mm]	H Flume	Maximum Height [mm]
0.5H	150	4.5 H	1370
0.75H	220	0.4 HS	120
1.0 H	300	0.6 HS	180
1.5 H	450	0.8 HS	240
2.0 H	610	1.0 HS	300
2.5 H	760	3.0 HS	910
3.0 H	910	4.0 HS	1220

TRAPEZOIDAL Flume



TRAPEZOIDAL Flume	Maximum height [mm]	TRAPEZOIDAL Flume	Maximum height [mm]
Sm. 60°V	90	2" 45° WSC	250
Lg. 60°V	150	12" 45° SRCRC	380
XL 60°V	285	2.0' SRCRC	860
3.0' 60°V	755		

DIY Curve/Special

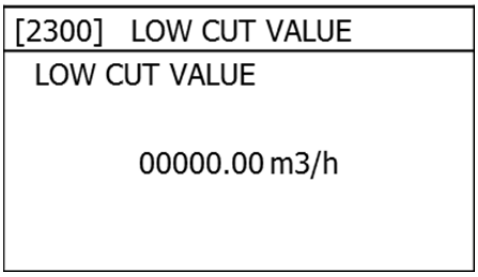


This menu is used for measurement of flow rate, regardless of the type of device.

- DIY Curve: This option equally divides the known level-based flow rate into 10 parts and measures the flow rate according to change of level.
- Q=K*H(PWR): This option inputs constant values, K and PWR, to a exponentially changing device and measures the flow rate.
- Rectangular Weir: This option selects Crest Length of all Rectangular Weirs in mm unit and measures the flow rate.

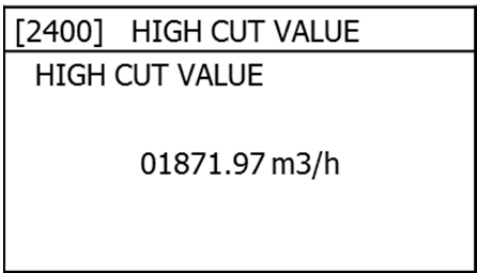
3) LOW CUT VALUE

This is the menu to set minimum measurable flow rate. Those below this value will be treated as "0". The initial value is 0.00m3/h(0.00 gal/m). (Setting range: 0.00 ~ Max. Flow Rate, Unit: 0.01m3/h(0.01 gal/m)).



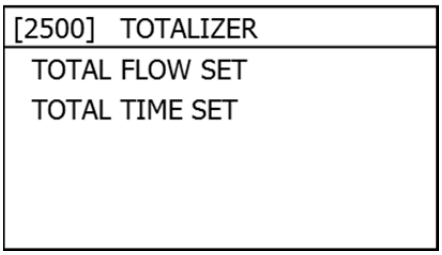
4) HIGH CUT VALUE

This is the menu to set maximum measurable flow rate. Those above this value will be treated as the maximum flow rate. The initial value is maximum flow rate of the device (gal/m). (Setting range: 0.00 ~ Max. flow rate)



5) TOTALIZER

This is a menu for setting the default value of TOTAL FLOW and TOTAL TIME.

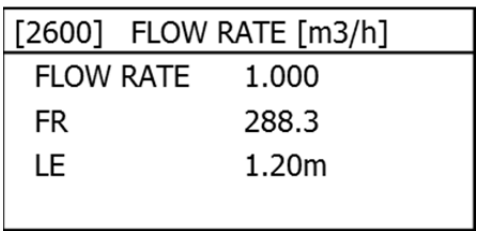


6) FLOW RATE

This menu is to revise and output the flow rate that are measured in arbitrary ratio by user. This menu also can be used for weight conversion, error correction.

Display & Output = Measured value x FLOW RATE

(Setting range: 0.001~ 9.999)



7) FLOW INDEX

Highest or lowest flow rate based on the selected height of the channel can be searched by m3/h or gal/h unit.

[2700] FLOW INDEX	
FLOW INDEX	00.183m
m3/h	0.016
GPM	0.069

3. RELAY (RELAY1~3)

[3000] RELAY
RELAY 1
RELAY 2
RELAY 3
RELAY SIMULATION

[3100] RELAY 1
DETAIL
ON POINT
OFF POINT

[3110] DETAIL	
FUNCTION	NONE
GROUP	1

DETAIL

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.

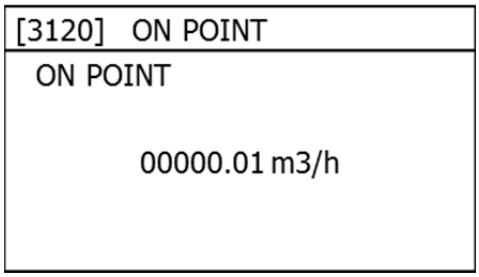
2) GROUP

This menu is for setting a group for ALTERNATE.

- Selection range: 1~3

ON POINT

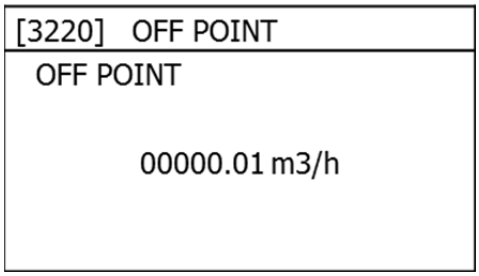
This menu is for setting a point that RELAY is ON. If OFF POINT is less than ON POINT, RELAY become ON when the measured value is bigger than ON POINT. If OFF POINT is bigger than ON POINT, RELAY become ON when the measured value is less than ON POINT.



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.

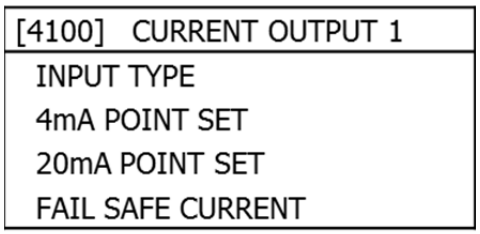


RELAY SIMULATION

The ON / OFF test of RELAY is available.

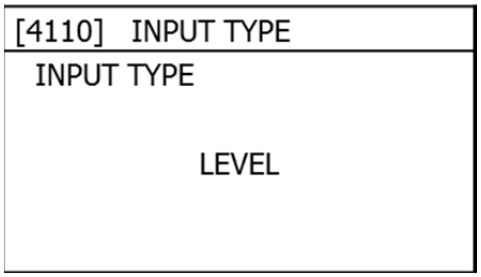
4. CURRENT OUTPUT

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



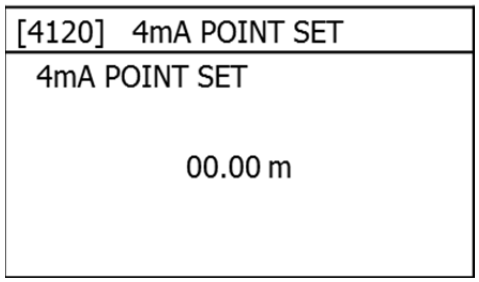
1) INPUT TYPE

This menu is for selecting the measurement of Level or Flow.



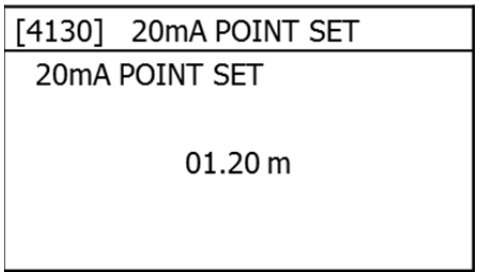
2) 4mA POINT SET

This menu is to set 4mA.



3) 20mA POINT SET

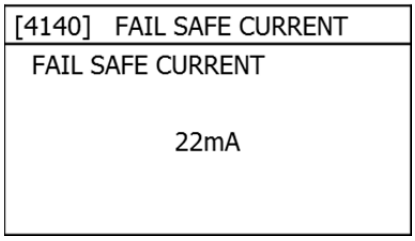
This menu is to set 20mA.



4) FAIL SAFE CURRENT

This menu is for setting the operation of the current output when an error occurs.

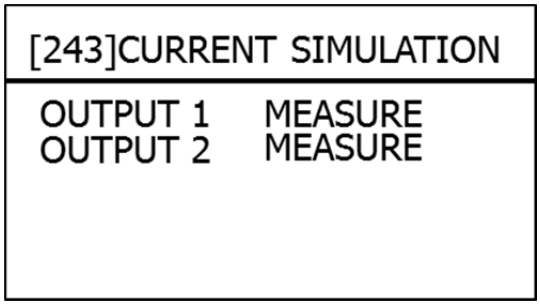
- 3.8Ma
- HOLD
- 22mA



5) CURRENT SIMULATION

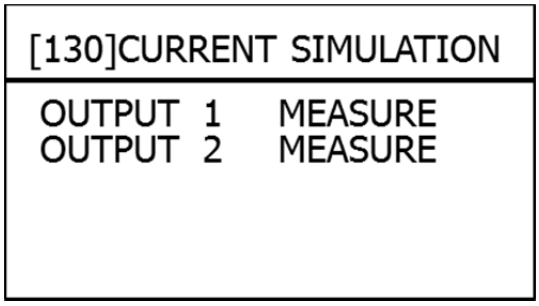
This menu is that displays the output of CURRENT OUTPUT SENSOR1 and SENSOR2 as selected value.

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



6) 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.



OUTPUT 1

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

- HOLD
- 3.8mA
- 4mA
- 12mA
- 20mA
- 22mA

OUTPUT 2

Same as the OUTPUT 1

5. PULSE OUTPUT

[5000] PULSE OUTPUT	
FUNCTION	DISABLE
PULSE WIDTH	0.10 sec
PULSE VALUE	001.0 m3

1) FUNCTION

It is the menu for selection of pulse output use.

- DISABLE: PULSE OUTPUT is not used.
- ENABLE: PULSE OUTPUT is used.

2) PULSE WIDTH

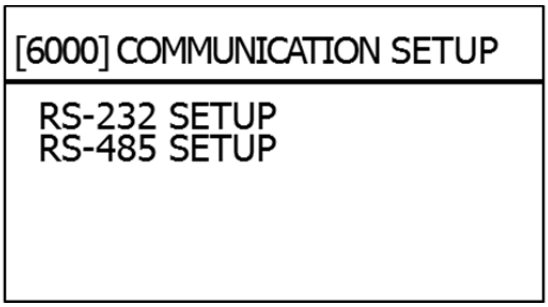
This is a Menu to set the width of the pulse that one pulse is output depending on the flow rate value that has been set at the PULSE VALUE..

(Default setting: 0.10sec, Setting range: 0.01~ 1.00, Unit: 0.01sec)

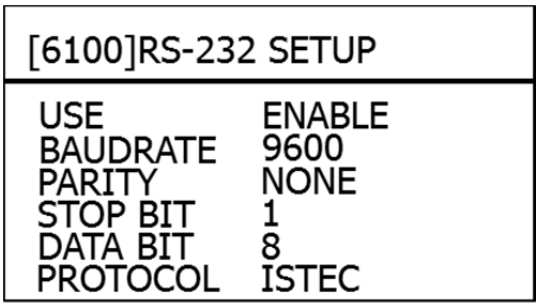
3) PULSE VALUE

This is a menu to set the flow rate value per pulse. If you enter 1.0 ㎥, It mean 1 pulse is discharged 1.0 ㎥.

6. COMMUNICATION SETUP



4) RS-232 SETUP



USE

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

- ENABLE / DISABLE

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

PARITY

This menu is for selecting the Parity bit use state.

- None
- Odd
- Even

STOP BIT

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

- 1 bit (default)
- 2 bit

DATA BIT

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

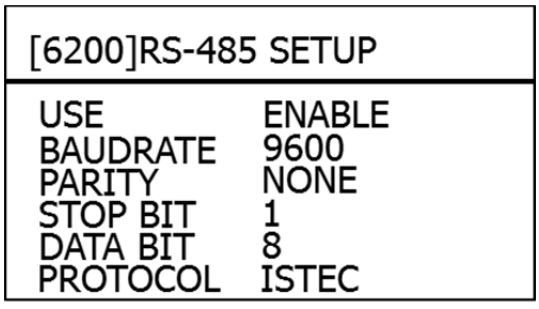
- 7 bit
- 8 bit (default)

PROTOCOL

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

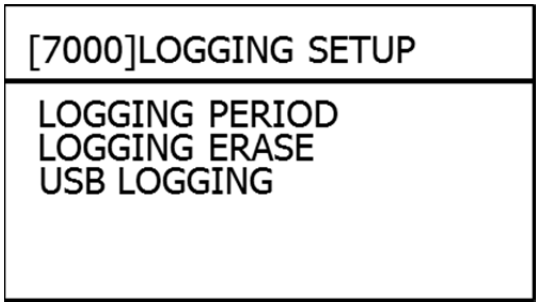
- SONDAR
- BKCM
- Modbus – RTU
- Modbus–ASCII

RS-485 SETUP



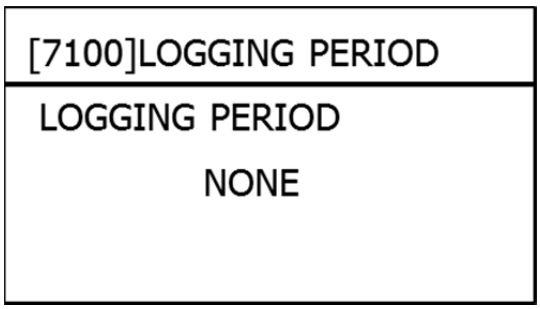
7. LOGGING SETUP

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



1) 3.1 LOGGING PERIOD

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



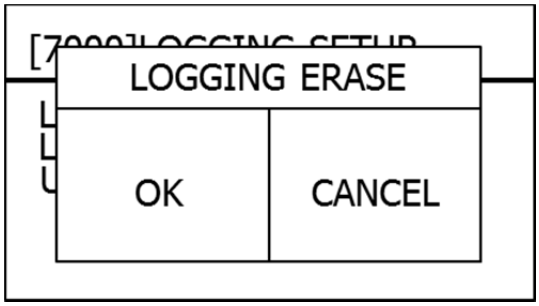
- NONE
- 10 SEC
- 1 MINUTE
- 5 MINUTE
- 10 MINUTE
- 15 MINUTE
- 30 MINUTE
- 60 MINUTE

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

Data logging period	Maximum storage period
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

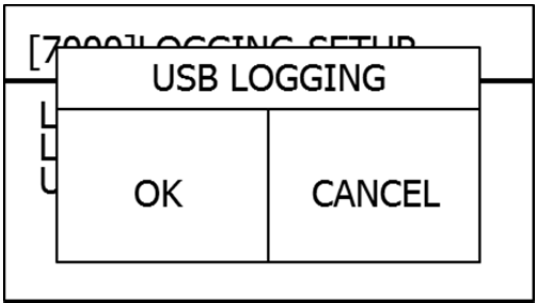
3.2 LOGGING ERASE

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

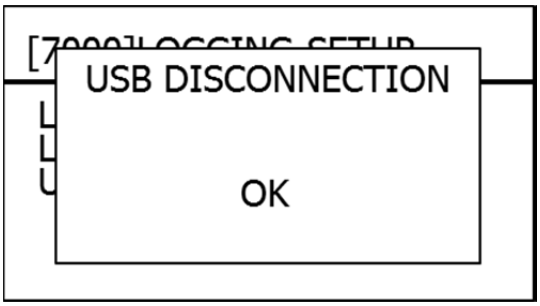


3.3 USB LOGGING

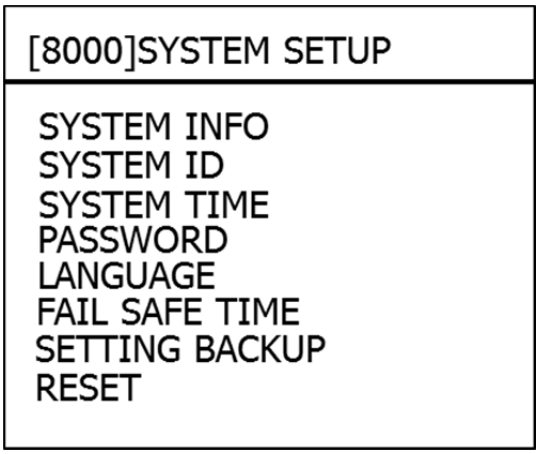
When USB is connected, screen will be displayed as shown in [Figure 6-26] . By selecting OK, it transfers logging data to USB as EXCEL file.



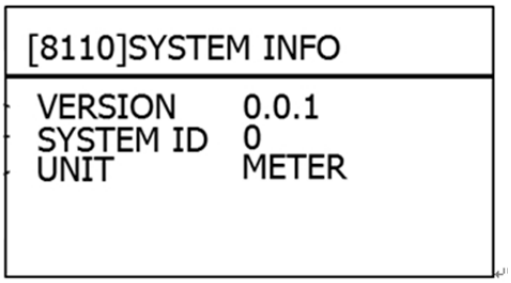
When USB is not connected, screen will be displayed as shown in the picture below. Please connect USB, and then click the OK button, the error pop-up will disappear.



8. SYSTEM SETUP



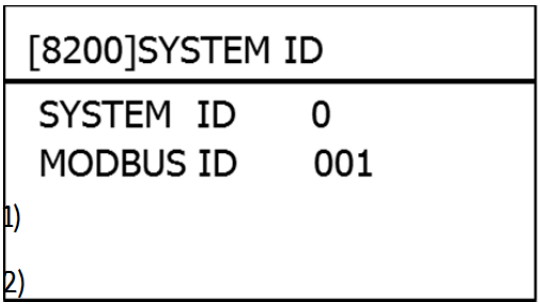
1) SYSTEM INFO



This menu is for showing system information.

- Version: Firmware version
- SYSTEM ID: System ID for SONDAR protocol
- UNIT: Measurement unit selected by a user

2) SYSTEM ID



3)

SYSTEM ID

This menu is for setting the SYSTEM ID to be used for SONDAR Protocol.

- Setting range: 0 ~ 99

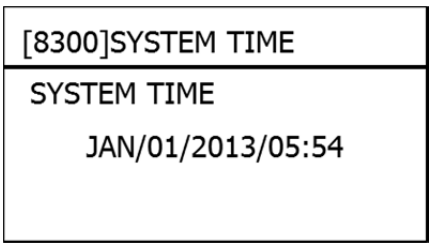
Modbus ID

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

4) 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.

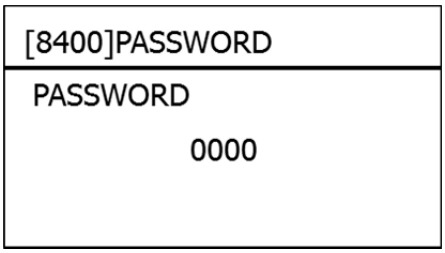
- Setting range: JAN/01/2000 00:00 ~ DEC/31/2099 23:59



5) PASSWORD

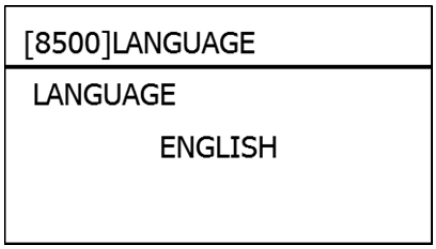
This menu is for setting a password by its user. No password is set at the factory. After you set a password, you must enter the password each time there is a menu change.

- Password setting range: 0000~9999



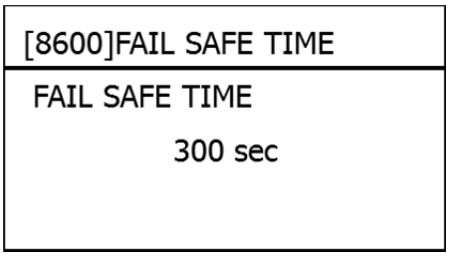
- User can't configure the menus when user forgets the password. Please note password number and pay attention not to lose it.

6) LANGUAGE



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

7) 4.6 FAIL SAFE TIME

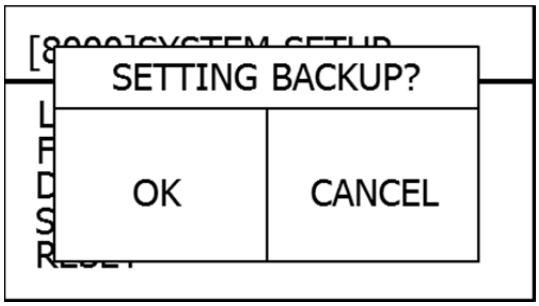


This menu is for setting the time for then alarm when the device malfunctions or there is no receiving signal.

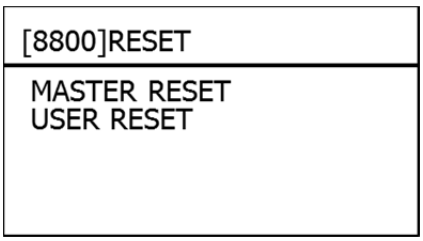
- [Default setting: 300sec, Setting range: 20 ~ 999sec]

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.

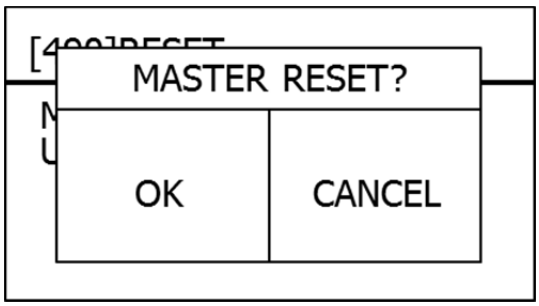


9) RESET



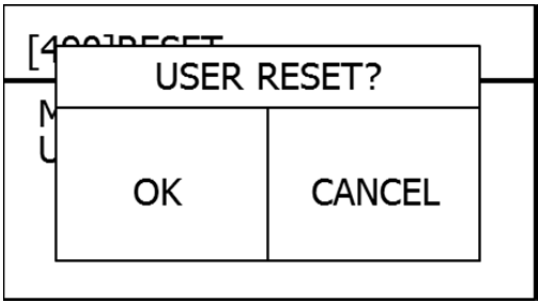
MASTER RESET

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.



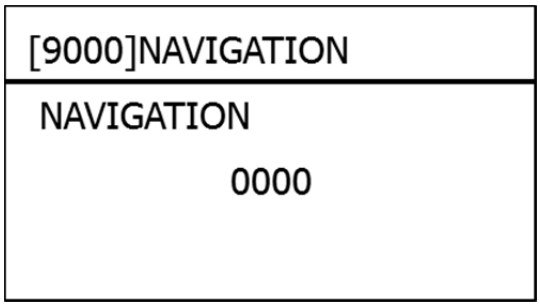
USER RESET

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.

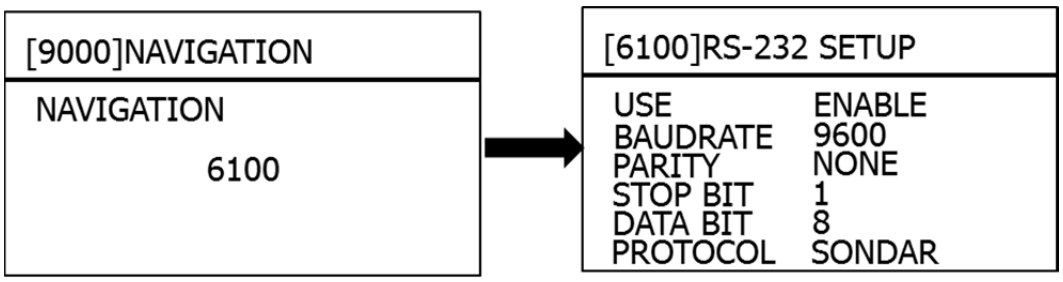


9. NAVIGATION

This menu allows for quick access to specific menus directly by entering the preset menu number. Refer to the menu list of SF-500S.



Ex) If you want to move to the menu of LOGGING PERIOD, please enter menu number [6100] . By entering menu number [6100] , you can access RS-232 SETUP menu immediately..



Maintenance

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 of SF-500S is CR-2032 from Maxwell Co. 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

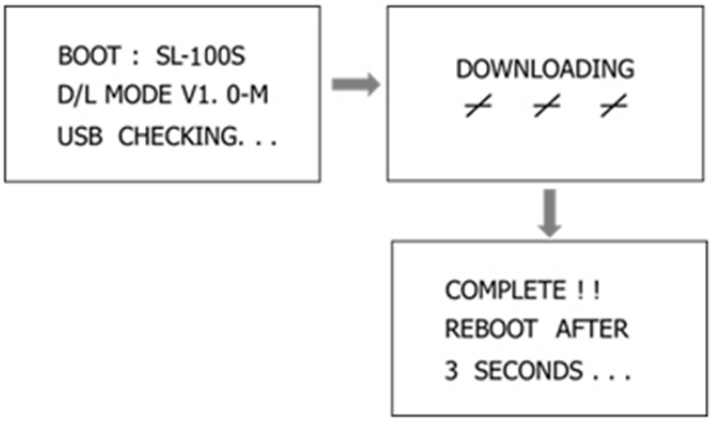
1) Check the sensor cable regularly.
2) Check the sensor bottom if there is contaminant and clean the bottom of the sensor.

3. Firmware upgrading

SL-100S provides the firmware upgrading by a user.

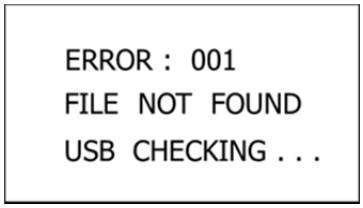
Duplicate the firmware to download at the highest folder of USD memory. (file system: FAT32). Connect the USB memory to the Controller. Keep pressing the ENTER key and turn on the power.

Firmware can be downloaded now.

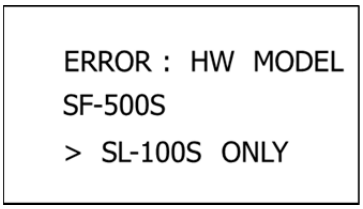


Firmware Download Error:

1. There is no Firmware file in the USB memory.



2. The downloaded firmware isn't SF-500Ss



4. Warranty Period

Warranty period is 3 years for SF-500S but if the problem is caused by user's fault or misuse, the repair charge will be incurred.

5. Repair Service

When some problem is occurred in SF-500S, the error code displays on the screen, it shows what the problem is. The error code information can be founded by scanning QR Code inside the controller door. Even though conduct every process by the guide, still the problem exists, contract an official distributor or SONDAR customer center.

When the product is sent for the repair, the repair request form has to be filled and enclose it with the products.

Despite of being in warranty period, if the problem is caused by user's fault or misuse, the repair charge will be incurred.

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Trouble shooting

VIII. Trouble shooting

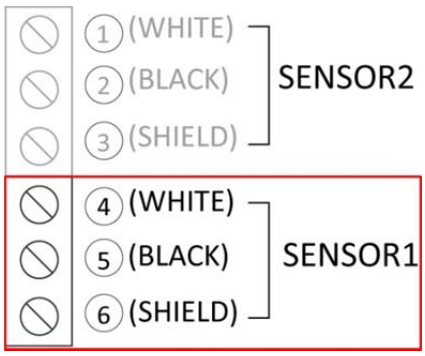
When some problem is occurred in SF-500S, the error code displays on the screen, it shows what the problem is. The error code information can be founded by scanning QR Code inside the controller door.

ERRPR 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).

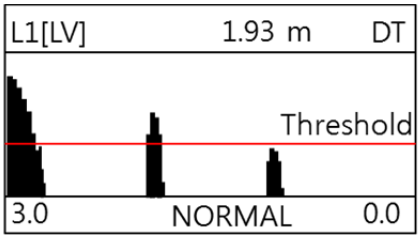
(2) Please check the sensor cable (white, black) visually or by using Multi-meter if it is cut or shorted. If you find a problem, please repair or replace the cable. If the problem has not been solved yet, please refer to (3)

(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.

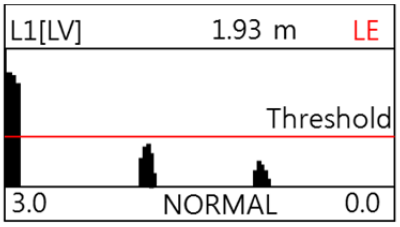
When the sensor makes sound radiation

(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

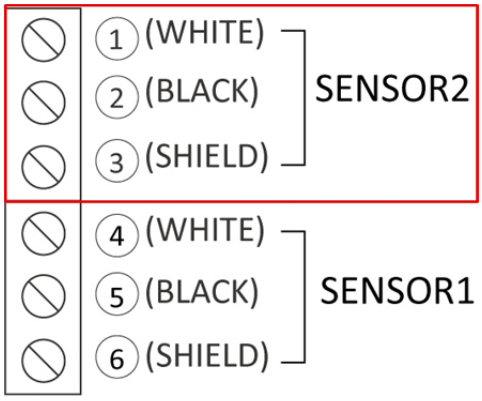
Abnormal condition

*** 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

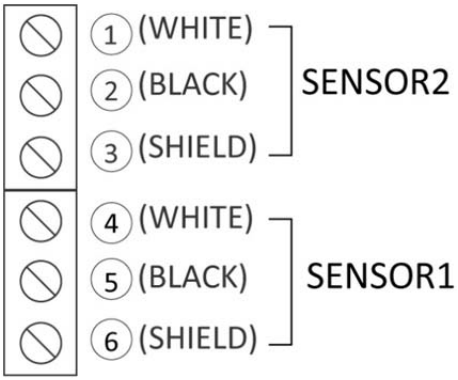


This error appears when sensor2 is not connected to the terminal or if it is connected to the terminal incorrectly. Please proceed as follows to solve this problem.

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.

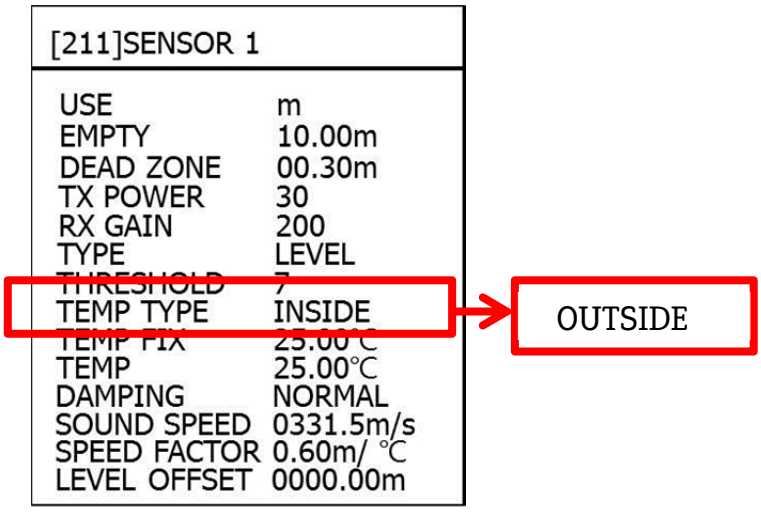
When the sensor makes sound radiation

(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.

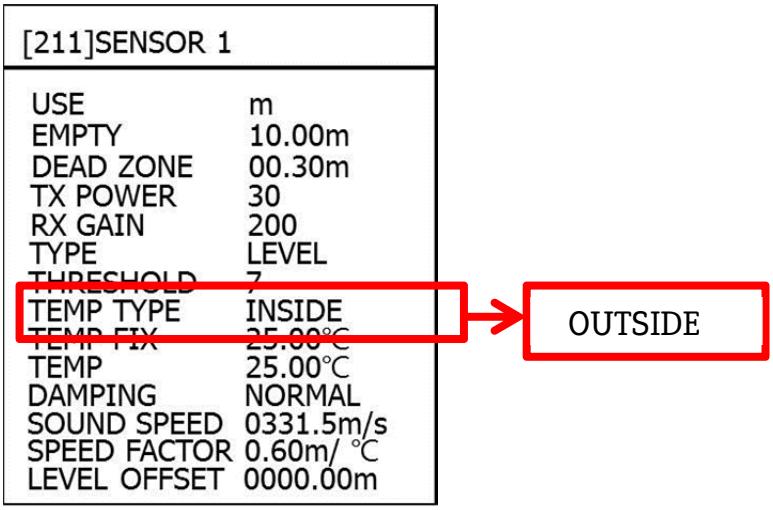
Processing method is the same as the E1102. （Please refer to Page 83）

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.



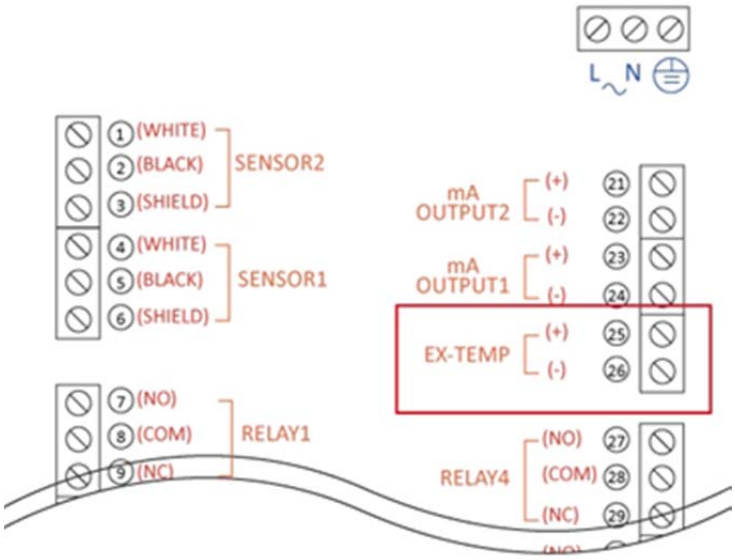
When the temperature sensor is connected incorrectly

(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.

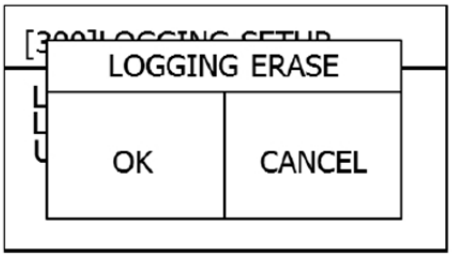
Logging data Recovery

If the flash memory is defective, it is diffi cult 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.

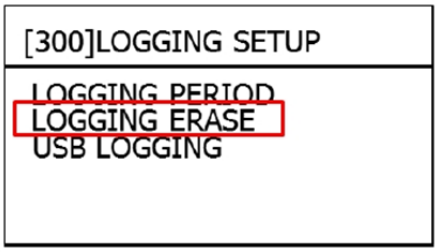
Memory Reset

(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

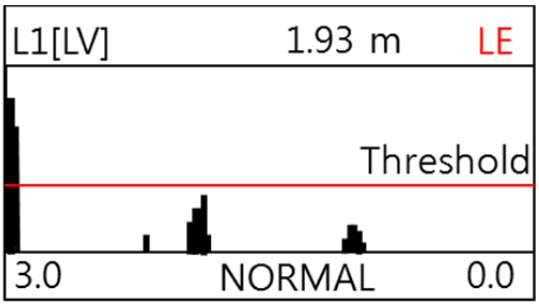
(2) REAL TIME CLOCK is sensitive and cannot be handled by non-experts. If you need specific inspection and repair, please contact our service center or your local dealer.

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.

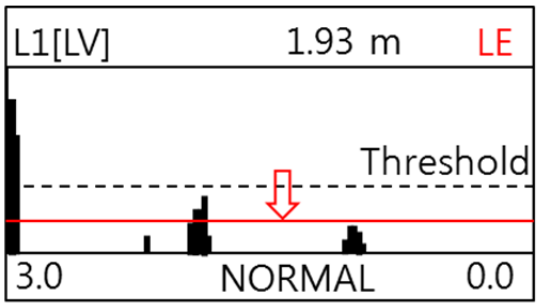
Adjust settings menu corresponding to the measurement object

(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

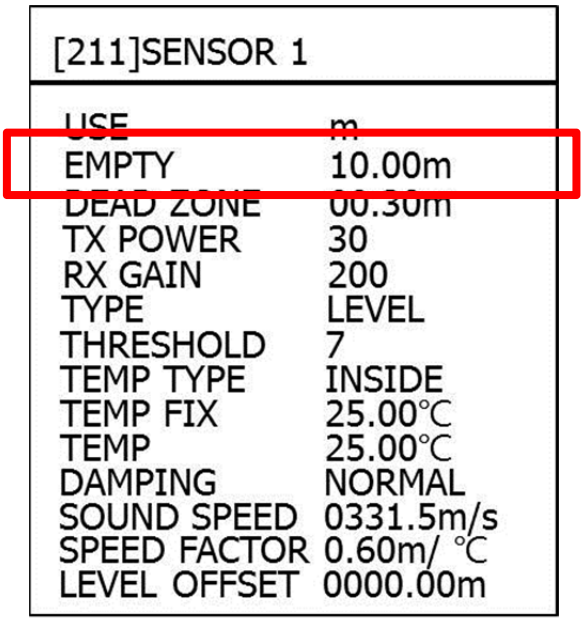
(7) If "LE" appears on the screen repeatedly and received value is lower than Threshold value, please change the default Threshold value from 4(0.8V) to 3(0.5V). if it is operating normally, "DT" will be displayed on the screen during normal operation.



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）

APPENDIX A

SF-500S MENU LIST

APENDIX A. SF-500S MENU LIST

LEVEL (1000)		
2rd MENU	Range	Default
UNIT	mm/ cm/ m/ in/ yd/ ft	meter
TEMP UNIT	℃ or ℉	℃
EMPTY	0.3m~4.5m	1.2m
DEAD ZONE	0.25m~4.5m	0.25m
TX POWER	1~100	30
RX GAIN	0~100	80
THRESHOLD	1[0.1V], 2[0.3V], 3[0.5V], 4[0.8V], 5[0.9V], 6[1.1V], 7[1.3V], 8[1.6V], 9[1.7V], 10[2.0V]	4[0.8V]
TEMP TYPE	INSIDE/ OUTSIDE/ FIX	INSIDE
TEMP FIX	-30~70℃	25℃
TEMP	Ambient temperature	
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/℃

FLOW (2000) > FLOW UNIT(2100)	
l/m, ft3/s, gal/min(US), gal/min(UK), MGD(US), MGD(UK), m3/h, m3/d	m3/h

FLOW (2000) > DEVICE SELECTION(2200)		
3rd MENU	Range	Default
1.Parshall Flume(2210)	1in/ 2in/ 3in/ 6in/ 9in/1ft/ 1.5ft/ 2ft/ 3ft/ 4ft/ 5ft/ 6ft/ 8ft/ 10ft/ 12ft	1in
2.Rect. Suppressed(2220)	1ft/ 1.5ft/ 2ft/ 2.5ft/ 3ft/ 4ft/ 5ft/ 6ft/ 8ft/ 10ft	1ft
3.Rect. Contracted(2230)	1ft/ 1.5ft/ 2ft/ 2.5ft/ 3ft/ 4ft/ 5ft/ 6ft/ 8ft/ 10ft	1ft
4. V-Notch Weir (2240)	22.5°/ 30°/ 45°/ 60°/ 90°/ 120°	22.5°
5. Cipoletti Weir (2250)	1ft/ 1.5ft/ 2ft/ 2.5ft/ 3ft/ 4ft/ 5ft/ 6ft/ 8ft/ 10ft	1ft
6.Leopold Lagco Flume(2260)	4in/ 6in/ 8in/ 10in/ 12in/ 15in/ 18in/ 21in/ 24in/ 30in	4in
7.Palmer Bowlus Flume(2270)	4in/ 6in/ 8in/ 10in/ 12in/ 15in/ 18in/ 21in/ 24in/ 30in	4in
8.H Flume(2280)	0.5H/ 0.75H/ 1.0H/ 1.5H/ 2.0H/ 2.5H/ 3.0H/ 4.5H/ 0.4HS/ 0.6HS/ 0.8HS/ 1.0HS/ 3.0HS/ 4.0HS	0.5H
9.TRAPEZOIDAL Flume(2281)	Sm.60°V / Lg.60°V / XL 60°V / 3.0' 60°V/ 2"45° WSC / 12" 45° SRCRC/ 2.0' SRCRC	Sm.60°V

FLOW (2000) > DEVICE SELECTION(2200) > 10.DIY Curve/Special (2290)			
4th MENU	5th MENU	Range	Default
DIY CURVE (2291)	MAX HEIGHT	DEAD ZONE ~ EMPTY	1.2m
	DIY CURVE 1~20	0.1~200000.0 m3/h	0.1
Q=K*H (PWR) (2292)	K	Constant (0.0001~9999.9999)	0.0001
	PWR	Constant (0.001~9.999)	0.001
	H	mm/ cm/ m/ in/ yd/ ft	m
	Q	m3/h or gal/h	m3/h
Rectangular Weir(2293)	Crest Length	0~10m	0.10m
	Selection	1.Suppressed Weir/ 2.Contraced Weir	1

FLOW (2000) > LOW CUT VALUE(2300)	
0.00 ~ Max. peak flow	0
FLOW (2000) > HIGH CUT VALUE(2400)	
0.00 ~ Max. peak flow	20929.28

FLOW (2000) > FLOW RATE (2600)	
0.001~9.999	1
FLOW (2000) > FLOW INDEX (2700)	
0.001m~ EMPTY	

RELAY (3000) > RELAY1~RELAY3(3100~3300)			
3rd MENU	4th MENU	Range	Default
DETAIL (3210)	FUNCTION	NONE/ LIMIT/ ALTERNATE/ ALARM	NONE
	GROUP	1,2	1
ON POINT (3220)		0.01~ Max. peak flow unit: 0.01m3/h	0.01
OFF POINT (3130)		0.01~ Max. peak flow unit: 0.01m3/h	0.01

RELAY (3000) > SIMULATION (3400)		
3rd MENU	Range	Default
RELAY 1	ON/ OFF	OFF
RELAY 2	ON/ OFF	OFF
RELAY 3	ON/ OFF	OFF

CURRENT OUTPUT(4000)			
2nd MENU	3rd MENU	Range	Default
CURRENT OUTPUT 1 (4100)	INPUT TYPE(4110)	LEVEL/FLOW	FLOW
	4mA POINT SET(4120)	0.00 ~ Max. peak Flow or (0.00~ EMPTY)	0 m3/h
	20mA POINT SET(4130)	0.00 ~ Max. peak Flow or (0.00~ EMPTY)	0 m3/h
	FAIL SAFE CURRENT (4140)	3.8mA/HOLD/22mA	22mA
CURRENT OUTPUT 1 (4200)	INPUT TYPE(4110)	LEVEL/FLOW	LEVEL
	4mA POINT SET(4120)	0.00 ~ Max. peak Flow or (0.00~ EMPTY)	0
	20mA POINT SET(4130)	0.00 ~ Max. peak Flow or (0.00~ EMPTY)	0 m3/h
	FAIL SAFE CURRENT (4140)	3.8mA/HOLD/22mA	22mA
SIMULATION(4300)	OUTPUT 1	MEASURE/3.8mA/4mA/12mA/20mA/21mA	MEASURE
	OUTPUT 2	MEASURE/3.8mA/4mA/12mA/20mA/21mA	MEASURE

PULSE OUTPUT (5000)		
2nd MENU	Range	Default
FUNCTION	NONE/USE	NONE
PULSE WIDTH	0.01~1.00 단위 0.01sec	0.10 sec
PULSE VALUE	0.1~999.9 m3, 0~9.99999MG	1 m3

COMMUNICATION SETUP (6000)			
2nd MENU	3rd MENU	Range	Default
RS-232 SETUP (6100)	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	SONDAR/ KICT/Modbus-RTU/ Modbus-ASCII	SONDAR
RS-485 SETUP (6200)	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	SONDAR/KICT/ Modbus-RTU/ Modbus-ASCII	SONDAR

APPENDIX B

RS-232/RS-485 Protocol

APPENDIX B. RS-232/RS-485 Protocol

1. SONDAR 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

SF-500S 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(SF-500S)
							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

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

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]	0.5	0.26	0.16	0.09	2.36	1.47	0.81	6.54	4.09	2.25	12.83	8.02	4.41	21.21	13.25	7.29
	1.0	0.65	0.52	0.33	5.89	4.71	2.95	16.36	13.09	8.18	32.07	25.66	16.04	53.01	42.41	26.51
	1.5	1.05	0.92	0.66	9.42	8.25	5.96	26.18	22.91	16.57	51.31	44.90	32.47	84.82	74.22	53.68
	2.0	1.44	1.31	1.05	12.96	11.78	9.42	36.00	32.72	26.18	70.55	64.14	51.31	116.63	106.03	84.82
	2.5	1.83	1.70	1.44	16.49	15.32	12.96	45.81	42.54	36.00	89.80	83.38	70.55	148.44	137.84	116.63
	3.0	2.23	2.09	1.83	20.03	18.85	16.49	55.63	52.36	45.81	109.04	102.63	89.80	180.25	169.65	148.44
	3.5	2.62	2.49	2.23	23.56	22.38	20.03	65.45	62.18	55.63	128.28	121.87	109.04	212.06	201.45	180.25
	4.0	3.01	2.88	2.62	27.10	25.92	23.56	75.27	71.99	65.45	147.52	141.11	128.28	243.87	233.26	212.06
	4.5	3.40	3.27	3.01	30.63	29.45	27.10	85.08	81.81	75.27	166.77	160.35	147.52	275.67	265.07	243.87
	5.0	3.80	3.67	3.40	34.16	32.99	30.63	94.90	91.63	85.08	186.01	179.59	166.77	307.48	296.88	275.67
	5.5	4.19	4.06	3.80	37.70	36.52	34.16	104.72	101.45	94.90	205.25	198.84	186.01	339.29	328.69	307.48
	6.0	4.58	4.45	4.19	41.23	40.06	37.70	114.54	111.26	104.72	224.49	218.08	205.25	371.10	360.50	339.29
	6.5	4.97	4.84	4.58	44.77	43.59	41.23	124.35	121.08	114.54	243.74	237.32	224.49	402.91	392.31	371.10
	7.0	5.37	5.24	4.97	48.30	47.12	44.77	134.17	130.90	124.35	262.98	256.56	243.74	434.72	424.12	402.91
	7.5	5.76	5.63	5.37	51.84	50.66	48.30	143.99	140.72	134.17	282.22	275.81	262.98	466.53	455.92	434.72
	8.0	6.15	6.02	5.76	55.37	54.19	51.84	153.81	150.53	143.99	301.46	295.05	282.22	498.34	487.73	466.53
	8.5	6.54	6.41	6.15	58.90	57.73	55.37	163.62	160.35	153.81	320.70	314.29	301.46	530.14	519.54	498.34
	9.0	6.94	6.81	6.54	62.44	61.26	58.90	173.44	170.17	163.62	339.95	333.53	320.70	561.95	551.35	530.14
	9.5	7.33	7.20	6.94	65.97	64.80	62.44	183.26	179.99	173.44	359.19	352.77	339.95	593.76	583.16	561.95
	10.0	7.72	7.59	7.33	69.51	68.33	65.97	193.08	189.80	183.26	378.43	372.02	359.19	625.57	614.97	593.76
	10.5	8.12	7.98	7.72	73.04	71.86	69.51	202.89	199.62	193.08	397.67	391.26	378.43	657.38	646.78	625.57
	11.0	8.51	8.38	8.12	76.58	75.40	73.04	212.71	209.44	202.89	416.92	410.50	397.67	689.19	678.58	657.38

	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

HORIZONTAL CYLINDER - FLAT HEAD

D[m]		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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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