Instruction Manual

HYBRID ULTRASONIC FLOWMETER <Duosonics>

TYPE: FSH (Flow transmitter)
FSW (Detector)
FLY (Signal cable)

Fuji Electric Systems Co., Ltd.

INF-TN1FSH-E

PREFACE

We thank you very much for purchasing Fuji's ultrasonic flowmeter.
The instruction manual concerns the installation, operation, checkup and maintenance of the Flow transmitter (FSH) and Detector (FSW) of ultrasonic flowmeter. Read it carefully before operation.

- Before using, be sure to read this instruction manual carefully to ensure correct installation, operation and maintenance of the flowmeter. Note that incorrect handling may lead to trouble or personal injury.
- The specifications of this flowmeter are subject to change for improvement without prior notice.
- Do not attempt to modify the flowmeter without permission. Fuji is not responsible for any trouble caused by modification without permission. If it becomes necessary to modify the flowmeter, contact our office in advance.
- This instruction manual should always be kept on hand by the operator.
- After reading, be sure to keep this manual in a place where it can easily be seen by the operator.
- Make sure that this manual is presented to the end user.
- If the instruction manual has been lost, request another one (with charge) to our local business office.

Manufacturer: Fuji Electric Instrumentation Co., Ltd.
Type: Shown on nameplate of Flowmeter
Date of manufacture: Shown on nameplate of Flowmeter
Product nationality: Japan

NOTICE

Issued in July 2005

SAFETY PRECAUTION

Before using, read the following safety precaution to ensure correct handling of the flowmeter.

- The following items are important for safe operation and must be fully observed. These items are classified into "DANGER" and "CAUTION".

Warning & Symbol	Meaning
⚠ DANGER	Incorrect handling may lead to a risk of death or heavy injury.
⚠ CAUTION	Incorrect handling may lead to a risk of medium or light injury, or to a risk of physical damage.

- The items noted under "⚠ CAUTION" may also result in serious trouble depending on circumstances.
- All the items are important and must be fully observed.

Caution on Installation and Piping	
⚠ DANGER	• This product has not an explosion-proof structure. Do not use it in a place with explosive gases, otherwise, it can result in serious accidents such as explosion, fire, etc.
⚠ CAUTION	• The unit should be installed in a place conforming with the installation requirements noted in this instruction manual. Installation in an improper location may lead to a risk of electric shocks, fire, malfunction, etc. • The unit should be installed as noted in the manual. Improper installation will cause falling, trouble or malfunction of the unit. • During installation, make sure that the inside of the unit is free from cable chips and other foreign objects to prevent fire, trouble, malfunction, etc. • The items under "Caution on Installation" noted in the manual must be fully observed. Careless installation may result in trouble or malfunction of the unit.

Caution on Wiring	
⚠ CAUTION	• When performing wiring termination to prevent output trouble caused by moisture, dew condensation or water leak, follow “Section 3.3. Flow transmitter wiring” described in this manual • Before performing the wiring work, be sure to turn OFF the main power to prevent electric shocks. • Do not perform wiring work outdoors in rainy days to prevent insulation deterioration and dew condensation. Otherwise, it can result in trouble, malfunction, etc. • Be sure to connect a power source of correct rating. Connection of a power source of incorrect rating may lead to a risk of fire. • The unit must be earthed as specified to prevent electric shocks or malfunction. • The analog output signal cable should be wired as far away as possible from high-voltage lines to prevent entry of noise signals as it will cause malfunction of the unit. • To prevent malfunction of the unit, the analog output signal cable and power cable should be wired using separate conduits.

Caution on Maintenance/Inspection	
⚠ CAUTION	• The unit should be inspected everyday to always obtain good results of measurements. • When measuring the insulation resistance between the power/output terminal and the case, follow “Section 5.2.4. Measuring insulation resistance” described in this manual. • If the fuse is blown, detect and eliminate the cause, and then replace the fuse with a spare. If there are no spares, replace the fuse with the one specified in this manual (that must be prepared by customer). Use of a fuse other than specified or its short-circuit may cause an electric shock or fire. The fuse should be replaced according to “Section 5.3. Replacing fuse” described in this manual.

CAUTION ON INSTALLATION LOCATION

⚠ CAUTION

(1) Sufficient space for daily inspection, wiring, etc.
(2) A place not exposed to direct sunshine or weathering.
(3) Isolation from vibration, dust and moisture
(4) A place not subjected to radiated heat from a heating furnace etc.
(5) A place not subjected to explosive gas and corrosive atmosphere
(6) A place not submerged
(7) A place remote from electrical devices (motor, transformer, etc.) which generate electromagnetic induction noise, electrostatic noise, etc.
(8) A place not subjected to excessive fluid pulsation (pump discharge side)
(9) A place that provides enough place for the length of the straight pipe.
(10) A place where ambient temperature and humidity are • 10 to +50°C and 90% RH or less for flow transmitter (FSH), and • 20 to +80°C and 100% RH or less for detector (FSW).

Contents

1. PRODUCT OUTLINE

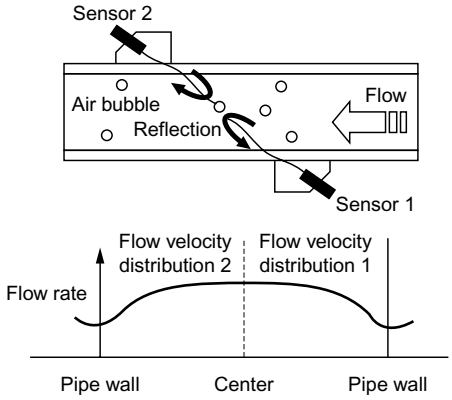
1.1. Outline

This high precision flowmeter is the world's first clamp-on type ultrasonic flowmeter that adopts the pulse Doppler method and the transit time method as its measurement principles. The ultrasonic flowmeter for industrial use employs the pulse Doppler method, which directly measures flow distribution, thus easing straight pipe conditions and allowing measurement of flows that have not grown into eddy or laminar flow. Combined use of the transit time method allows the hybrid ultrasonic flowmeter to be used for measuring a significantly wide range of liquids. The pulse Doppler method, which uses echoes coming from reflectors in a liquid to be measured, is ideal for the measurement of liquids that contain air bubbles and particles. On the other hand, the transit time method, which allows ultrasonic waves to pass through for measurement, is ideal for the measurement of clean liquids.
The new hybrid technique employing both the pulse Doppler and the transit time methods allows the flowmeter to be used for wider range of applications. In addition, our self-developed switching algorithm ensures automatic switching between the two methods depending on the conditions of a liquid to be measured (such as mixing status of air bubbles or particles and flow rate), thus facilitating measurement.

1.1.1. Measurement principle

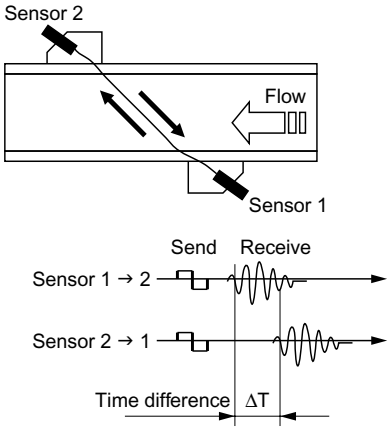
<Pulse Doppler method>

- The pulse Doppler method measures flow distribution and flow rate based on the fact that Doppler frequency of the echo coming from reflectors such as air bubbles and particles in liquids changes with fluctuation of flow rate.



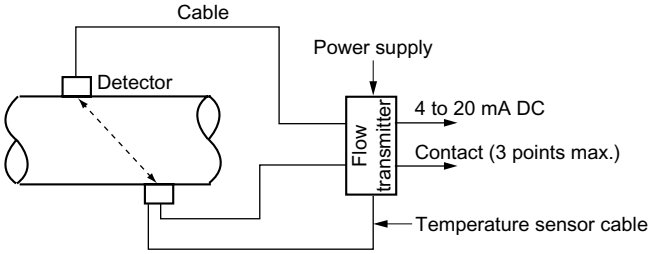
<Transit time method>

- Under the transit time method, ultrasonic pulses are propagated slanted from both upstream and downstream sides, and time difference of flows are detected to measure the flow rate.

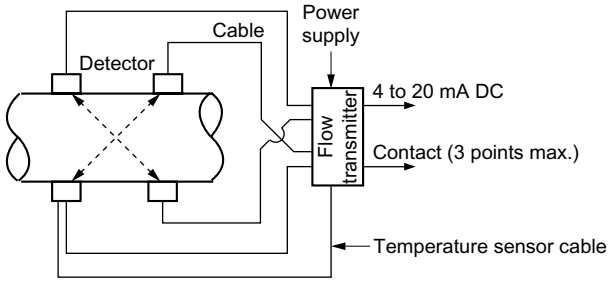


Configuration

(1) 1 measurement line method (Z method)



(2) 2 measurement line method (Z method)



1.2. Checking delivered items

Flow transmitter (FSH)
- Flow transmitter main unit ····· 1 set
- Waterproof gland (Built into the main unit) ····· 1 set
- Wall mount fittings (Built into the main unit) ····· 1 set

Detector (FSWS12, 21, 40)
- Detector main unit (FSWS12, 21) ····· 1 set
- Detector main unit (FSWS40) ····· 1 set
- Absorber unit ····· 1 set
- Stainless steel belt ····· 1 set
- Fittings ····· 1 set
- Silicon rubber ····· 1 pc

Detector (FSWS50)
- Detector main unit (FSWS50) ····· 1 set
- Absorber unit ····· 1 set
- Wire rope ····· 1 set
- Spring for mounting ····· 1 set

Signal cable (FLY6)
- Cable for ultrasonic signals ····· 1 pair (2 pcs.)

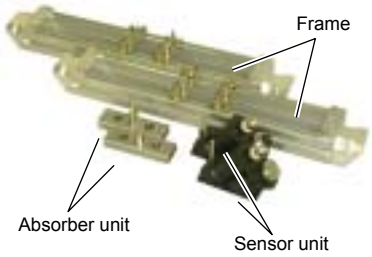
Signal cable (FLY7)
- Cable for temperature sensor ····· 1

CD-ROM (Instruction manual and Loader software) ····· 1

Flow transmitter (FSH)

Detector (FSWS12, 21, 40)

Detector (FSWS12, 21)

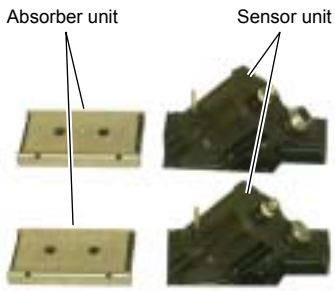


Detector (FSWS40)

Stainless steel belt

Silicon rubber

Detector (FSWS50)



Wire rope

Spring for mounting

Signal cable (FLY6)
Cable for ultrasonic signals

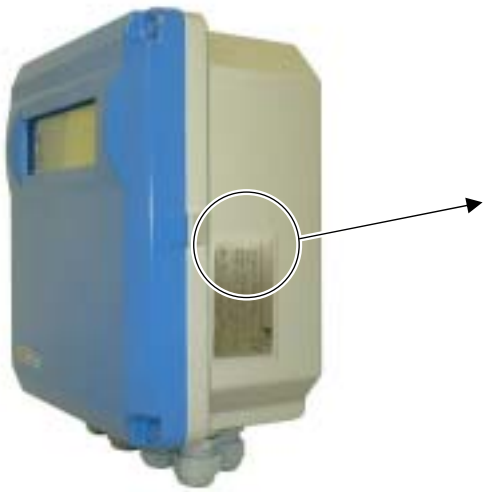
Signal cable (FLY7)
Cable for temperature sensor

1.3. Checking type and specifications

The specification plates attached to the flow transmitter and the detector list the type and specifications of the product. Check that they represent the type you ordered, referring to the following code symbols.

< Flow transmitter (FSH)>

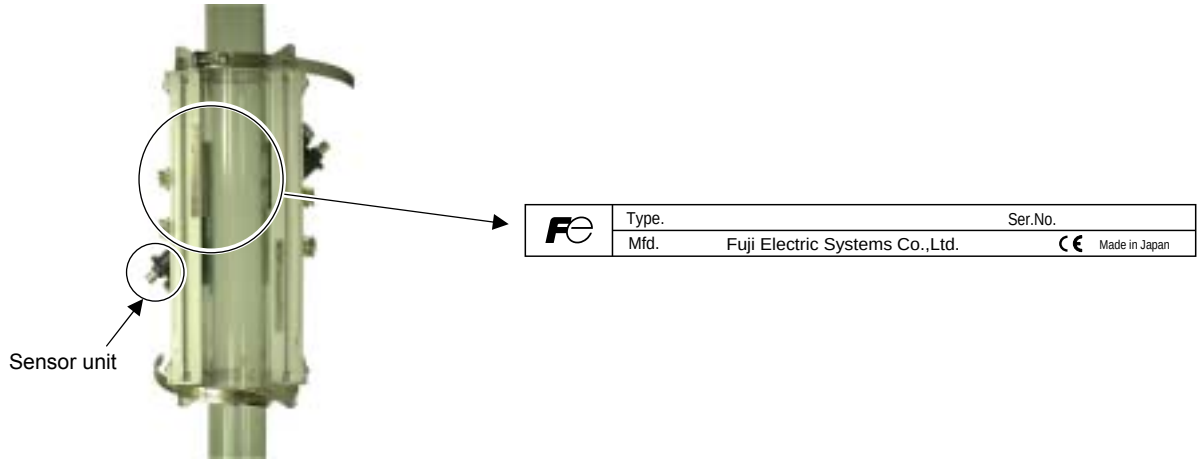
1 2 3 4 5 6 7 8	9 10 11 12	Description
F S H	1 – S	
S		Type (4th digit) Standard (Japanese)
E		Standard (English)
Y		Velocity profile output (5th digit) None
A		Available
Y		Use (6th digit) Single path or Changeover two-path (Note) Note: 2 sets of detectors and coaxial cables (FLY6) needed for two-path system
1		Power supply (7th digit) 100 to 240VAC, 50/60Hz
4		20 to 30VDC
1		Modification No. (8th digit)
S		Case structure (9th digit) Watertight type (IP67)
Y		Conduit connection (10th digits) [G1/2 and G3/8 (female screw)] with waterproof gland
A		[G1/2 (female screw)] with union gland (for plica) Note: The wiring port for coaxial cable (for ultrasonic sensor) and 3-wire cable (for temperature sensor) is provided with waterproof gland [G3/8 (female screw)].
Y		For use with explosion-proof detector (11th digit) None
	Y	Parameter setting, Tag plate (12th digit) None
	A	With setting
	B	With setting + Tag plate
	C	Tag plate



Ultrasonic Flow Meter CE
Type _____
Output DC4-20mA
Power Supply ☐AC100-240V 50/60Hz
☐DC20-30V
Ser.No. _____ Mfd. _____
Fuji Electric Systems Co.,Ltd. Made in Japan

<Detector (FSW)>

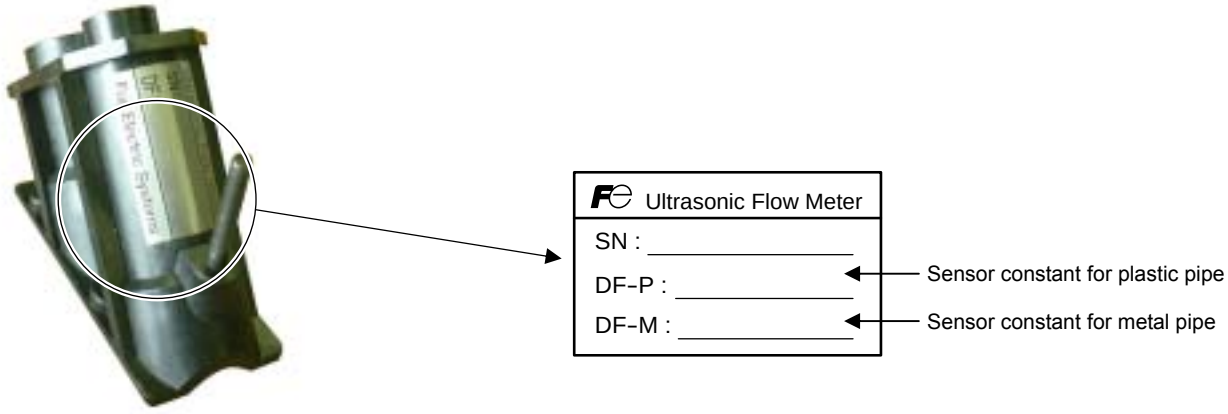
1 2 3 4 5 6 7 8 9 10 11	Description
F S W 1 –	
S	Type (4th digit) Standard
1 2	Kind of detector (5th and 6th digit) Small diameter detector (ϕ 50 to 100 mm)
2 1	Small size detector (ϕ 100 to 200 mm)
4 0	Middle size detector (ϕ 200 to 500 mm)
5 0	Large size detector (ϕ 500 to 1000 mm)
0	Use (7th digit) Watertight type (IP67)
1	Modification No. (8th digit) Mark 1
Y	Signal cable (9th digit) None
Y	Acoustic coupler (10th digit) None
A	Silicone compound
Y	Option (11th digit) None
A	Tag Plate



Note: To use the flowmeter employing the transit time method only, a detector (FLW) and a flow transmitter (FSH) must be used in combination. See data sheet EDS6-71 or EDS6-111 for details of selection of the detector (FLW) and dedicated cables (FLY1, FLY2).

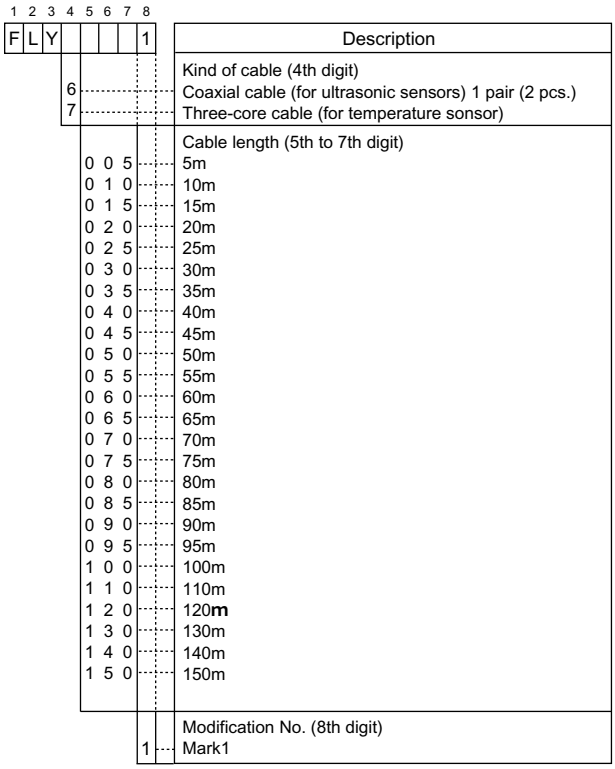
<Sensor unit>

The numeric value marked on the DF field of the nameplate of the sensor unit represents the sensor constant, which is determined by actual current calibration performed as part of the delivery test at the factory.



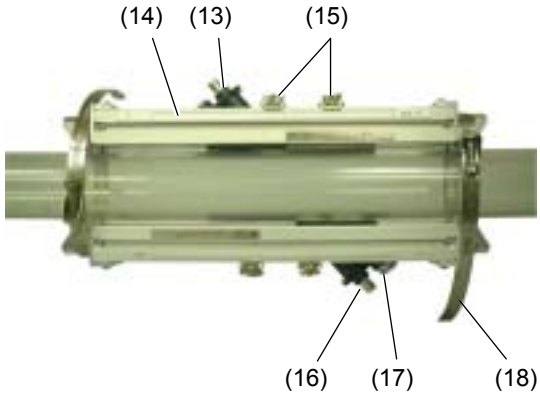
Note: Use a detector (FLW) and a transmitter (FSH) in combination to use the instrument by transit time method only. Refer to data sheet EDS6-71 or EDS6-111 for details of selection of the detector (FLW) and dedicated cables (FLY1, FLY2).

<Signal cable (FLY)>



1 2 3 4 5 6 7 8	Description
F L Y 1	
	Kind of cable (4th digit)
6	Coaxial cable (for ultrasonic sensors) 1 pair (2 pcs.)
7	Three-core cable (for temperature sonsor)
	Cable length (5th to 7th digit)
0 0 5	5m
0 1 0	10m
0 1 5	15m
0 2 0	20m
0 2 5	25m
0 3 0	30m
0 3 5	35m
0 4 0	40m
0 4 5	45m
0 5 0	50m
0 5 5	55m
0 6 0	60m
0 6 5	65m
0 7 0	70m
0 7 5	75m
0 8 0	80m
0 8 5	85m
0 9 0	90m
0 9 5	95m
1 0 0	100m
1 1 0	110m
1 2 0	120**m**
1 3 0	130m
1 4 0	140m
1 5 0	150m
	Modification No. (8th digit)
1	Mark1

1.4. Names of each part and functions



No.	Name	Description
(1)	Wiring connection port for power cable	Wiring port for power cable
(2)	Wiring connection port for ultrasonic signal cable	Wiring port for ultrasonic signal cable
(3)	Wiring connection port for temperature sensor cable	Wiring port for temperature sensor cable
(4)	Wiring connection port for DO output cable	Wiring port for for DO output cable
(5)	Display and setting unit	Displays flow rate, etc. Used for various setting operations.
(6)	LCD	Displays flow rate and various settings.
(7)	Setting key	Used for making settings.
(8)	Power terminal	Connect power cable to this terminal.
(9)	I/O terminal	Connect power output cable, communication cable, and temperature sensor cable to this terminal.
(10)	Input terminal	Connect ultrasonic signal cable to this terminal.
(11)	Output terminal	Connect Do output cable to this teminal.
(12)	LCD contrast adjusting knob	Used for adjusting the contrast of the LCD.
(13)	Sensor unit	Used for transmitting/receiving ultrasonic waves.
(14)	Sensor frame	Used for fastening the sensor unit to the piping.
(15)	Unit arm	Used for fastening the sensor by pressing it against the piping.
(16)	BNC connector for ultrasonic signal cable	Transmits ultrasonic send/receive signals.
(17)	Water-tight connector for temperature sensor cable	Transmits temperature sensor signals.
(18)	Stainless steel belt	Used for fastening the sensor frame to the piping.

2. SELECTING INSTALLATION LOCATION

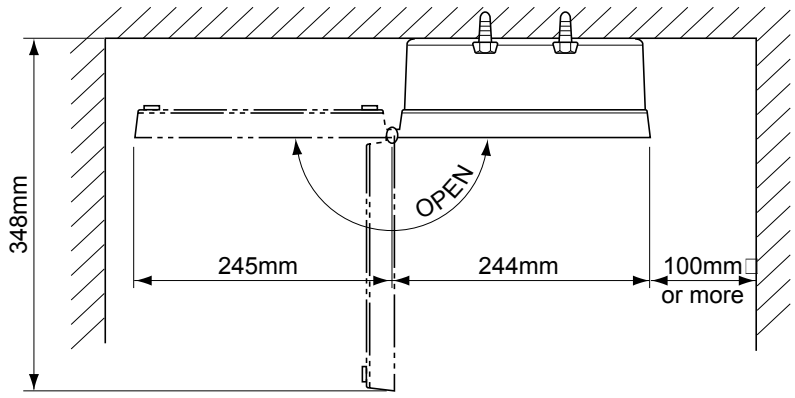
Select an installation location that satisfies the following conditions, with ease of maintenance and inspection, service life of the instrument, and assurance of reliability taken into consideration.

⚠ CAUTION

(1) A place where ambient temperature and humidity are as follows:
Flow transmitter (FSH): −10 to +50°C, 90%RH or lower
Detector (FSW): −20 to +80°C, 100%RH or lower
(2) A place not subject to direct sunlight or weather
(3) A place provided with space for daily inspection and wiring work
(4) A place not subject to radiant heat from a heating furnace, etc.
(5) A place not in an atmosphere of corrosive or explosive gas
(6) A place not subject to flooding
(7) A place not subject to vibration, dust, or moisture

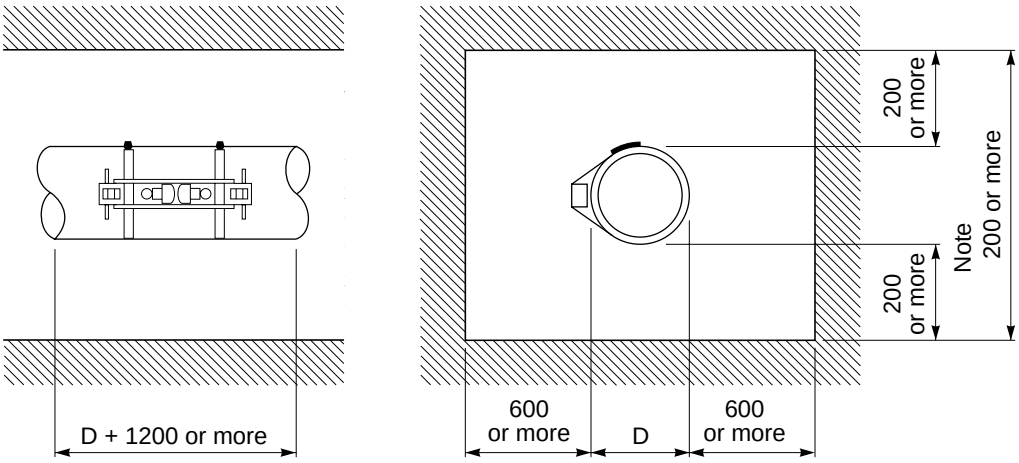
2.1. Flow transmitter

Allow space of 100 mm or more between the flow transmitter and the surrounding walls. Allow sufficient space for opening of the front cover for maintenance.
Allow sufficient space for wiring at the bottom of the case.



2.2. Detector

The mounting position of the detector, in other words, the state of the piping where the flow rate is to be measured, affects the accuracy of measurement to a great extent. Select a place that satisfies the conditions described in 2.2.1. Length of straight section of pipe. Assure sufficient working space for installation and maintenance, referring to the figures shown below.



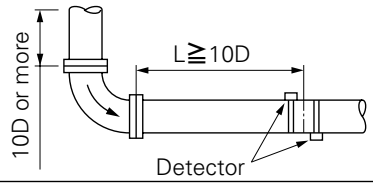
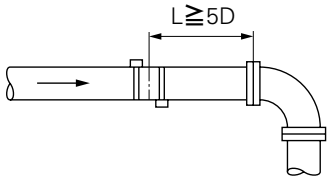
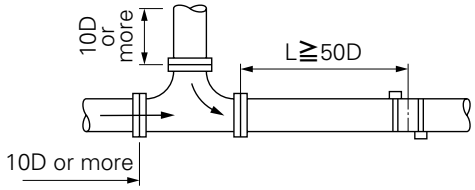
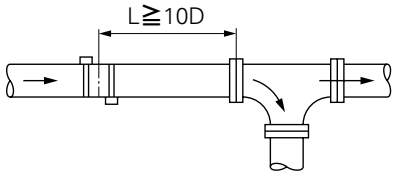
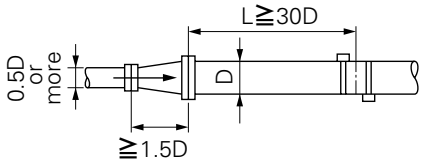
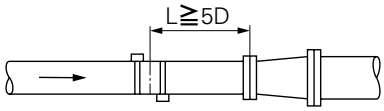
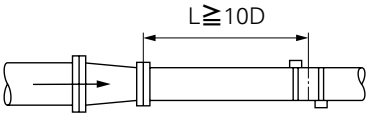
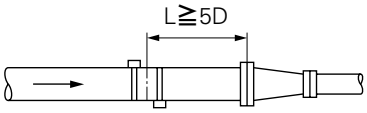
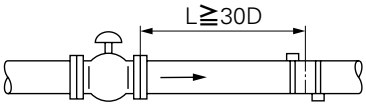
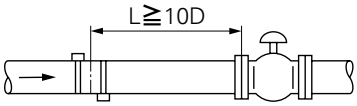
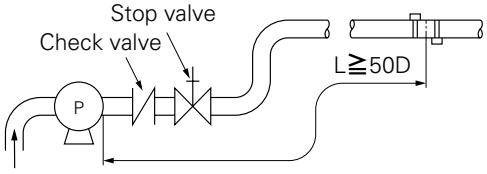
D: Pipe diameter

Space required for mounting of detector

2.2.1. Length of straight section of pipe

To assure the accuracy of flow rate measurement, allow sufficient length of the straight section of the pipe on the upper/lower stream side, referring to “straight pipe conditions” shown below.

(D : Inside diameter of pipe)

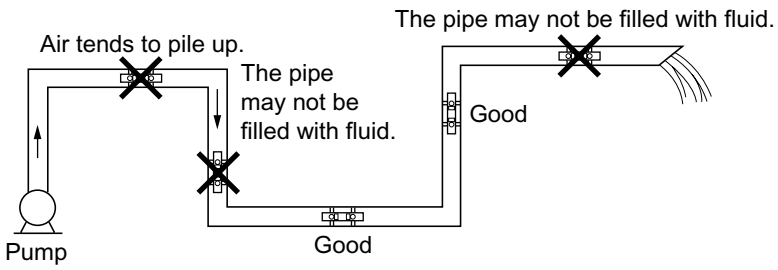
Classification	Upstream side	Downstream side
90 bend		
Tee		
Diffuser		
Reducer		
Various Valve	 In case that flow control valve exists on upstream side.	 In case that flow control valve exists on downstream side.
Pump		

(Note) The source : JEMIS-032

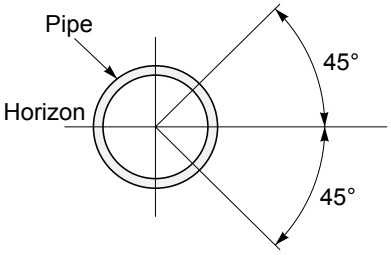
2.2.2. Mounting position

The instrument can be mounted horizontally or in any other position. However, pay attention to the following.

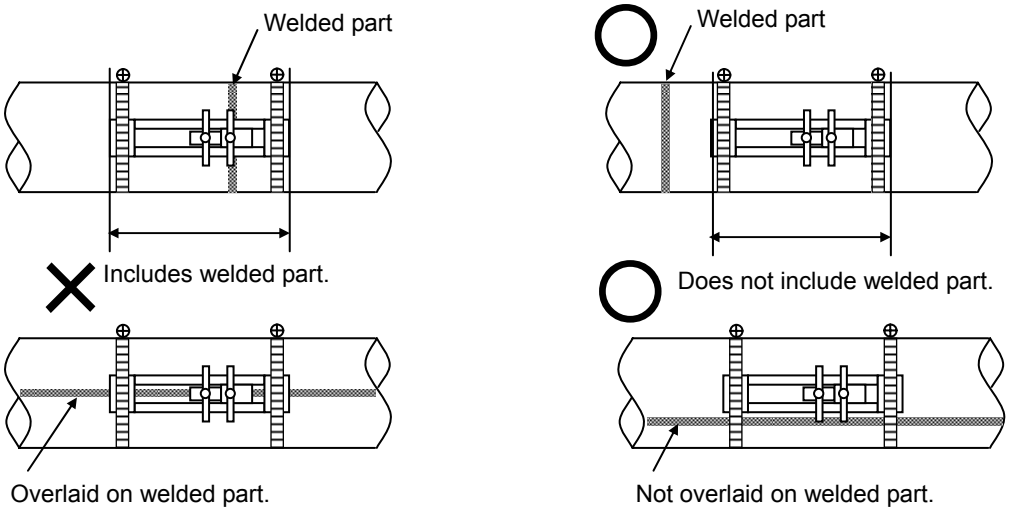
(1) Allow fluid to fill the pipe and keep it flowing at all times.



(2) Mount the flowmeter within ±45° from the center plane in the case of horizontal pipe run.
Mount it at an arbitrary position on the outer periphery in the case of vertical pipe run.



(3) Avoid mounting the flowmeter in a position where the pipe is deformed, or on a flange or welded part.



2.2.3. Mounting the sensor

The detector can be mounted either by Z method or V method as shown by Fig. 1.
The top surface of the sensor is referenced as shown by Fig. 2. Mount a pair of sensors, allowing the specified spacing between the surfaces of both sensors.

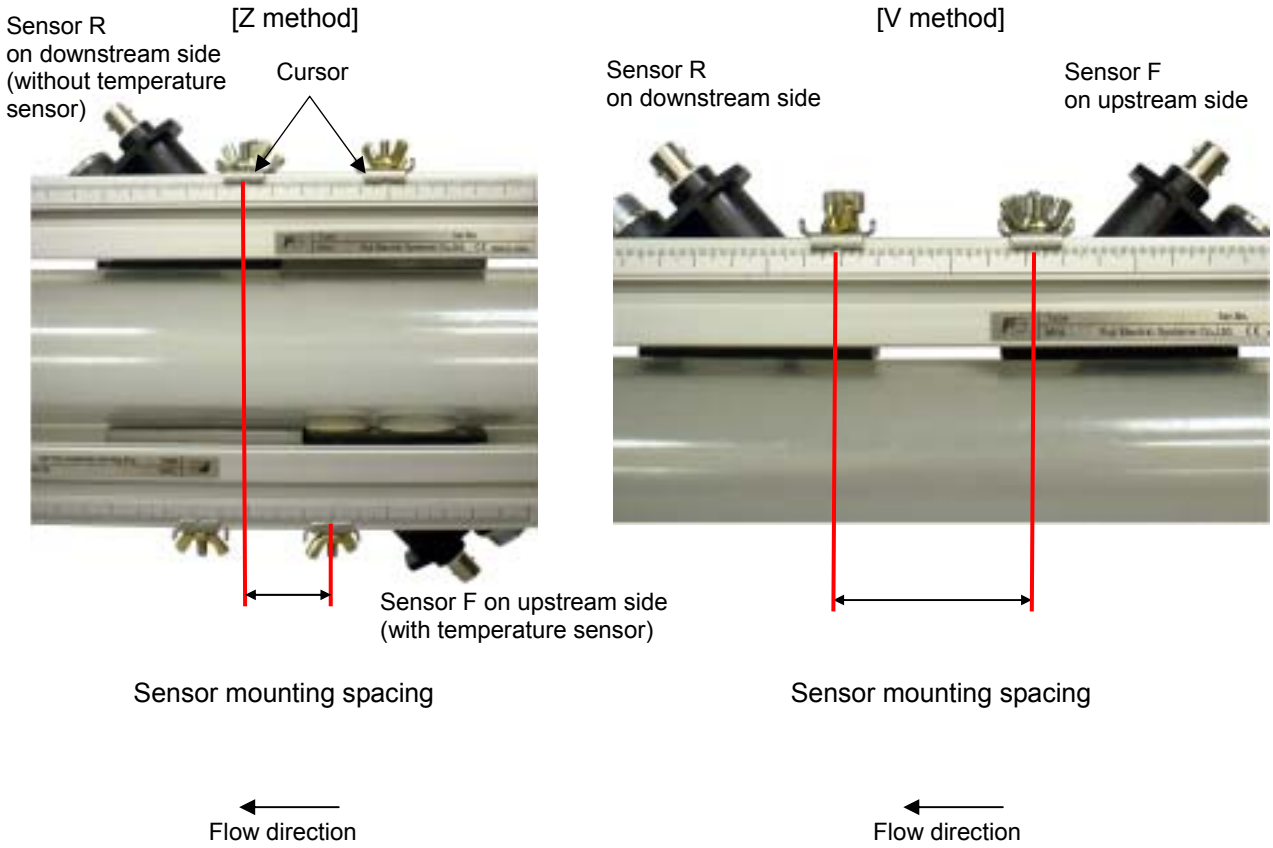


Fig. 1 Mounting of sensor

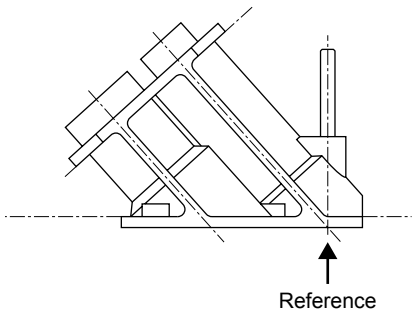


Fig. 2 Reference surface of sensor

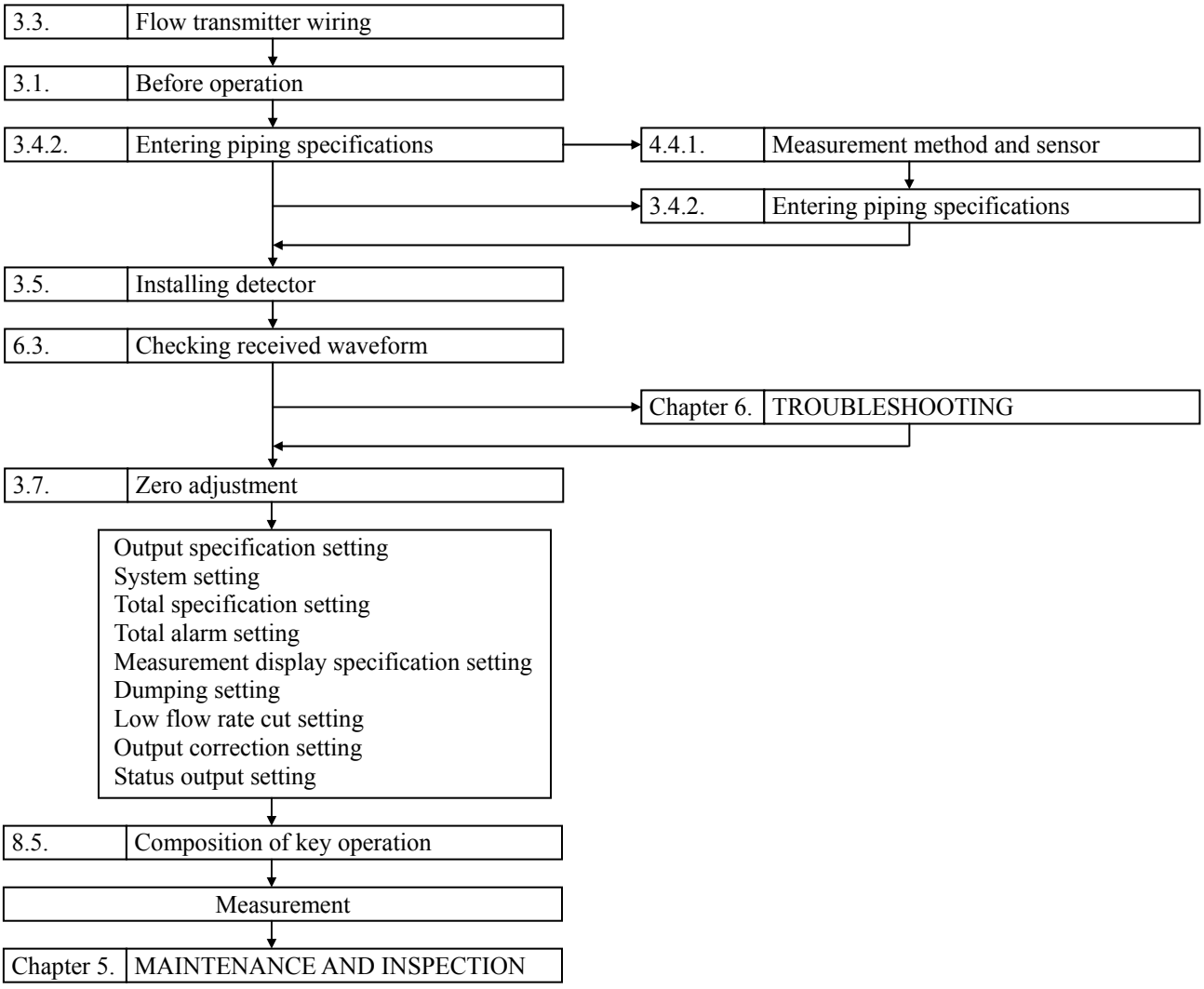
Mount the sensor by Z method in the case of hybrid measurement system.
Mount it by Z method to take measurements under the following conditions by transit time method only.

- To measure high turbidity fluids such as sewage influent
- When the pipe is provided with mortar lining
- When the pipe is old and thick scale is considered to have attached within the pipe

3. INSTALLATION AND BEFORE START OF OPERATION

3.1. Before operation

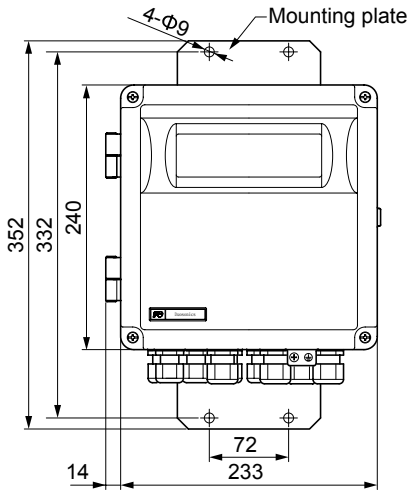
(1) Selection of installation location of flow transmitter and detector
(2) Installation and wiring of flow transmitter
(3) Power ON
Check the power supply specifications and wiring before turning on the power.
(4) Entering of piping parameters and calculation of the spacing between the sensor units (*Check the spacing of sensor units if parameter setting is provided.)
(5) Mounting of frame to measurement piping (*When using a frame for mounting)
(6) Mounting of sensor unit
Be careful not to mount the unit with wrong dimension.
(7) Setting of measurement range (*Not required if measurement range is specified by parameter setting provided.)
(8) Zero point adjustment
Before performing zero point adjustment, check that the pipe is filled with fluid, the fluid is in still state, and that the measurement status is normal.
(9) Start of measurement



3.2. Installing the flow transmitter

The flow transmitter can be mounted on a wall or on a panel.

Use four M8 bolts to mount the flow transmitter on a wall or a panel. Drill holes according to the mounting hole dimensions shown below, and fasten the flow transmitter using the M8 bolts.



3.3. Flow transmitter wiring

3.3.1. Cautions in wiring

⚠ CAUTION

(1) Use a dedicated cable (FLY) as a signal cable between the detector (FSW) and the flow transmitter (FSH). Do not join cable in the middle.
(2) Be sure to let the signal cables installed between the detector and the flow transmitter run through a metal conduit tube. The signal cables for upper and the lower streams can be made to run through the conduit tube together. However, do not let the power cable run through the conduit tube together with the signal cables to avoid induction problems.
(3) Use shielded cables for output signals as far as possible.
(4) To prevent noise from coming in, avoid installing wiring in a duct together with the power cable.
(5) Directly ground the power cable that includes a ground lead.
(6) The flowmeter is not equipped with a power switch. Mount one separately.
(7) Tightly seal the unused wiring ports with supplied sealing caps.

3.3.2. Applicable wires

Use the following cables.

- Power cable:
  3-wire or 2-wire cabtyre cable
  Nominal sectional area: 0.75 mm^2 or more
  Finished outer diameter: ϕ11 mm
- Output signal cable:
  2-wire or multi-wire cabtyre cable as required
  Finished outer diameter: ϕ11 mm
- Cable between detector and flow transmitter:
  Cable for ultrasonic wave signals (High-frequency coaxial double shield cable with characteristic impedance of 50 Ω, With waterproof BNC connector provided on one side)
  Finished outer diameter: ϕ7.3 mm
  Cable for temperature sensor (3-wire shielded cable, With waterproof connector provided on one side)
  Finished outer diameter: ϕ6.9 mm

3.3.3. Treatment of wiring port

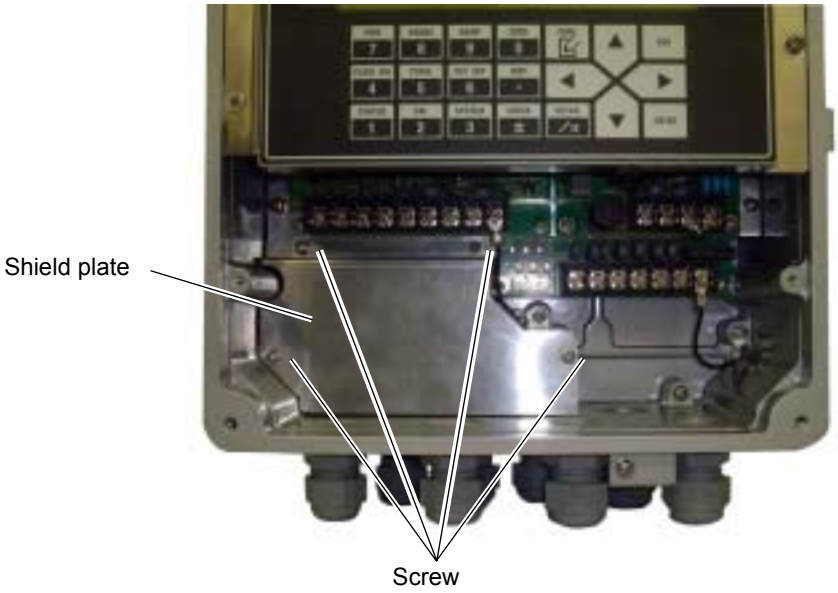
The casing of the flow transmitter is of watertight type (IP67). However, to prevent entry of moisture and occurrence of condensation, airtight processing of wiring ports is required. Be sure to take measures against entry of water using the waterproof glands supplied with the instrument. Tightly seal unused glands using the supplied sealing caps.

⚠ CAUTION

Do not install the flow transmitter in a place subject to the occurrence of flooding.

3.3.4. Removing and mounting the shield plate

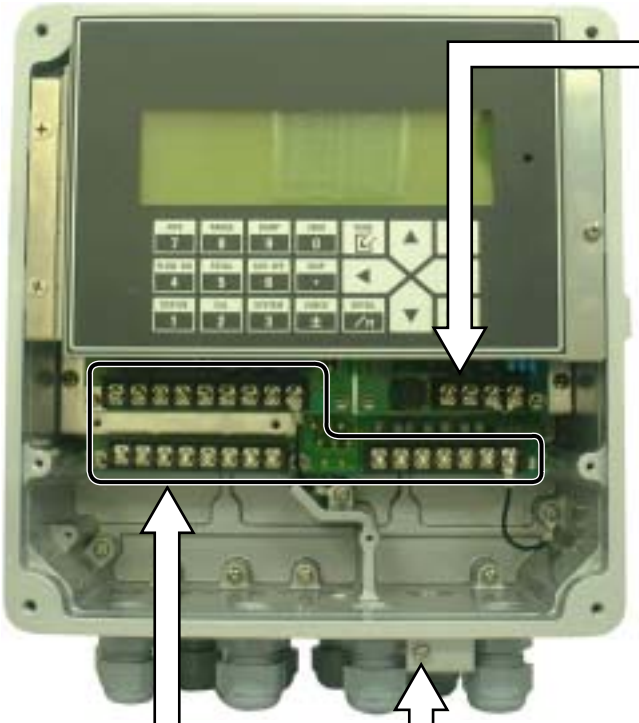
Before installing wiring, remove the 4 M3 screws and then the shield plate.



Be sure to mount the shield plate back in position after wiring is completed.

3.3.5. Wiring to each terminal

Install wiring according to the layout shown below.



Power board terminal block

Power supply terminal (AC)

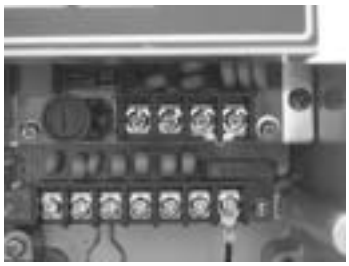
1	2	3	4
L	N	⏚	⏚

100 to 200 V AC

Power supply terminal (DC)

1	2	3	4
+	−	⏚	⏚

20 to 30 V AC



Outer earth terminal

Signal terminal

1	2	3	4	5	6	7	8	9
B	B	A				+	−	⏚

SERIAL　Iout

[Control board terminal block]

Cable (Black)　Cable (Black)　Cable (Yellow /Green)

To Temp. sensor

SERIAL

No.	RS485	RS232C
4	TRX2 (−)	TXD
5	TRX1 (+)	RXD
6	SHILD	COM

[Measurement board terminal block]

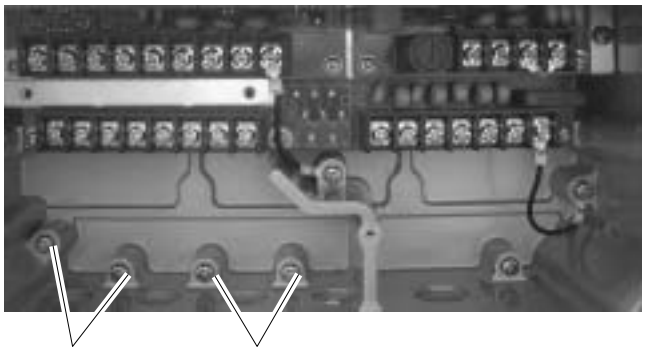
1	2	3	4	5	6	7	8
HF	GND	HF	GND	HF	GND	HF	GND

UP STR　DOWN STR　UP STR　DOWN STR

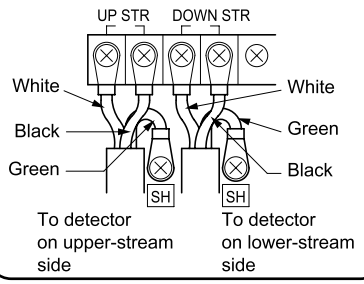
LINE1　LINE2　*Use LINE1 terminals in case of single path.

1	2	3	4	5	6	7
+	−	+	−	+	−	⏚

DO1　DO2　DO3



Details of wiring of ultrasonic signal cables



3.4. Setting piping parameters and calculating the spacing between sensor units

Make the setting to calculate the spacing between the sensor units as follows.

3.4.1. Selecting sensor type, mounting the sensor

Description

The data of the sensor required for measurement can be set as follows.
If the sensor mounting method or sensor type is changed, the sensor spacing in piping specifications is also changed.
Enter the data for each item according to the display (see the table shown below).
Refer to 4.4.1 for details of the setting.

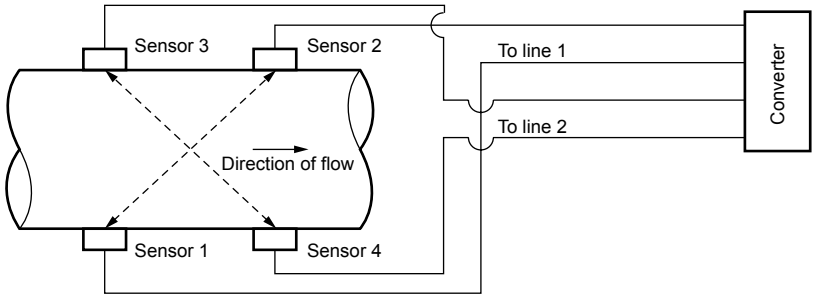
Item	Input method	Range or menu
Sensor mounting method	Select	V method, Z method
Sensor type	Select	FLW11, FLW41, FLW12, FLD12, FLD22, FLW32, FLW50, FLW51, FSW12, FSW21, FSW40, FSW50
Sensor calibration		
Line #-F: METAL PIPE	Numeric value	0.00% to 300.00%
Line #-R: METAL PIPE	Numeric value	0.00% to 300.00%
Line #-F: PLASTIC PIPE	Numeric value	0.00% to 300.00%
Line #-R: PLASTIC PIPE	Numeric value	0.00% to 300.00%
(#: Line No.)		

*1) Select sensor type by the model of the sensor to be used in combination (5 digits).
*2) In sensor calibration, set the sensor constant calculated based on actual current calibration performed as part of the delivery test at the factory. Set the sensor constant for each of the sensor units mounted to the pipe. The sensor constant appears as the DF value marked on the nameplate of the sensor unit. The setting need not be changed normally. (Make the setting when the detector or the flow transmitter is replaced.)
▪ It appears as the DF-P value on the nameplate of the sensor unit if the sensor is mounted on a plastic pipe.
▪ It appears as the DF-M value on the nameplate of the sensor unit if the sensor is mounted on a metal pipe.

	Pipe material
Plastic Pipe	PVC, FRP, PEEK, PVDF, Acrylic, Others
Metal Pipe	Carbon steal, Stainless steel, Copper, Cast iron, Aluminium, Ductile iron

Refer to “1.3 Checking type and specifications” for sensor unit.

*3) The sensor calibration value is for the sensors in the following figure.



Sensor calibration line 1-F: Sensor 1
Sensor calibration line 1-R: Sensor 2
Sensor calibration line 2-F: Sensor 3
Sensor calibration line 2-R: Sensor 4

*4) Perform sensor calibration only when the sensor type is FSW12, FSW21, FSW40, or FSW50.

Operation (example)	When Z method as sensor mount, FSW12 as sensor type, 102% for sensor calibration line 1-F (METAL), 101% for 1-R (METAL)	
Key operation	Description	Display
FUNC SYSTEM	Display System.	UNIT & LANGUAGE SKIP
▲ or ▼	Select “SENSOR MOUNT”	SENSOR MOUNT V METHOD
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “Z METHOD” and press ENTER.	SENSOR MOUNT Z METHOD
▲ or ▼	Select “SENSOR TYPE”	SENSOR TYPE FSW21
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “FSW12” and press ENTER.	SENSOR TYPE FSW12
▼	Select “SENSOR CALIBRATION”	SENSOR CALIBRATION SKIP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “Setting,” and press ENTER.	LINE 1-F: METAL 100.00%
ENTER 1 0 2 ENTER	Enter numeric value enter mode, enter “102” using ten keys, and press ENTER.	LINE 1-F: METAL 102.00%
▲ or ▼	Select “LINE 1-R”	LINE 1-R: METAL 100.00%
ENTER 1 0 1 ENTER	Enter numeric value enter mode, enter “101,” and press ENTER.	LINE 1-R: METAL 101.00%
ESC	Return to “SENSOR CALIBRATION”	SENSOR CALIBRATION SKIP
ESC	Display measurement, reflecting the setting.	(Measurement display screen)

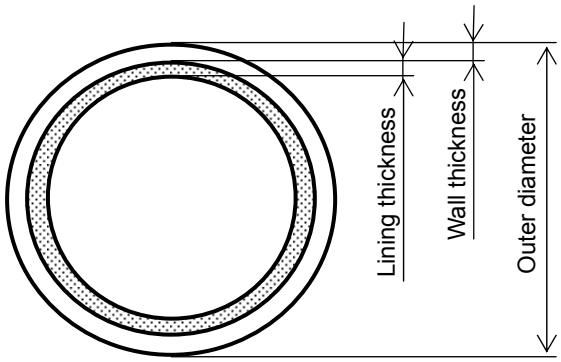
3.4.2. Entering piping specifications

Description

By setting the conditions of the piping where measurement is to be taken, the spacing between the sensor units to be mounted can be calculated. The sensor spacing is calculated automatically.

Enter data for each item listed in the following table according to the display.

Item	Input method	Range or menu
Outer diameter	Numeric value	10.00 mm to 6200.00 mm
Pipe material	Select	Carbon steel, stainless steel, PVC, copper, cast iron, aluminum, FRP, ductile iron, PEEK, PVDF, acrylic, and others
Pipe S.V.*1	Numeric value	1000 m/s to 3700 m/s
Wall thickness	Numeric value	0.10 mm to 100.00 mm
Lining material	Select	No lining, tar epoxy, mortar, rubber, Teflon, pyrex glass, PVC, and others
Lining S.V.*2	Numeric value	1000 m/s to 3700 m/s
Lining thickness*3	Numeric value	0.01 mm to 100.00 mm
Kind of fluid	Select	Water, seawater, dist. water, ammonia, alcohol, benzene, bromide, ethanol, glycol, kerosene, milk, methanol, toluol, lube oil, fuel oil, petrol, and others
Fluid S.V.*4	Numeric value	500 m/s to 2500 m/s
Viscosity*4	Numeric value	$0.0010E^{-6}$ m^2/s to $999.9999E^{-6}$ m^2/s



*1) When “others” is selected as pipe material only.
*2) When “others” is selected as lining material only.
*3) In the cases other than “No lining” only
*4) When “others” is selected for the kind of fluid only.

Operation (example)	When outer diameter of the pipe is 114.3 mm, pipe material is carbon steel, wall thickness is 6.0 mm, lining material is tar epoxy, lining thickness is 1.25 mm, kind of fluid is heavy water, sound velocity is 1388 m/s, and kinematic viscosity is $1.129E^{-6}$ m^2/s (When the sensor is mounted by “Z method,” sensor type is “FSW12.”

Key operation	Description	Display
FUNC PIPE	Display sensor spacing.	SENSOR SPACING 9.17 mm
▼	Select “OUTER DIAMETER”	OUTER DIAMETER 60.00 mm
ENTER 1 1 4 . 3 ENTER	Enter numeric value enter mode, enter 114.30 using ten keys, and then press ENTER.	OUTER DIAMETER 114.30 mm
▼	Select “PIPE MATERIAL”	PIPE MATERIAL PVC

ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "CARBON STEEL," and then press ENTER.	PIPE MATERIAL CARBON STEEL
▼	Select "WALL THICKNESS"	WALL THICKNESS 4.50 mm
ENTER 6 ENTER	Enter numeric value enter mode, enter "6" using ten keys, and press ENTER.	WALL THICKNESS 6.00 mm
▼	Select "LINING MATERIAL"	LINING MATERIAL NO LINING
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "TAR EPOXY," and press ENTER.	LINING MATERIAL TAR EPOXY
▼	Select "LINING THICKNESS"	LINING THICKNESS 0.01 mm
ENTER 1 . 2 5 ENTER	Enter numeric value enter mode, enter "1.25" using ten keys, and press ENTER.	LINING THICKNESS 1.25 mm
▼	Select "KIND OF FLUID"	KIND OF FLUID Water
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "OTHERS," and press ENTER.	KIND OF FLUID OTHERS
▼	Select "FLUID S.V."	FLUID S.V. 1440 m/s
ENTER 1 3 8 8 ENTER	Enter numeric value enter mode, enter "1388" using ten keys, and press ENTER.	FLUID S.V. 1388 m/s
▼	Select "VISCOSITY"	VISCOSITY 1.0038 $E^{-6}m^2/s$
ENTER 1 . 1 2 9 ENTER	Enter numeric value enter mode, enter "1.129" using ten keys, and press ENTER.	VISCOSITY 1.1290 $E^{-6}m^2/s$
ESC	Select "SENSOR SPACING"	SENSOR SPACING 39.16 mm
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

SENSOR SPACING
39.16 mm

← Set the piping data, and then mount the detector at dimensions displayed.

3.5. Installing Detector

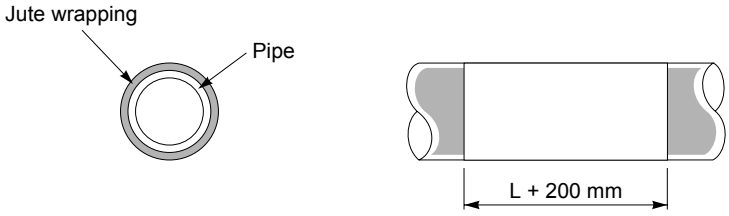
3.5.1. Outline of detector installation procedure

1. Treatment of mounting surface of the detector
2-1 Mounting small-diameter and small/medium size sensor
(1) How to mount the frame (using a jig)
(2) How to mount the frame (not using a jig)
(2)-1 How to determine the mounting position
(2)-2 How to mount the frame
(3) How to mount the sensor unit
2-2 Mounting a large sensor
(1) Mounting position
(2) How to mount the sensor

3.5.2. Treatment of mounting surface

Using thinner and sand paper, remove rust, pitch, and irregularities, if any, on the surface of the piping to which the detector is to be mounted over the length of the frame to be used.

Note 1: If the pipe is wrapped with jute, remove the jute wrapping over the entire circumference in width of frame length (L) + 200 mm, and then perform surface treatment described above.



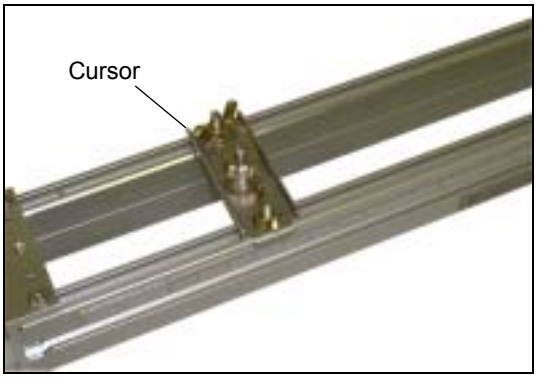
⚠ CAUTION

- Be careful not to cut your hand with the stainless steel belt when mounting the frame.
- Mount the sensor unit equipped with a temperature sensor on the upstream side.

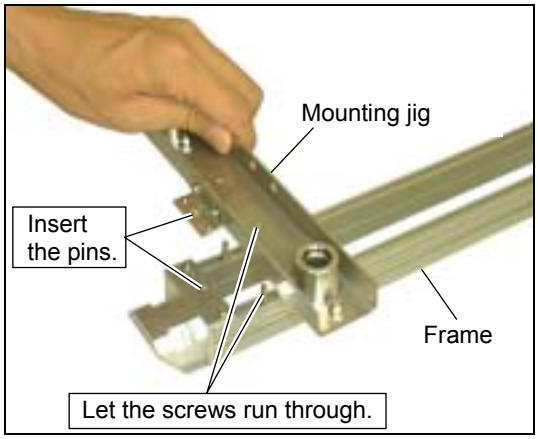
3.5.3. Mounting the detector by Z method using the frame

(1) How to mount the frame (using a jig)

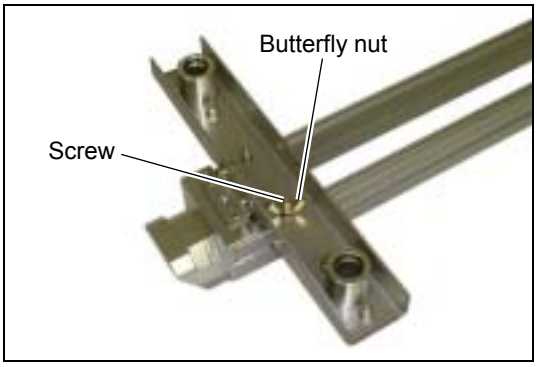
(1) Remove the butterfly nut of the cursor, and remove it out of the frame.



(2) Temporarily place the mounting jig (option) on the frame.

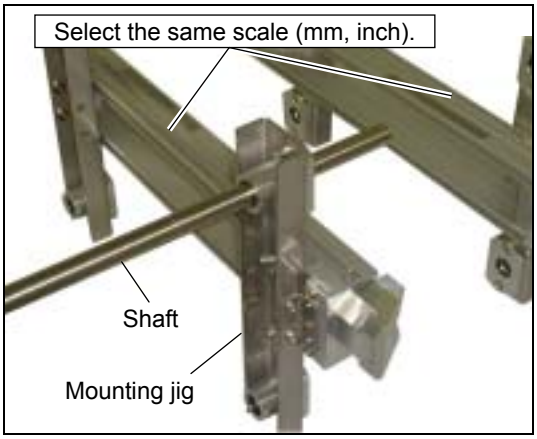


(3) Fasten the mounting jig to the frame using the butterfly nut and the screw.



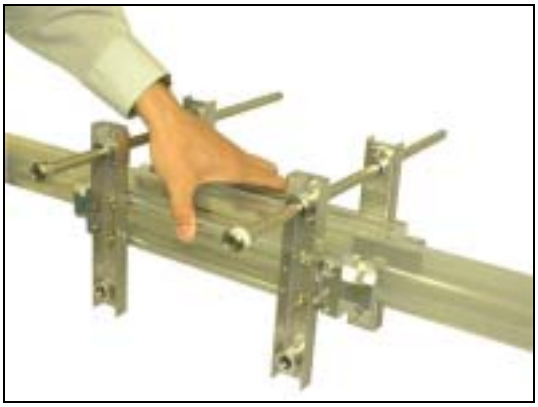
(4) Mount the mounting jig on the opposite side of the frame.

(5) Let the shaft run through the mounting jig.
Note: Pay attention when letting the shaft run through the jig so that the scale unit of the frame coincides with that of the shaft.

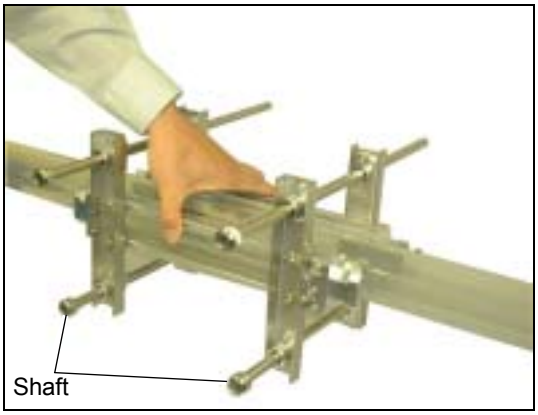


(6) Let the shaft run through the mounting jig on the opposite side.

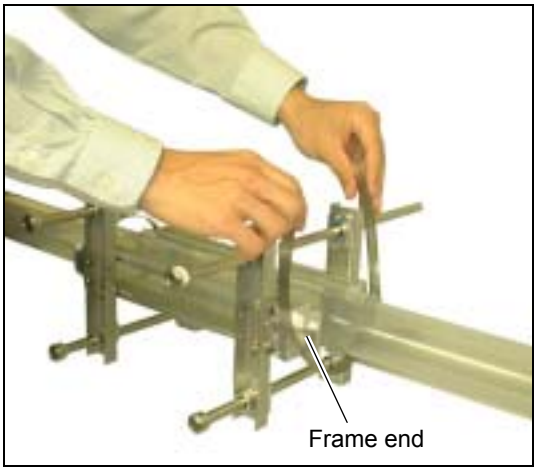
(7) Place the frame between the pipes.



(8) Let the shaft run through the holes at the bottom of the mounting jig.

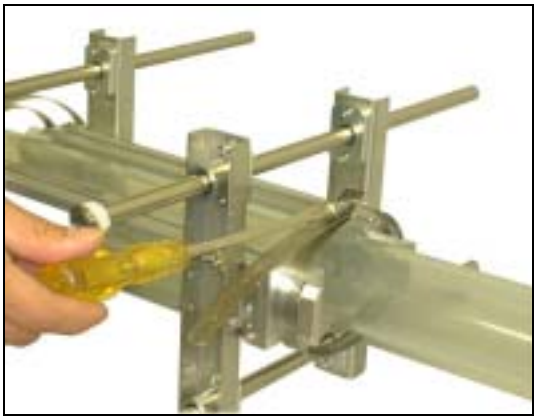


(9) Wrap the stainless belt around the frame end.



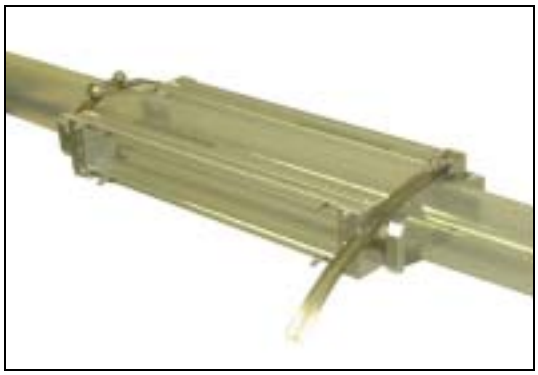
(10) Lift the screw of the stainless belt to let the tip of the belt run through it.

(11) Fasten the screw, wrapping the stainless belt around the frame end.



(12) Fasten both ends of the frame with the stainless belt.

(13) Remove the mounting jig.
Remove the shaft first, and then remove the mounting jig.

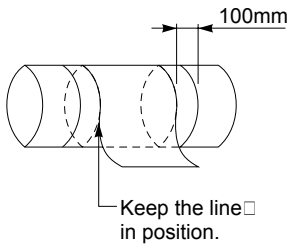


(2) How to mount the frame (not using a jig)

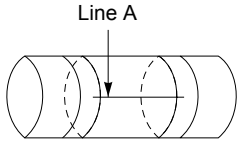
Gage paper is required to mount the frame by this method. (See "8.7. Making gauge paper" for details.)

(2)-1 How to determine the mounting position

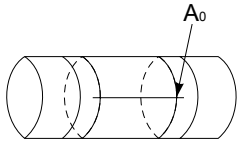
(1) Align the edge of the gauge paper to the place 100mm from one of the edges treated for mounting, and wrap it around the pipe, keeping the line on the gauge paper in parallel with the axis of the pipe. (Fasten with tape to prevent it from being dislocated.) Keep the edge of the gauge paper at specified position.



(2) Write straight line A on the pipe, extending the line written on the gauge paper.

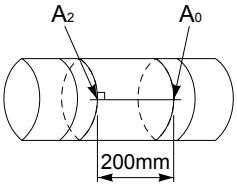


(3) Write a line along one edge of the gauge paper. Let the point of intersection of that line and line A be A_0.



V method

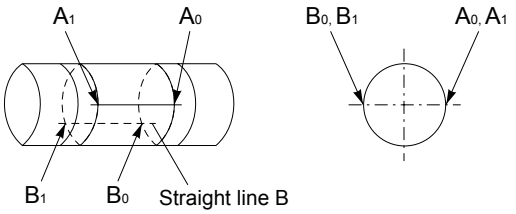
Example: When L=200mm



(4) Peel off the gauge paper, measure the sensor spacing from A_0, and draw a line that intersects with straight line A at right angles. (Find A_2.)

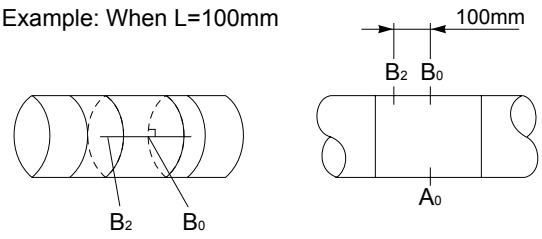
From A_0 to A_2 is defined as the mounting position.

Z method



(4) Measure the circumference beginning from A_0 using a measure. Determine the points that equally divide the circumference and let them be B_0 and B_1 respectively. Draw a line connecting these two points (straight line B).

Example: When L=100mm



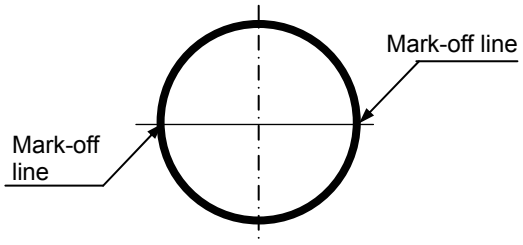
(5) Mark point B_0, and then peel off the gauge paper. Measure the sensor spacing from B_0, and draw a line that intersects with straight line B at right angles. (Find B_2.)

From A_0 to B_2 is defined as the mounting position.

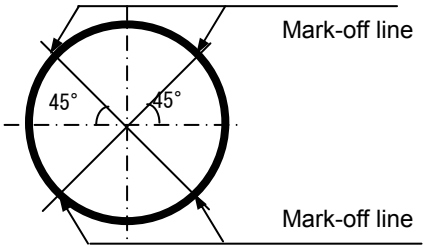
(2)-2 Mounting the Frame

(1) Checking the mark-off line

"In the case of 1 measurement line"
Draw a horizontal mark-off line that includes the center point of the cross sectional view of the pipe.



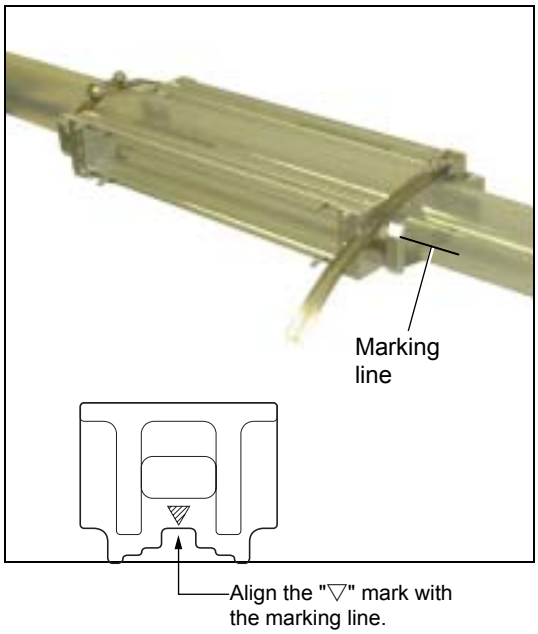
"In the case of 2 measurement lines"
Draw a mark-off lines at an angle ±45° from the horizon.



(2) Wrap the stainless belt around the pipe.

(3) Lift the screw of the stainless belt and let the tip of the belt run through it.

(4) Place the frame so that the marking line and the "▽" mark on the frame end are aligned, and then fasten it with a band.



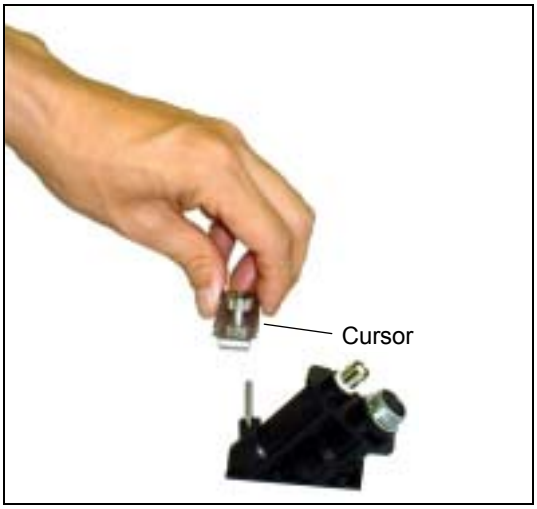
(3) How to mount the sensor unit

Mount the sensor unit comprising of two sensors facing opposite to each other, keeping the spacing displayed after the piping parameter setting is completed. See "2.2.3. Mounting the sensor" for details.

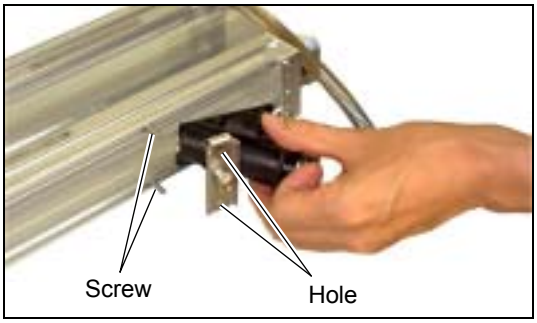
Note: Mount the sensor unit equipped with a temperature sensor on the upstream side.

(1) Before mounting the sensor unit to the frame, apply silicon rubber evenly over the entire transmitting surface of the sensor unit and the surface of the thermometer that is to contact the pipe.

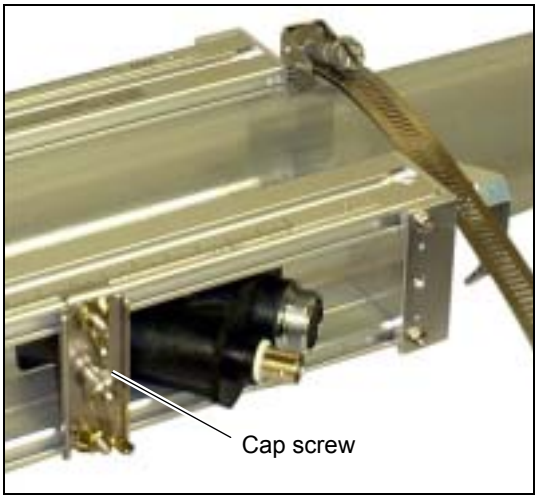
(2) Temporarily place the cursor on the sensor unit.



(3) Insert the sensor unit into the frame, aligning the holes of the cursor with the screws of the frame.



(4) Fasten the sensor unit with butterfly nuts. Then bring the sensor unit into intimate contact with the pipe, fastening the cap screw.



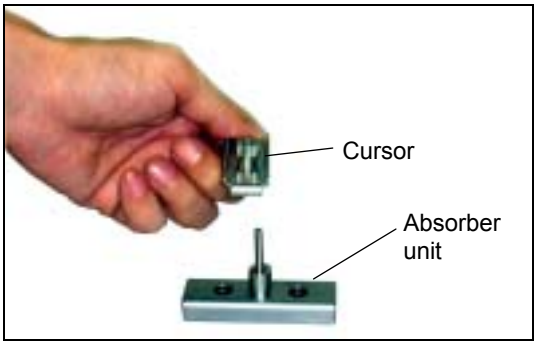
(5) Mount the sensor unit, paying attention to the spacing of the sensors facing opposite to each other.

(6) Mount the two sensors with the front surface of each facing to each other. Mount only one sensor to one frame.

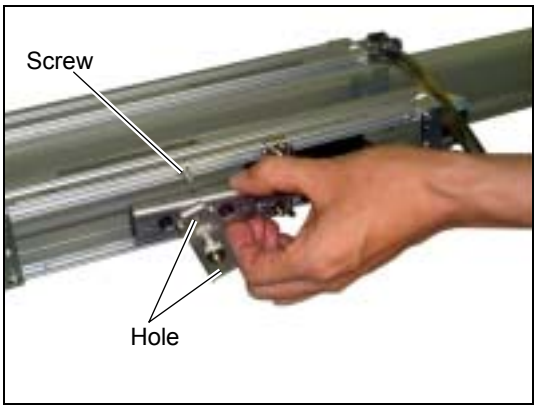
Mounting of resin piping has now been completed. In the case of metal piping, mount the absorber unit as shown below.

(7) Before mounting the absorber unit, apply silicon rubber evenly over the entire installation surface of the absorber unit.

(8) Temporarily place the cursor onto the absorber unit.

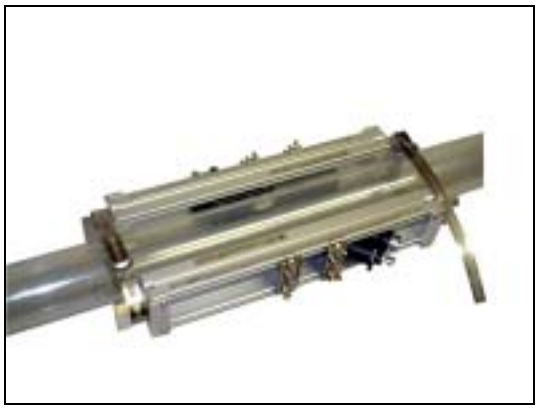


(9) Aligning the screws of the frame to the holes of the cursor, insert the absorber unit into the frame.



(10) Fasten the absorber unit with the butterfly nut at the position where the absorber unit comes in contact with the sensor unit. Then fasten the cap screw.

(11) Fasten the absorber unit onto both frames.



3.5.4. Mounting the sensor unit by V method using a frame (1 measurement line)

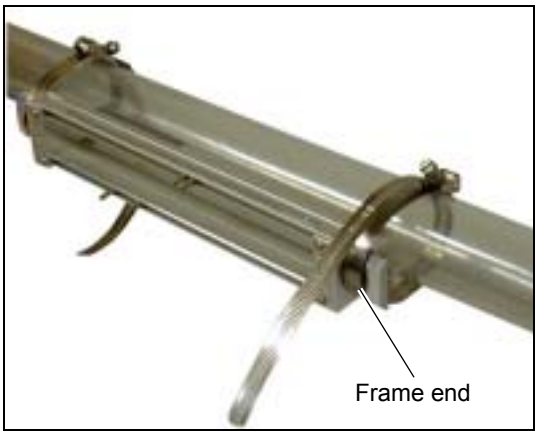
(1) Mounting the frame

Unlike Z method, only one frame is used. No mounting jig is used.

(1) Wrap the stainless steel belt around the pipe.

(2) Lift the screw of the stainless belt to let the tip of the belt run through it.

(3) Wrap the stainless steel belt around the frame ends, keeping the frame in parallel with the pipe, to fasten the frame temporarily.



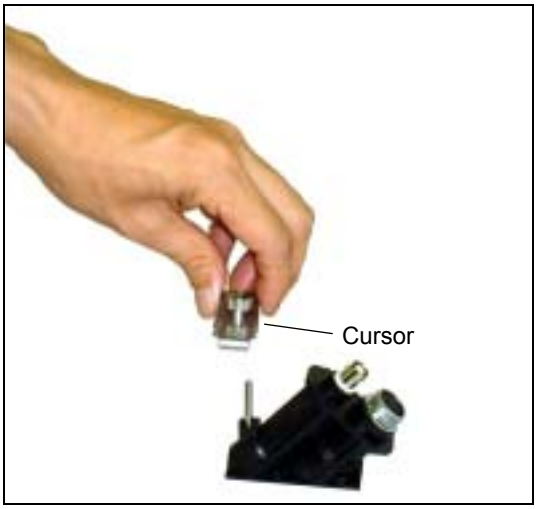
(2) Mounting the sensor unit

Mount both sensor units at the spacing shown in "Sensor spacing" that is to be displayed after pipe parameter setting is made. The spacing is the distance between the tips of both sensors.

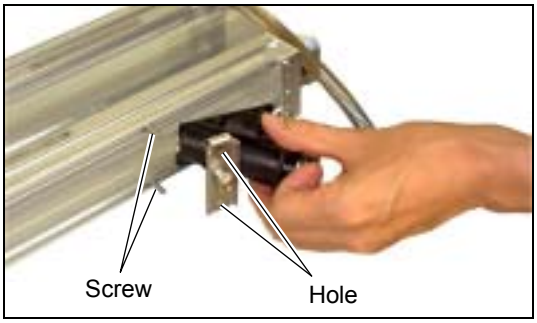
Note: Mount the sensor unit equipped with a temperature sensor on the upstream side.

(1) Apply silicon rubber evenly over the entire transmission surface of the sensor unit and the contact surface of the pipe of the thermometer before mounting the sensor unit to the frame.

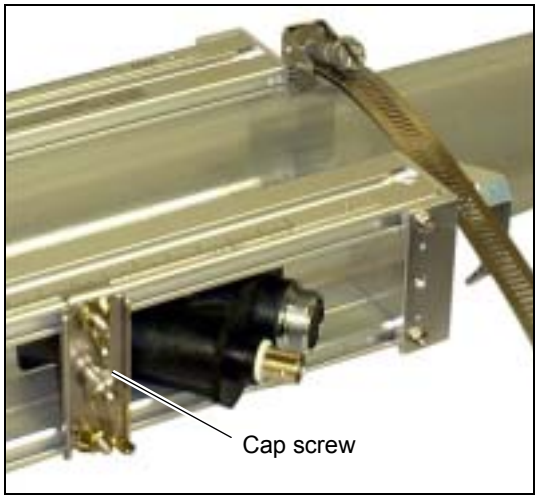
(2) Temporarily place the cursor on the sensor unit.



(3) Insert the sensor unit into the frame, aligning the holes of the cursor with the screws of the frame.



(4) Fasten the sensor unit with butterfly nuts. Then bring the sensor unit into intimate contact with the pipe, fastening the cap screw.



(5) Mount the sensor unit opposing to each other, paying attention to the mounting spacing. (Mount the two sensors with the front of each facing opposite to each other.)

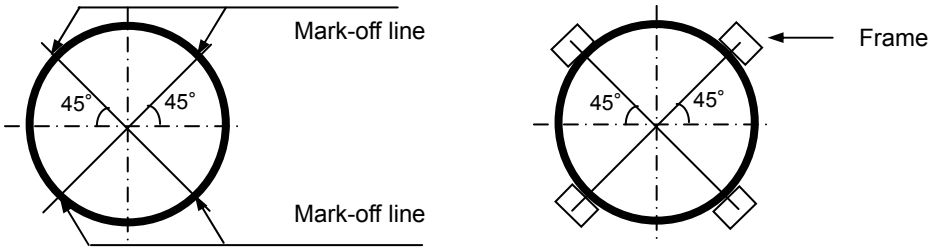
Note:
The sensor can be mounted by V method only when transit time method is employed. Consequently an absorber is not used even if the pipe is made of metal.

3.5.5. Mounting the sensor unit by Z method using a frame (2 measurement lines)

(1) Mounting the frame

Two pairs of frames are required.

(1) Draw a mark-off line at an angle ±45° from the horizon. See 3.5.7. (1) how to draw a mark-off line.



(2) Align the center of the end frame so that it comes over the make-off line, and temporarily fasten it using cloth belt, etc. not on the frame ends but on the frame.
(3) Then wrap a stainless steel belt around the frame end to fasten it securely. Follow the description in 3.5.3. to fasten the stainless steel belt.

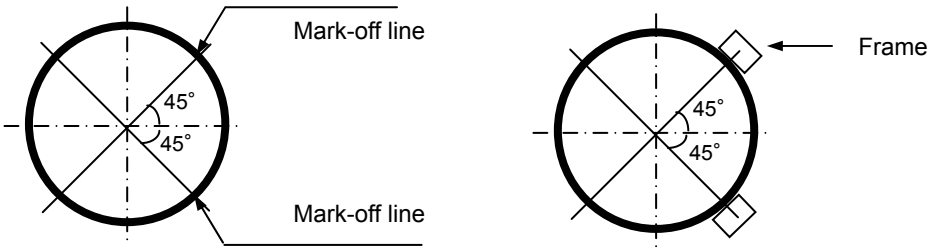
(2) Mounting the sensor unit

Two pairs of sensor units and two pairs of absorbers (in the case of a metal pipe) are required for mounting. Mount the sensor units following the same procedure as “3.5.3.(3) How to mount the sensor unit.” Mount each pair of frames to install the sensor unit.

3.5.6. Mounting the sensor unit by V method using a frame (2 measurement lines)

(1) Mounting the frame

The method is valid only when transit time method is employed. Two pairs of sensor units and 2 frames are required for this measurement method. Mount the frames following the same procedure as Z method.



(2) Mounting the sensor unit

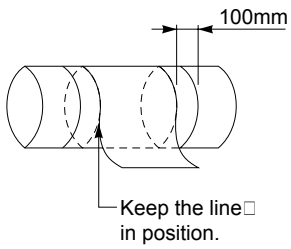
Follow the same procedure as “3.5.4.(2) Mounting the sensor unit.” to mount the sensor unit. Mount each frame to install the sensor unit.

3.5.7. Mounting the sensor unit to a large-diameter pipe

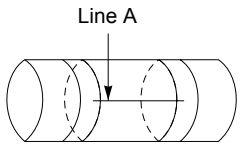
(1) How to determine the mounting position

Do not use a mounting jig to install the sensor unit to a pipe of diameter of 500 A or more. Mount the sensor with wire in such cases. (Do not use a frame.)
Perform the following to determine the mounting position.
Gauge paper is required for the work. (See "8.7. Making gauge paper" for details.)

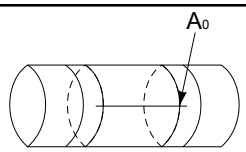
(1) Align the edge of the gauge paper to the place 100mm from one of the edges treated for mounting, and wrap it around the pipe, keeping the line on the gauge paper in parallel with the axis of the pipe. (Fasten with tape to prevent it from being dislocated.) Keep the edge of the gauge paper at specified position.



(2) Write straight line A on the pipe, extending the line written on the gauge paper.

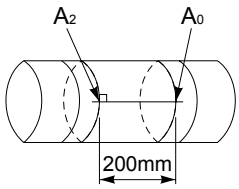


(3) Write a line along one edge of the gauge paper. Let the point of intersection of that line and line A be A_0.



V method

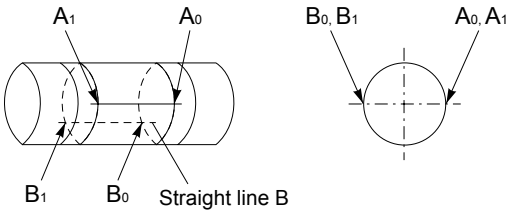
Example: When L=200mm



(4) Peel off the gauge paper, measure the sensor spacing from A_0, and draw a line that intersects with straight line A at right angles. (Find A_2.)

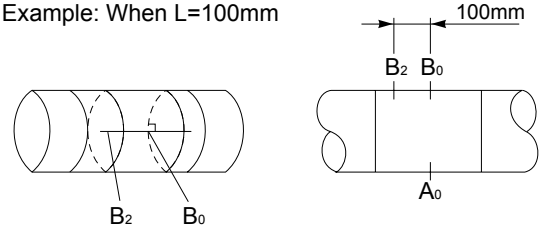
From A_0 to A_2 is defined as the mounting position.

Z method



(4) Measure the circumference beginning from A_0 using a measure. Determine the points that equally divide the circumference and let them be B_0 and B_1 respectively. Draw a line connecting these two points (straight line B).

Example: When L=100mm



(5) Mark point B_0, and then peel off the gauge paper. Measure the sensor spacing from B_0, and draw a line that intersects with straight line B at right angles. (Find B_2.)

From A_0 to B_2 is defined as the mounting position.

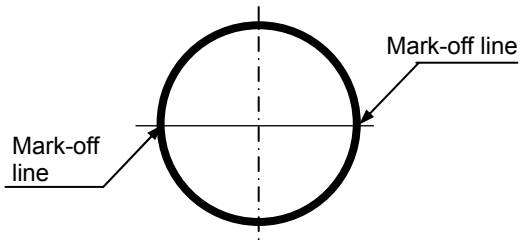
(2) Mounting the sensor

Use sensor FSW50 for large-diameter pipes.

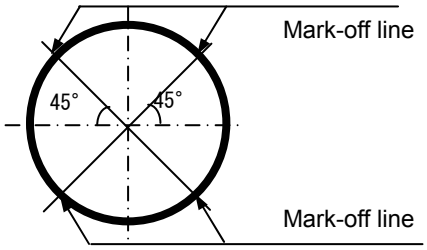
Note: Mount the sensor unit equipped with a temperature sensor on the upstream side.

(1) Checking the mark-off line

"In the case of 1 measurement line"
Draw a horizontal mark-off line that includes the center point of the cross sectional view of the pipe.



"In the case of 2 measurement lines"
Draw a mark-off lines at an angle ±45° from the horizon.



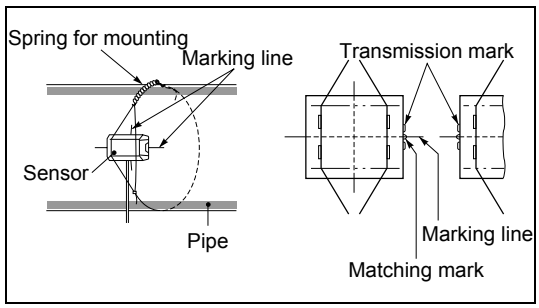
(2) Provide a wire rope for the sensor unit on the upstream and downstream sides and the absorber unit. Allow the length of the wire rope to be the same or longer than the pipe diameter.

(3) Lay the wire rope around the pipe on the upstream side. Then hang the spring for mounting on the wire rope.

(4) Apply silicon rubber evenly over the entire transmitting surface of the sensor unit, paying attention not to let air bubbles mix in.

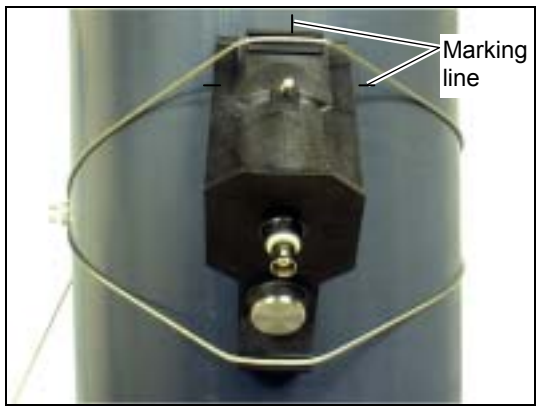
(5) Clean the surface of the piping, and then mount the sensor unit.

(6) Split up the wire rope around the marking line to right and left, bring the sensor unit into intimate contact with the pipe, and then lay the wire rope around them, paying attention to let the marking of the sensor unit be aligned with the marking line.



(7) Check that the matching mark on the sensor unit and the marking line are aligned, and then connect the coaxial cable to the flow transmitter.

Note: Do not pull the coaxial cable. Otherwise the sensor unit may move, thus causing measurement trouble.

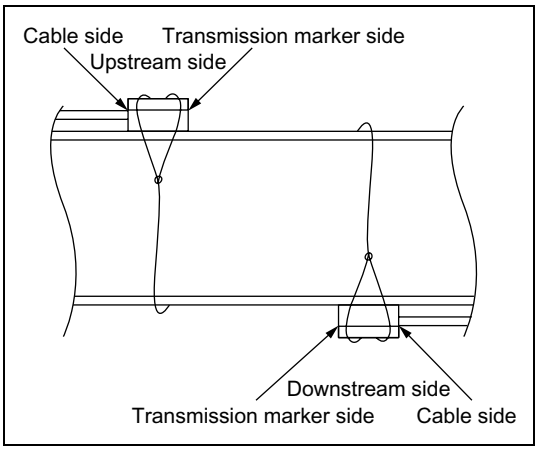


(8) Lay the wire rope on the side provided with the transmission marker.

(9) Apply silicon rubber evenly over the entire installation surface of the absorber unit.

(10) Clean the surface of the pipe, and then mount the absorber unit. Split up the wire rope to right and left, bring the absorber unit into intimate contact with the sensor unit, and then lay the wire rope around them.

(11) Follow the same procedure to mount the sensor on the downstream side.



3.6. Setting analog output range and total pulse

The following table lists the analog output and total pulse settings.

3.6.1. Analog output range setting

Description

Make the setting as shown below when outputting the measured value (flow rate or flow velocity) in specified range within 4 to 20 mA.
The following is an example of operation. Refer to 4.4.4. for details of the setting.

Operation (example)	In the case of Bi-directional range, and full scale 1 set to 100 m^3/h, full scale 2 to −100 m^3/h, range hys. to 5%, lower limit to −10% (2.4 mA), upper limit to 110% (21.6 mA), output burnout to the lower limit value, burnout timer to 30 seconds, rate limit to 5 m^3/h, and rate limit timer to 15 sec.

Key operation	Description	Display
[FUNC] [RANGE]	Display range unit.	RANGE UNIT m/s
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "m^3/h," and press ENTER.	RANGE UNIT m^3/h
[▼]	Select "RANGE TYPE"	RANGE TYPE SINGLE
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "Bi-directional" range, and press ENTER.	RANGE TYPE BI-DIR
[▼]	Select "FULL SCALE 1"	FULL SCALE 1 56.32 m^3/h
[ENTER] [1] [0] [0] [ENTER]	Enter numeric value enter mode, enter "100" using ten keys, and press ENTER.	FULL SCALE 1 100.0 m^3/h
[▼]	Select "FULL SCALE 2"	FULL SCALE 2 112.64 m^3/h
[ENTER] [±] [1] [0] [0] [ENTER]	Enter numeric value enter mode, enter "−100" using ten keys, and press ENTER.	FULL SCALE 2 −100 m^3/h
[▼]	Select "RANGE HYS."	RANGE HYS. 10.00%
[ENTER] [5] [ENTER]	Enter numeric value enter mode, enter "5" using ten keys, and press ENTER.	RANGE HYS. 5.00%
[▼]	Select "OUTPUT LIMIT Lo."	OUTPUT LIMIT Lo. −20%
[ENTER] [1] [0] [ENTER]	Enter numeric value enter mode, enter "10" using ten keys, and press ENTER.	OUTPUT LIMIT Lo. −10%
[▼]	Select "OUTPUT LIMIT Hi."	OUTPUT LIMIT Hi. 120%
[ENTER] [1] [1] [0] [ENTER]	Enter numeric value enter mode, enter "110" using ten keys, and press ENTER.	OUTPUT LIMIT Hi. 110%
[▼]	Select "OUTPUT BURNOUT"	OUTPUT BURNOUT HOLD
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "LOWER," and press ENTER.	OUTPUT BURNOUT LOWER
[▼]	Select "BURNOUT TIMER"	BURNOUT TIMER 10 sec

ENTER 3 0 ENTER	Enter numeric value enter mode, enter “30” using ten keys, and press ENTER.	BURNOUT TIMER 30 sec
▼	Select “RATE LIMIT”	RATE LIMIT 0.00 m^3/h
ENTER 5 ENTER	Enter numeric value enter mode, enter “5,” and press ENTER.	RATE LIMIT 5.00 m^3/h
▼	Select “RATE LIMIT TIMER”	RATE LIMIT TIMER 0 sec
ENTER 1 5 ENTER	Enter numeric value enter mode, enter “15” using ten keys, and press ENTER.	RATE LIMIT TIMER 15 sec
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

3.6.2. Total pulse output setting

Description

Make the setting to perform pulse output of the total measurement value (flow rate).
The following is an example of operation. Refer to 4.4.9. and 4.4.11. for details of the setting.

Definition of total pulse to DO (example)	When DO1 is output as total pulse output in forward direction	
Key operation	Description	Display
FUNC STATUS	Display Status.	SELECT STATUS DO.1
ENTER ▲ or ▼	Select "DO.1."	SELECT STATUS DO.1▲▼
ENTER	Display "OUTPUT DO.1"	OUTPUT DO.1 NOT USED
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "F: TOTAL PULSE," and press ENTER.	OUTPUT DO.1 F: TOTAL PULSE
▲ or ▼	Display "MODE DO.1"	MODE DO.1 REVERSE
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "NORMAL," and press ENTER.	MODE DO.1 NORMAL
ESC ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

Total setting (example)	When performing integration, holding output burnout with total pulse output set to 100 m^3 for 1 pulse, burnout timer set to 15 sec, and pulse width 1 set as 100msec.	
Key operation	Description	Display
FUNC TOTAL	Display Total mode.	TOTAL MODE TOTAL RUN
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "TOTAL STOP," and press ENTER. (Setting is allowed.)	TOTAL MODE TOTAL STOP
▲ or ▼	Select "TOTAL UNIT"	TOTAL UNIT mL
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "m^3," and press ENTER.	TOTAL UNIT m^3
▲ or ▼	Select "TOTAL RATE"	TOTAL RATE 10.000 m^3
ENTER 1 0 0 ENTER	Enter numeric value enter mode, enter "100" using the ten key, and press ENTER.	TOTAL RATE 100.000 m^3
▲ or ▼	Select "OUTPUT BURNOUT"	OUTPUT BURNOUT NOT USED
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "HOLD," and press ENTER.	OUTPUT BURNOUT HOLD
▲ or ▼	Select "BURNOUT TIMER"	BURNOUT TIMER 10 sec
ENTER 1 5 ENTER	Enter numeric value enter mode, enter "15" using ten keys, and press ENTER.	BURNOUT TIMER 15 sec
▲ or ▼	Select "PULSE WIDTH 1"	PULSE WIDTH 1 50 msec

ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “100,” and press ENTER.	PULSE WIDTH 1 100 msec
▲ or ▼	Select “TOTAL MODE”	TOTAL MODE TOTAL STOP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “TOTAL RESET,” and press ENTER.	TOTAL MODE TOTAL RESET
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

3.7. Zero adjustment

Description

Close the valves on upper and lower streams of the flowmeter to stop the flow completely, and then perform zero adjustment.

Note 1: If no valves are provided or the flow cannot be stopped, select "Clear" when performing "Zero adjustment." Note that zero point may deviate slightly in this case.

Note 2: ZERO: Press "Zero" to perform zero adjustment in a state where the flow is stopped completely.
CLEAR: Press "Clear" to perform zero adjustment in a state where the flow cannot be stopped.

Operation (example)	When performing zero adjustment in still state	
Key operation	Description	Display
[FUNC] [ZERO]	Display zero adjustment.	ZERO ADJUSTMENT CLEAR
[ENTER] [▲] or [▼]	Enter select/enter mode, and select "ZERO"	ZERO ADJUSTMENT ZERO▲▼
[ENTER]	While calibration is in progress, elapsed time is displayed in lower stage.	ZERO ADJUSTMENT ■■■■■■
	When calibration is successfully completed, "ZERO" is displayed. When it is unsuccessfully completed, "CLEAR" is displayed in lower stage.	ZERO ADJUSTMENT ZERO
[ESC]	Display the measurement, reflecting the setting.	(Measurement display screen)

⚠ CAUTION

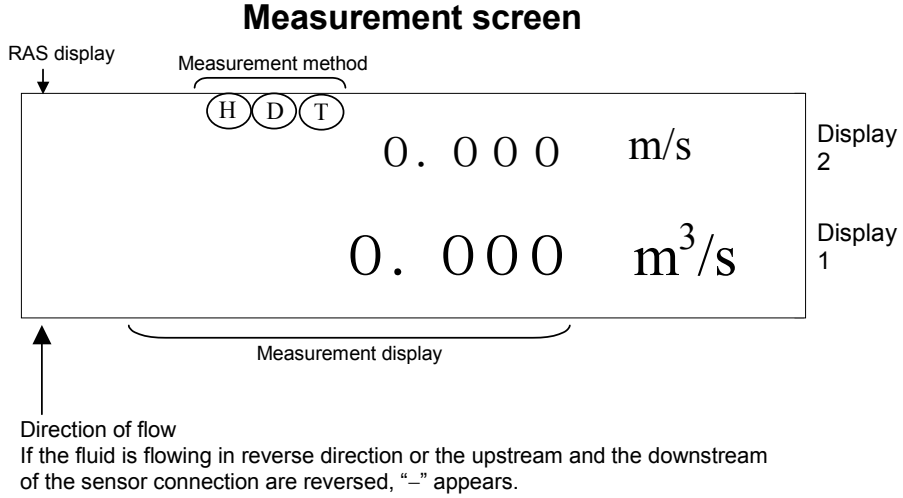
- If "Clear" is selected and executed at this time, the zero adjustment value currently stored is cleared to zero.

4. SETTING PARAMETERS

4.1. Description of display/setting unit

4.1.1. Description of display

Turn on the power, and the following display appears. The meaning of displayed numeric values and symbols are as follows.



4.1.2. Description of keys

Press the 

key, and the functions displayed above the ten keys can be executed.

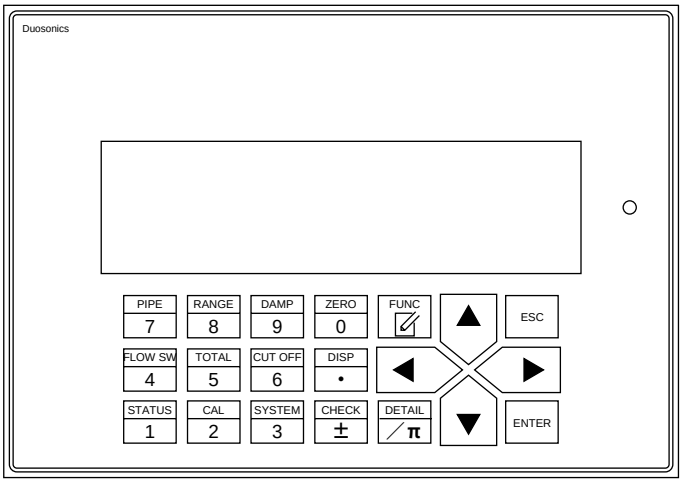


Table 1 Description of keys

Name	Key	Description
Ten key	[0] to [9], [・], [±]	Used to enter numeric values for data and piping specifications.
ENTER	[ENTER]	Press this key to set the numeric data entered using keys or items selected by dialog. In the case of entry by dialog, the next item to be set appears.
Left arrow key, Right arrow key	[◀], [▶]	Used to move the cursor when changing numeric values. Press ◀ to move the selection to left, and press ▶ to move the selection to right.
Up arrow key, Down arrow key	[▲], [▼]	Press ▲ to go to the next menu, and press ▼ to go back to the previous menu. Used to select the menu item displayed during dialog.
ESCAPE (Cancellation)	[ESC]	Used to cancel the dialog.
FUNCTION	[FUNC]	Press this key to execute the function displayed above each key (ten keys).
/π	[/π]	Enter the outer periphery of the pipe and press this key, and the outer diameter is displayed (valid only when outer pipe diameter is selected).
PIPE (Piping specifications)	[FUNC] [PIPE]	Used to enter the dimensions, material, etc. of the pipe to which the sensor is to be mounted.
RANGE (Output setting)	[FUNC] [RANGE]	Used to set the analog output conditions (unit, range, limit, burnout, rate limit).
DAMP (Damping)	[FUNC] [DAMP]	Used to set damping.
ZERO (Zero adjustment)	[FUNC] [ZERO]	Used to set zero adjustment.
DISP (Display setting)	[FUNC] [DISP]	Used to set items and units that appear on the measurement screen.
CUT OFF (Low flow rate cutoff)	[FUNC] [CUT OFF]	Used to set low flow rate cutout.
TOTAL (Integration)	[FUNC] [TOTAL]	Used to set the conditions of flow rate integration (unit, rate, preset value, total switch, pulse width).
FLOW SW (Flow switch)	[FUNC] [FLOW SW]	Used to set the upper/lower limit switch of the measurement value.
STATUS (Status output)	[FUNC] [STATUS]	Used to set the conditions of status output (total pulse, measurement status).
CAL (Output calibration)	[FUNC] [CAL]	Used to calibrate the reading of zero point and 100% point.
SYSTEM	[FUNC] [SYSTEM]	Used to switch measurement unit systems and languages, and check or calibrate analog output.
CHECK	[FUNC] [CHECK]	Displays error contents and measurement status in case an error display appears.
DETAIL (Details of measurement)	[FUNC] [DETAIL]	Used to display the version of software or perform detailed measurement setting.

4.2. Setting item list

Refer to Appendix “8.5. Composition of key operation” for details of composition of key operation.

Measurement screen	Piping specifications ([FUNC] [PIPE])		4.4.2.
	Output setting ([FUNC] [RANGE])	Range unit, range type, full scale	4.4.4.1.
		Output limit	4.4.4.2.
		BURNOUT	4.4.4.3.
		Rate limit	4.4.4.4.
	Damping ([FUNC] [DAMP])		4.4.5.
	Zero adjustment ([FUNC] [ZERO])		4.4.6.
	Display setting ([FUNC] [DISP])		4.4.7.
	Low flow rate cutout ([FUNC] [CUT OFF])		4.4.8.
	Integration ([FUNC] [TOTAL])	Total unit	4.4.9.1.
		Total pulse (Total rate, pulse width)	4.4.9.2.
		Total preset	4.4.9.3.
		Total switch	4.4.9.4.
		BURNOUT	4.4.9.5.
	Flow switch ([FUNC] [FLOW SW])		4.4.10.
	Status output ([FUNC] [STATUS])		4.4.11.
	Output calibration ([FUNC] [CAL])		4.4.12.
	System ([FUNC] [SYSTEM])	System unit	4.4.13.
		System language	4.4.14.
		Serial communication	4.4.15.
		Calibration and check of analog output	4.4.16.1.
		Check of status output	4.4.16.2.
		Calibration of wedge temperature	4.4.16.3.
		Check of wedge temperature	4.4.16.4.
		Test mode	4.4.16.5.
		Measurement method	4.4.1.
		Sensor (Mounting method, type, calibration, transmission voltage)	4.4.1.
		Measurement mode	4.4.3.
		LCD backlight	4.4.17.
		Key lock	4.4.18.
	Details of measurement *1 ([FUNC] [DETAIL])	Transit time	4.4.20.1
		Pulse Doppler	4.4.20.2.
		Initialization	4.4.20.3.

*1) Intended for our service personnel.

4.3. Parameter specification table

The following table lists factory settings (not applicable to the type with parameter settings).

No.	Setting item		Settable range	Initial value	Settable value
1	PiPing specification	Outer diameter	10.00 to 6200.00 mm (0.393 to 244.100 inch)	60.00 mm (2.362 inch)	[mm, inch]
2		Pipe material	12 menus	PVC	Carbon steel, Stainless steel, PVC, Copper, Cast iron, Aluminum, FRP, Ductile iron, PEEK, PVDF, Acrylic, Others
3		Wall thickness	0.10 to 100.00 mm (0.003 to 3.940 inch)	4.00 mm (0.157 inch)	[mm, inch]
4		Lining material	8 menus Lining S.V.: 1000 to 3700 m/s (3280 to 12140 ft/s)	No lining	No lining, Tar epoxy, Mortar, Rubber, Teflon, Pyrex glass, PVC, Others (Sound velocity: [m/s, ft/s])
5		Lining thickness	0.01 to 100.00 mm (0.000 to 3.940 inch)	–	[mm, inch]
6		Kind of Fluid	17 menus Fluid S.V.: 500 to 2500m/s (1641 to 8203 ft/s) Viscosity: 0.001 to 999.9999 × $10^{-6}m^2/s$ (0.0107 to 10763.9088 × 10^{-6} ft^2/s)	Water	Water, Seawater, DIST. water, Ammonia, Alcohol, Benzene, Bromide, Ethanol, Glycol, Kerosene, Milk, Methanol, Toluol, Lube oil, Fuel oil, Petrol, Others (Sound velocity: [m/s, ft/s]) (Viscosity [× $10^{-6}m^2/s$, ft^2/s])
7		Range unit	19 menus	m/s (ft/s)	m/s, L/s, L/min, L/h, L/d, kL/d, ML/d, m^3/s, m^3/min, m^3/h, m^3/d, km^3/d, Mm^3/d, BBL/s, BBL/min, BBL/h, BBL/d, KBBL/d, MBBL/d (ft/s, ft^3/s, ft^3/min, ft^3/h, ft^3/d, kft^3/d, Mft^3/d, gal/s, gal/min, gal/h, gal/d, kgal/d, Mgal/d, BBL/s, BBL/min, BBL/h, BBL/d, kBBL/d, MBBL/d)
8	Range setting	Range type	4 menus	Single	Single, Auto 2, Bi-dir, Bi-dir Auto 2
9		Full scale or Full scale 1	In terms of flow velocity 0.00, ±0.30 to ±32.00m/s (0.00, ±0.98 to ±104.98 ft/s)	2.00 m/s (6.56 ft/s)	[(19) Unit]
10		Full scale 2	In terms of flow velocity 0.00, ±0.30 to ±32.00m/s (0.00, ±0.98 to ±104.98 ft/s)	4.00 m/s (13.12 ft/s)	[(19) Unit]
11		Range HYS.	0.00 to 20.00%	10.00%	%
12		Output limit LO.	–20 to 0%	–20%	%
13		Output limit HI.	100 to 120%	120%	%
14		Output burnout	5 menus	Hold	Not used, Hold, Upper, Lower, Zero
15		Burnout timer	0 to 900sec	10sec	sec
16		Rate limit	0.00 to 5.00m/s (0.00 to 16.40 ft/s) in terms of flow velocity	0.00m/s (0.00 ft/s)	[(19) Unit]
17		Rate limit timer	0 to 900sec	0 sec	sec
18	Damping		0.0 to 100.0sec	5.0 sec	sec
19	Zero adjustment		2 menus	Clear (unadjusted)	Zero, Clear (Default: Clear)
20	Display setting	1: Display kind	7 menus	Flowrate (m3/s)	Velocity, Flowrate, Total forward, Total reverse, F: Total pulse, R: Total pulse, Flow rate (%)
21	Display setting	2: Display kind	7 menus	Velocity (m/s)	Velocity, Flowrate, Total forward, Total reverse, F: Total pulse, R: Total pulse, Flow rate (%)

No.	Setting item			Settable range	Initial value	Settable value
22	Low flow cut off			0.00 to 5.00m/s (0.00 to 16.40 ft/s) in terms of flow velocity	0.01 m/s (0.03 ft/s)	[(19) Unit]
23	Total	Total mode		3 menus	Total stop	Total stop, Total run, Total reset
24		Total unit		8 menus	mL (ft^3)	mL, L, m^3, km^3, Mm^3, mBBL, BBL, kBBL, (ft^3, kft^3, Mft^3, kgal, gal, mBBL, BBL, kBBL, ACRF)
25		Total rate		0.000 to 999999.999	0.000	[(8) Unit]
26		F: Total preset		0.000 to 9999999999.999	0.000	[(8) Unit]
27		F: Total SW		0.000 to 9999999999.999	0.000	[(8) Unit]
28		R: Total preset		0.000 to 9999999999.999	0.000	[(8) Unit]
29		R: Total SW		0.000 to 9999999999.999	0.000	[(8) Unit]
30		Output burnout		2 menus	Hold	Not used, Hold
31		Burnout timer		0 to 900sec	10 sec	sec
32		Pulse width 1		3 menus	50 ms	50, 100, 200
33		Pulse width 2		9 menus	50.0 ms	0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0, 100.0, 200.0
34	Flow switch	Flow sw low		In terms of flow velocity 0.00 to ±32.00 m/s (0.00 to ±104.98 ft/s)	0.00 m/s (0.00 ft/s)	[(19) Unit]
35		Flow sw high		In terms of flow velocity 0.00 to ±32.00 m/s (0.00 to ±104.98 ft/s)	4.00 m/s (13.12 ft/s)	[(19) Unit]
36		Flow sw HYS.		0 to 20%	10%	%
37	Status output	Output DO.1		15 menus	Not used	Not used, Signal error, F: Total pulse, R: Total pulse, F: Total alarm, R: Total alarm, F: Total overflow, R: Total overflow, Flow SW high, Flow SW Low, Full scale2, AO range over, Pulse range over, R: Flow direction, Device error
38		Mode DO.1		2 menus	Normal	Normal, Reverse
39		Output DO.2		15 menus	Not used	Same as DO1 output type
40		Mode DO.2		2 menus	Normal	Normal, Reverse
41		Output DO.3		15 menus	Not used	Same as DO1 output type
42		Mode DO.3		2 menus	Normal	Normal, Reverse
43	Calibration range	CAL. zero		0.00 to 5.00 m/s (000 to 16.40 ft/s) in terms of flow velocity	0.00 m/s (0.00 ft/s)	[(19) Unit]
44		CAL. span		±200.00%	100.00%	%
45	System	System unit		2 menus	Metric	Metric, English
46		Language		5 menus	English	Japanese, English, German, French, Spanish
47		Serial com.	COM. speed	3 menus	38400 bps	9600 bps, 19200 bps, 38400 bps
48			COM. parity	3 menus	None	None, Even, Odd
49			COM. stop bit	2 menus	1 bit	1bit, 2 bits
50			Serial method	2 menus	RS232C	RS232C, RS485
51			StationNo.	31 menus	1	1 to 31
52		Analog output calibration		4 mA, 20 mA	Calibration value	-
53		Wedge temp.		100 Ω, 140 Ω	Calibration value	-

No.	Setting item			Settable range	Initial value	Settable value
54	System	Measure method		2 menus	Hybrid	Hybrid, Transit time
55		Measurement mode	Measurement mode	2 menus	1 Path	1 Path, 2 Path
56			AO definition	3 menus	Line 1	Average, Line 1, Line 2
57		Sensor	Mount	2 menus	Z Method	V Method, Z Method
58			Type	4 menus	FSW12	FSW12, FSW21, FSW40, FSW50
59			Calibration	0.00 to 300.00%	Calibrated value	%
60			Trans. voltage	4 menus	80 Vpp	20 Vpp, 40 Vpp, 80 Vpp, 160 Vpp
61		LCD display backlight		3 menus	On	On, Off, Auto
62		Key lock		2 menus	Off	On, Off
63		Password		Numeral 4 digits	0000	4-digit numeral
64	Details of measurement	Transit time	#: Transmission count	6 menus	128	8, 16, 32, 64, 128, 256
65			#: Trigger control	2 menus	Auto	Auto, Manual
66			#: Window control	2 menus	Auto	Auto, Manual
67			#: Saturation level	0 to 256	32	
68			#: Measurement method	3 menus	Method 2	Method 1, Method 2, Method 3
69			#: Signal balance	0 to 100%	25%	%
70			#: Transmission pattern	7 menus	Burst 3	Burst 1, Burst 2, Burst 3, Burst 4, Burst 5, Chirp 4, Chirp 8
71			#: AGC gain	2 menus	Auto	Auto, Manual
72			#: Signal peak	4 menus	3071	2048, 3071, 4096, 5120
73			#: Trans. wait time	1 to 30 msec	3 msec	msec
74		Pulse Doppler	Wedge S.V.	2 menus	Auto	Auto, Manual
75			Pipe S.V.	2 menus	Auto	Auto, Manual
76			Lining S.V.	2 menus	Auto	Auto, Manual
77			Fluid S.V.	2 menus	Auto	Auto, Manual
78			Transmission frequency	2 menus	Auto	Auto, Manual
79			Transmission pulse No.	8 menus	4	0, 1, 2, 4, 8, 16, 32, 64
80			Sampling frequency	2 menus	Auto	Auto, Manual
81			Receipt wait time	2 menus	Auto	Auto, Manual
82			Repetition frequency	2 menus	Auto	Auto, Manual
83			Reference count	4 to 512	256	Select
84			No. of channels	2 menus	Auto	Auto, Manual
85			Measurement range	3 menus	F radius	F radius, N radius, Diameter
86			Phase angle shift	4 menus	Normal 2	Normal 1, Normal 2, Positive, Negative
87			Gain	2 menus	Auto	Auto, Manual
88			#: Power	0 to 10.00×10^4	$4.00E^4$	
89			#: Deviation	0 to 1.00	0.50	
90			#: Success rate	0.00 to 100.00%	70.00%	%

(#: Line No.)

4.4. Setting parameters

The units are displayed in metric or English system.

Description

Parameters can be set by entering numeric values or by selection.

Setting item	Input method	Range or menu
Numeric value input	Direct input	Outer diameter of pipe specifications, etc. can be entered directly. • Values cannot be entered exceeding the number of digits in the input range. • If negative values are not included in the input range, a symbol key "±" is ignored. • Use symbols that are displayed. If "12" is entered in a state where symbol "–" is displayed, it is interpreted as "–12."
	Change input	Specific numeric values only in outer diameter, etc. of pipe specifications can be changed.
Selection	Item selection	Lining materials, etc. of pipe specifications can be selected.
	Numeric selection	Numeric values such as transmission voltage of the system can be selected.

Direct input (example)	When entering outer diameter 114.3 mm		
Key operation		Description	Display
		Select "OUTER DIAMETER"	OUTER DIAMETER 60.00 mm
[ENTER]		Enter numeric value enter mode.	OUTER DIAMETER 60.00■mm
[1] [1] [4] [.] [3]		Enter "114.3" using ten keys.	OUTER DIAMETER 114.3■mm
[ENTER]		Press ENTER.	OUTER DIAMETER 114.3 mm

Change input (example)	When changing outer diameter 114.3 mm to 115.3 mm		
Key operation		Description	Display
		Select "OUTER DIAMETER"	OUTER DIAMETER 114.30 mm
[ENTER]		Enter numeric value enter mode.	OUTER DIAMETER 114.30■mm
[◀]		Move the cursor to left. The value "0," on which the cursor is placed, can be changed.	OUTER DIAMETER 114.3**0** mm
[◀] [◀]		Move the cursor to left. The value "4," on which the cursor is placed, can be changed.	OUTER DIAMETER 11**4**.30 mm
[5]		Enter "5" using ten keys.	OUTER DIAMETER 11**5**.30 mm
[ENTER]		Press ENTER.	OUTER DIAMETER 115.30 mm

Item selection (example)	When selecting carbon steel as pipe material	
Key operation	Description	Display
	Select “PIPE MATERIAL”	PIPE MATERIAL STAINLESS STEEL
ENTER	Enter select/enter mode.	PIPE MATERIAL STAINLESS STEEL▲▼
▲ or ▼	Select “CARBON STEEL”	PIPE MATERIAL CARBON STEEL▲▼
ENTER	Press ENTER.	PIPE MATERIAL CARBON STEEL

Item selection (example)	When changing trans. voltage 80 Vpp to 160 Vpp	
Key operation	Description	Display
	Select “TRANS. VOLTAGE”	TRANS. VOLTAGE 80 Vpp
ENTER	Enter select/enter mode.	TRANS. VOLTAGE 80▲▼Vpp
▲ or ▼	Select “160”	TRANS. VOLTAGE 80▲▼Vpp
ENTER		TRANS. VOLTAGE 160 Vpp

Note: The setting change is reflected on the measurement after the measurement display screen is displayed.

4.4.1. Measurement method and sensor

(Measurement method, sensor mount, sensor type, sensor calibration, transmission voltage)

Description

Measurement method and sensor data required for measurement can be set as follows. If the sensor mount or the type of sensor is changed, the sensor spacing in "4.4.2. Pipe specifications" is also changed.

⚠ CAUTION

Be sure to make the following parameter setting before mounting the sensors to the pipe. Mount the sensors, observing the specified sensor spacing.

- If sensors are mounted not by strictly observing the sensor spacing, measurement error increases.
- Or receive wave error may result.
- Select the sensor constant of the applicable unit as sensor calibration value. Otherwise the measurement error may increase.

Enter data for each item (see the following table) according to the display.

Item	Input method	Range or menu
Measurement method	Selection	HYBRID, TRANSIT TIME
Sensor mount	Selection	V METHOD, Z METHOD
Sensor type	Selection	FLW11, FLW41, FLW12, FLD12, FLD22, FLW32, FLW50, FLW51, FSW12, FSW21, FSW40, FSW50
Sensor calibration		
Line #-F: METAL PIPE	Numeric value	0.00% to 300.00%
Line #-R: METAL PIPE	Numeric value	0.00% to 300.00%
Line #-F: PLASTIC PIPE	Numeric value	0.00% to 300.00%
Line #-R: PLASTIC PIPE	Numeric value	0.00% to 300.00%
(#: Line No.)		
Transmission voltage	Selection	20 Vpp, 40 Vpp, 80 Vpp, 160 Vpp

*1) If hybrid is selected as measurement method, select sensor type from "FSW12, FSW21, FSW40, and FSW50." If hybrid method is selected, sensor type can be selected only from "FSW12, FSW21, FSW40, and FSW50."

*2) In sensor calibration, set the sensor constant calculated based on actual current calibration performed as part of the delivery test at the factory. Set the sensor constant for each of the sensor units mounted to the pipe. The sensor constant appears as the DF value marked on the nameplate of the sensor unit. The setting need not be changed normally. (Make the setting when the detector or the flow transmitter is replaced.)

- It appears as the DF-P value on the nameplate of the sensor unit if the sensor is mounted on a plastic pipe.
- It appears as the DF-M value on the nameplate of the sensor unit if the sensor is mounted on a metal pipe.

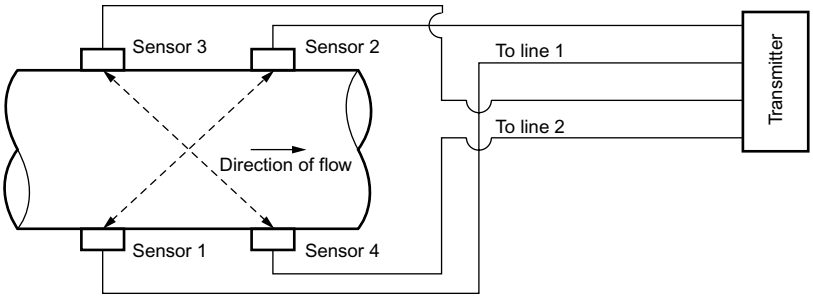
	Pipe material
Plastic Pipe	PVC, FRP, PEEK, PVDF, Acrylic, Others
Metal Pipe	Carbon steal, Stainless steel, Copper, Cast iron, Aluminium, Ductile iron

Refer to "1.3 Checking type and specifications" for sensor unit.

*3) Set the sensor calibration as calibration value of each sensor by measurement method as shown by the following table.

Measurement method	Sensor calibration value of line 1	Sensor calibration value of line 2
Pulse Doppler	Line 1-F: Forward-direction sensor (Sensor 1) Line 1-R: Reverse-direction sensor (Sensor 2)	Line 2-F: Forward-direction sensor (Sensor 3) Line 2-R: Reverse-direction sensor (Sensor 4)
Time transit	Line 1-P: Sensor pair	Line 2-P: Sensor pair

* Sensor calibration value for line 2 need not be set in 1-path measurement mode.



2-path system (Z method)

*4) Select sensor calibration only when the sensor type is selected from FSW12, FSW21, FSW40, and FSW50.

Operation (example)	When hybrid is selected as measurement method, Z method as sensor mount, FSW12 as sensor type, 102% for sensor calibration line 1-F: (METAL), 101% for 1-R: (METAL), and 160Vpp as transmission voltage (When "Hybrid" is selected as measurement method, and "1 path" is selected as measurement mode)	
Key operation	Description	Display
FUNC SYSTEM	Display SYSTEM.	UNIT & LANGUAGE SKIP
▲ or ▼	Select "MEAS. METHOD"	MEAS. METHOD TRANSIT TIME
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "HYBRID," and press ENTER.	MEAS. METHOD HYBRID
▼	Select "SENSOR MOUNT"	SENSOR MOUNT V METHOD
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "Z METHOD," and press ENTER.	SENSOR MOUNT Z METHOD
▼	Select "SENSOR TYPE"	SENSOR TYPE FSW21
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "FSW12," and press ENTER.	SENSOR TYPE FSW12
▼	Select "SENSOR CALIB."	SENSOR CALIB. SKIP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "SETTING," and press ENTER.	LINE 1-F : METAL 100.00%
ENTER 1 0 2 ENTER	Enter numeric value enter mode, enter "102" using ten keys, and press ENTER.	LINE 1-F : METAL 102.00%
▲ or ▼	Select "LINE 1-R"	LINE 1-R : METAL 100.00%
ENTER 1 0 1 ENTER	Enter numeric value enter mode, enter "101" using ten keys, and press ENTER.	LINE 1-R : METAL 101.00%
ESC	Return to "SENSOR CALIB."	SENSOR CALIB. SKIP
▼	Select "TRANS. VOLTAGE"	TRANS. VOLTAGE 80 Vpp
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "160," and press ENTER.	TRANS. VOLTAGE 160 Vpp
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.2. Pipe specifications

Description

Pipe data required for measurement can be set as follows. The sensor spacing is automatically calculated.

⚠ CAUTION

Be sure to make the following parameter setting before mounting the sensors to the pipe. Mount the sensors, observing the specified sensor spacing.

- If sensors are mounted not by strictly observing the sensor spacing, measurement error increases.
- Or receive wave error may result.

Enter data for each item (see the following table) according to the display.

Item	Input method	Range or menu
Outer diameter	Numeric value	10.00 mm to 6200.00 mm
Pipe material	Selection	Carbon steel, stainless steel, PVC, copper, cast iron, aluminum, FRP, ductile iron, PEEK, PVDF, acrylic, and others
Pipe S.V *1	Numeric value	1000 m/s to 3700 m/s
Wall thickness	Numeric value	0.10 mm to 100.00 mm
Lining material	Selection	No lining, tar epoxy, mortar, rubber, Teflon, pyrex glass, PVC, and others
Lining S.V *2	Numeric value	1000 m/s to 3700 m/s
Lining thickness *3	Numeric value	0.01 mm to 100.00 mm
Kind of fluid	Selection	Water, seawater, dist. water, ammonia, alcohol, benzene, bromide, ethanol, glycol, kerosene, milk, methanol, toluol, lube oil, fuel oil, petrol, and others
Fluid S.V.*4	Numeric value	500 m/s to 2500 m/s
Viscosity *4	Numeric value	$0.0010E^{-6}$ m^2/s to $999.9999E^{-6}$ m^2/s

*1) Set the sound velocity when pipe material is “others” only.
*2) Set the sound velocity when lining material is “others” only.
*3) Set the lining thickness when lining material is “No lining” only.
*4) Set the sound velocity when the kind of fluid is “others” only.

Operation (example)	When outer diameter is 114.3 mm, pipe material is carbon steel, wall thickness is 6.0 mm, lining material is tar epoxy, lining thickness is 1.25 mm, kind of fluid is heavy water, sound velocity is 1388m/s, and viscosity is 1.129 $E^{-6}m^2/s$ (When sensor mount is “Z method,” sensor type is “FSW12.”)

Key operation	Description	Display
[FUNC] [PIPE]	Display SENSOR SPACING.	SENSOR SPACING 9.17 mm
[▼]	Select “OUTER DIAMETER”	OUTER DIAMETER 60.00 mm
[ENTER] [1] [1] [4] [.] [3] [ENTER]	Enter numeric value enter mode, enter “114.3” using ten keys, and press ENTER.	OUTER DIAMETER 114.30 mm
[▼]	Select “PIPE MATERIAL”	PIPE MATERIAL PVC
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select “CARBON STEEL,” and press ENTER.	PIPE MATERIAL CARBON STEEL
[▼]	Select “WALL THICKNESS”	WALL THICKNESS 4.50 mm
[ENTER] [6] [ENTER]	Enter numeric value enter mode, enter “6” using ten keys, and press ENTER.	WALL THICKNESS 6.00 mm

▼	Select “LINING MATERIAL”	LINING MATERIAL NO LINING
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “TAR EPOXY,” and press ENTER.	LINING MATERIAL TAR EPOXY
▼	Select “LINING THICKNESS”	LINING THICKNESS 0.01 mm
ENTER 1 . 2 5 ENTER	Enter numeric value enter mode, enter “1.25” using ten keys, and press ENTER.	LINING THICKNESS 1.25 mm
▼	Select “KIND OF FLUID”	KIND OF FLUID WATER
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “OTHERS,” and press ENTER.	KIND OF FLUID OTHERS
▼	Select “FLUID S.V.”	FLUID S.V. 1440 m/s
ENTER 1 3 8 8 ENTER	Enter numeric value enter mode, enter “1388” using ten keys, and press ENTER.	FLUID S.V. 1388 m/s
▼	Select “VISCOSITY”	VISCOSITY 1.0038 $E^{-6}m^2/s$
ENTER 1 . 1 2 9 ENTER	Enter numeric value enter mode, enter “1.129” using ten keys, and press ENTER.	VISCOSITY 1.1290 $E^{-6}m^2/s$
ESC	Display SENSOR SPACING.	SENSOR SPACING 39.16 mm
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.3. Measurement mode (Measurement mode, AO definition)

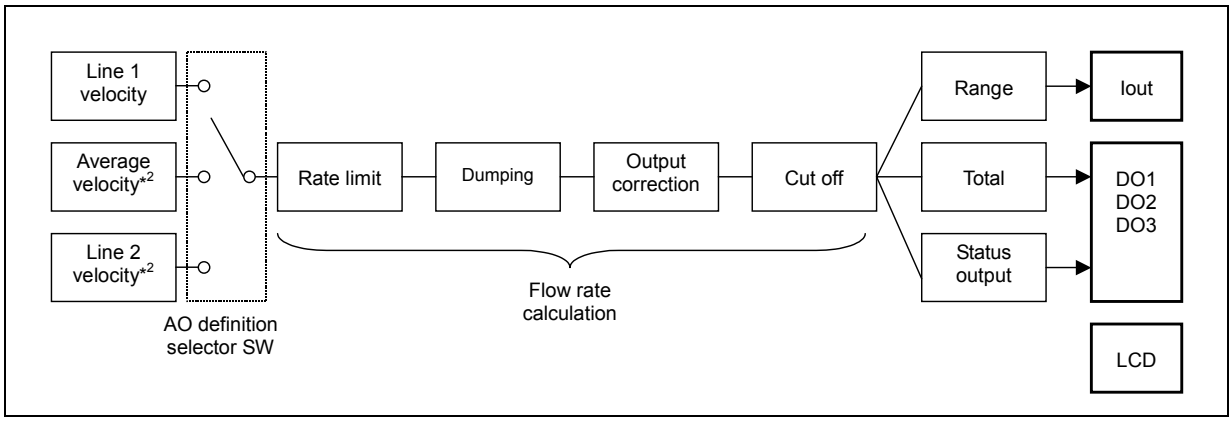
Description

Measurement can be taken using either 1 sensor (1 path) or a pair of sensors (2 path). When a pair of sensors is used, one from average, line 1, and line 2 can be selected for measurement calculation such as flow rate.

Item	Input method	Range or menu
Measurement mode	Selection	1 path, 2 path
AO definition	Selection	Average, line 1, line 2

*1) If "1 path" is selected, AO definition is for "line 1" only.

Function block diagram



*2) For "2 path" mode only.

Operation (example)	When selecting 2-path mode and setting AO definition to average	
Key operation	Description	Display
[FUNC] [SYSTEM]	Display SYSTEM.	UNIT & LANGUAGE SKIP
[▲] or [▼]	Select "MEAS. MODE"	MEAS. MODE 1 PATH
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "2 PATH," and press ENTER.	MEAS. MODE 2 PATH
[▼]	Select "AO DEFINITION"	AO DEFINITION LINE 1
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "AVERAGE," and press ENTER.	AO DEFINITION AVERAGE
[ESC]	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.4. Output setting

4.4.4.1. Range (range unit, range type, full scale, hysteresis) setting

Description

Make output setting to output measured value (flow rate or velocity) within specified range from 4 to 20 mA.

(Measurement contents)

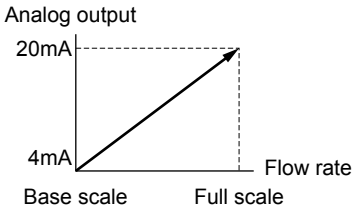
(1) Selecting range unit [*1]

Select one from the following units (metric system)

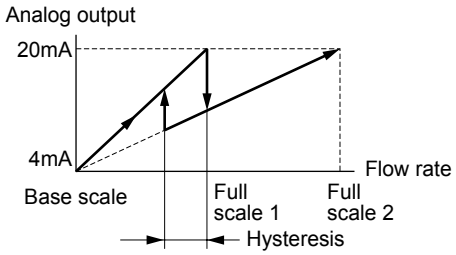
- m/s
- L/s, L/min, L/h, L/d, kL/d, ML/d
- m^3/s, m^3/min, m^3/h, m^3/d, km^3/d, Mm^3/d
- BBL/ s , BBL/min, BBL/h, BBL/d, kBBL/d, MBBL/d

(2) Selecting range type

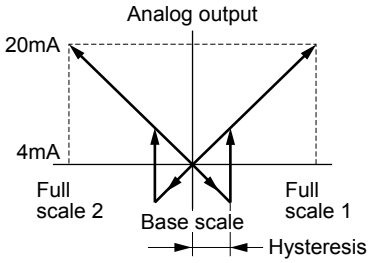
- Single
- Auto 2
- Bi-directional
- Bi-directional auto 2



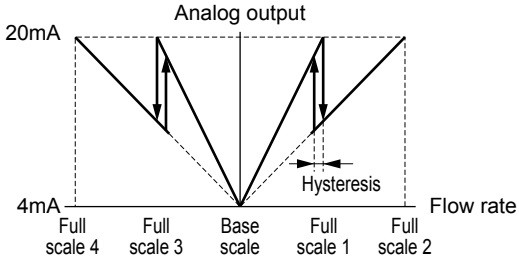
(a) Single range



(b) Auto 2 range



(c) Bi-directional range



(d) Bi-directional auto 2 range

(3) Setting range

Set the full scale by range type. Set the following depending on the range type. The based scale is fixed to 0.

- Full scale..... Single range only
- Full scale 1 and 2 ..... Auto 2 range, bi-directional range, bi-directional auto 2 range*[2]

(4) Setting hysteresis

When "AUTO 2," "BI-DIRECTIONAL" or "BI-DIRECTIONAL AUTO 2" is selected as range type, switching hysteresis can be provided.

The hysteresis can be set in the range from 0 to 20% of the span.

Auto 1 range: Hysteresis for full scale 1 or 2, whichever is smaller

Bi-directional range: Hysteresis for operation range

Bi-directional auto 2 range: Hysteresis for the span of full scale 1 and 2 and that of full scale 3 and 4, whichever is smaller.

*1) The flow rate or velocity of cut off/flow switch/output correction/rate limit changes with the selection of range unit.

*2) If full scale 1 and 2 are set, full scale 3 and 4 are automatically set.

The following relation holds between full scale 1 and 3 and full scale 2 and 4.

|Full scale 1| = |Full scale 3|

|Full scale 2| = |Full scale 4|

*3) Maximum measurement range in hybrid mode
In the case of pulse Doppler method, the measurable range varies depending on the piping specifications and the type of sensors used. If the measurement is to be made by hybrid method, set the full scale within the range that does not exceed the measurement range. If the full scale exceeds the measurement range, select the time difference method for measurement. After selecting the piping specifications and the sensor type, check the measurement range within the maximum measurement data information range. See "6.1.2.3." for details of checking.

The following table lists the maximum range in the case where stainless steel is selected as piping material, Schedule 20S as nominal wall thickness, and water as fluid to be measured.

(Example)

<Maximum measurable flow velocity>

Unit: m/s

Diameter	FSW12	FSW21	FSW40	FSW50
50A	6.04			
65A	4.99			
80A	4.40			
90A	3.92			
100A	3.54	6.95		
125A		5.86		
150A		5.04		
200A		3.96	7.59	
250A			6.26	
300A			5.32	
350A			4.82	
400A			4.25	
450A			3.80	
500A			3.45	3.45
550A				3.14
600A				2.89
650A				2.69
700A				2.50
750A				2.34
800A				2.19
850A				2.07
900A				1.95
1000A				1.76

<Maximum measurable flow rate>

Unit: m^3/h

FSW12	FSW21	FSW40	FSW50
48.5			
67.8			
81.8			
97.1			
110.2	222.0		
	279.2		
	343.2		
	462.8	887	
		1146	
		1404	
		1572	
		1831	
		2091	
		2393	2393
			2587
			2850
			3067
			3325
			3590
			3839
			4112
			4357
			4852

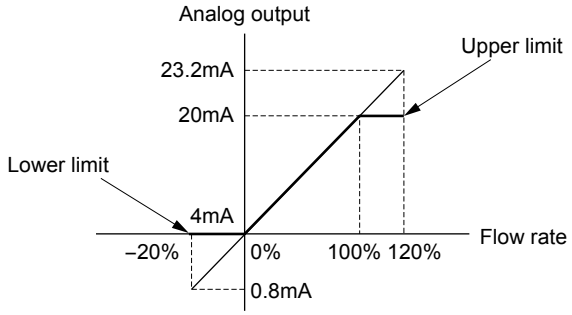
Operation (example)	When selecting bi-directional for range, 100 m^3/h for full scale 1, –100 m^3/h for full scale 2, and 5% for hysteresis	
Key operation	Description	Display
FUNC RANGE	Display RANGE UNIT.	RANGE UNIT m/s
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "m^3/h," and press ENTER.	RANGE UNIT m^3/h
▼	Select "RANGE TYPE"	RANGE TYPE SINGLE
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "BI-DIR," and press ENTER.	RANGE TYPE BI-DIR
▼	Select "FULL SCALE 1"	FULL SCALE 1 56.32 m^3/h

ENTER 1 0 0 ENTER	Enter numeric value enter mode, enter "100" using ten keys, and press ENTER.	FULL SCALE 1 100.00 m^3/h
▼	Select "FULL SCALE 2"	FULL SCALE 2 112.64 m^3/h
ENTER ± 1 0 0 ENTER	Enter numeric value enter mode, enter "100" using ten keys, and press ENTER.	FULL SCALE 2 100.00 m^3/h
▼	Select "HYSTERESIS"	HYSTERESIS 10.00%
ENTER 5 ENTER	Enter numeric value enter mode, enter "5" using ten keys, and press ENTER.	HYSTERESIS 5.00%
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.4.2. Output limit

Description

The upper limit and the lower limit of analog output can be set within the range from 0.8 mA to 23.2 mA (–20% to 120%).



Operation (example)	Lower limit: –10% (2.4 mA), upper limit: 110% (21.6 mA)	
Key operation	Description	Display
[FUNC] [RANGE]	Display RANGE UNIT.	RANGE UNIT m^3/h
[▲] or [▼]	Select “OUTPUT LIMIT Lo.”	OUTPUT LIMIT Lo. 20%
[ENTER] [1] [0] [ENTER]	Enter numeric value enter mode, enter “10” using ten keys, and press ENTER.	OUTPUT LIMIT Lo. 10%
[▼]	Select “OUTPUT LIMIT Hi.”	OUTPUT LIMIT Hi. 120%
[ENTER] [1] [1] [0] [ENTER]	Enter numeric value enter mode, enter “110” using ten keys, and press ENTER.	OUTPUT LIMIT Hi. 110%
[ESC]	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.4.3. How to set analog output at error (BURNOUT)

Description

Output burnout is a function of setting the analog output to specific values shown below when the measurement status becomes abnormal. Set the duration until burnout processing is performed with the burnout timer.
(Setting contents)

- Hold: Holds measurement value.
- Upper: Sets the analog output to the upper limit of the output limit.
- Lower: Sets the analog output to the lower limit of the output limit.
- Zero: Sets the analog output to 0% (4 mA)
- Not used: Burnout is not used.

Setting range of burnout timer: 0 to 900 sec.
The burnout processing is performed as follows.

1. LCD .....The measurement on the LCD changes with the analog output.

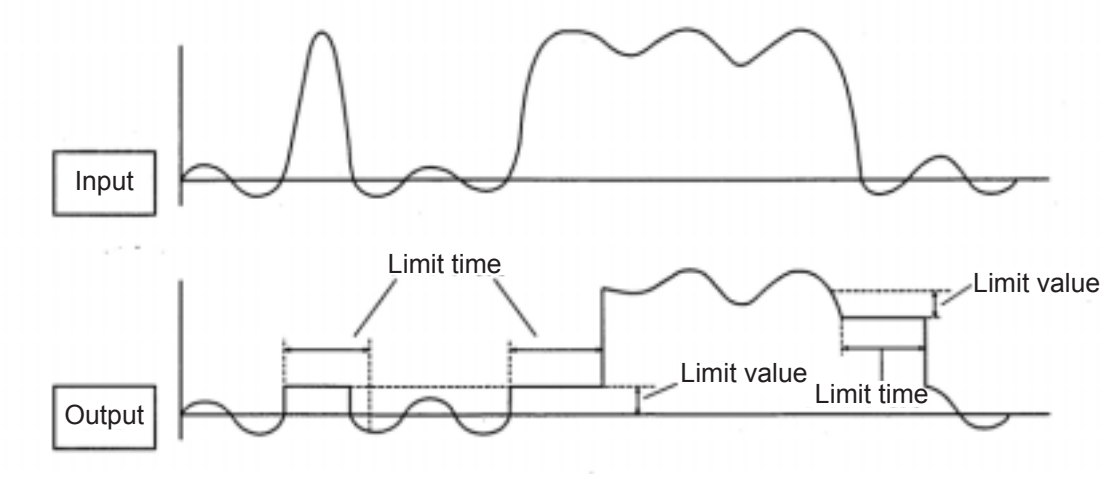
Operation (example)	When output burnout is set to the lower limit value and the burnout timer is set to 30 sec.	
Key operation	Description	Display
[FUNC] [RANGE]	Display RANGE UNIT.	RANGE UNIT m^3/h
[▲] or [▼]	Select "OUTPUT BURNOUT"	OUTPUT BURNOUT HOLD
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "LOWER," and press ENTER.	OUTPUT BURNOUT LOWER
[▼]	Select "BURNOUT TIMER"	BURNOUT TIMER 10 sec
[ENTER] [3] [0] [ENTER]	Enter numeric value enter mode, enter "30" using ten keys, and press ENTER.	BURNOUT TIMER 30 sec
[ESC]	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.4.4. Rate limit

Description

Spike noise input by slurry fluid, etc. can be cut before output.

Rate limit: 0 to 5 m/s in velocity. Enter absolute value.
Rate limit timer: 0 to 900 sec.



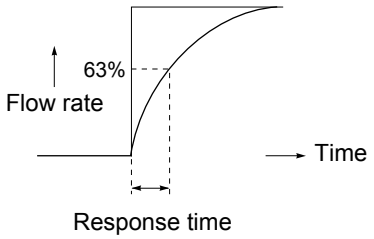
Note 1: If the input exceeding the limit value continues for more than the limit time, it is regarded as valid signals and output.
Note 2: If the limit time is set to 0, this function does not work.

Operation (example)	When rate limit is set to 5 m^3/h and rate limit timer is set to 15 sec.	
Key operation	Description	Display
FUNC RANGE	Display RANGE UNIT.	RANGE UNIT m^3/h
▲ or ▼	Select "RATE LIMIT"	RATE LIMIT 0.00 m^3/h
ENTER 5 ENTER	Enter numeric value input mode, enter "5" using ten keys, and press ENTER.	RATE LIMIT 5.00 m^3/h
▼	Select "RATE LIMIT TIMER"	RATE LIMIT TIMER 0 sec
ENTER 1 5 ENTER	Enter numeric value enter mode, enter "15" using ten keys, and press ENTER.	RATE LIMIT TIMER 15 sec
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.5. Damping

Description

Damping is used to suppress the fluctuation of measurement.
Set it by time constant (response time of about 63%) (Setting range: 0.0 to 100.0%)



Operation (example)	When set value is 20 sec.	
Key operation	Description	Display
FUNC DAMP	Display DAMPING.	DAMPING 5.0 sec
ENTER 2 0 ENTER	Enter numeric value enter mode, enter “20” using ten keys, and press ENTER.	DAMPING 20.0 sec
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.6. Zero adjustment

Description

The zero point of the measured value by time difference measurement can be adjusted as follows.
(Setting contents)

Zero: Perform zero adjustment in a state where the flow is stopped.
The measurement status at the specified time is set as 0.
Note: Perform adjustment in a state where the flow is stopped.
Note: Perform adjustment in normal measurement status.

Clear: Use Clear when the flow cannot be stopped.
Clears the value "adjusted."

Operation (example)	When zero adjustment is performed in a state where the flow is stopped.	
Key operation	Description	Display
[FUNC] [ZERO]	Display ZERO ADJUSTMENT.	ZERO ADJUSTMENT CLEAR
[ENTER] [▲] or [▼]	Enter select/enter mode, and select "ZERO"	ZERO ADJUSTMENT ZERO▲▼
[ENTER]	Adjustment is performed. Elapsed time is displayed in the lower row while adjustment is in progress.	ZERO ADJUSTMENT ■■■■■■
	When adjustment is completed successfully, "ZERO" is displayed, and when it is completed unsuccessfully, "CLEAR" is displayed on the lower row.	ZERO ADJUSTMENT ZERO
[ESC]	Display the measurement, reflecting the setting.	(Measurement display screen)

⚠ CAUTION

- If "CLEAR" is selected and executed, currently stored zero adjustment value is cleared.

4.4.7. Display setting

Description

Measurement value to be displayed in display unit and display kind can be selected from the following.

(1) Selection

Measurement value to be displayed can be selected from the following.

Velocity: Instantaneous velocity [m/s]
Total forward *[1]: Total value in forward direction
Total reverse *[1]: Total value in reverse direction
F: Total pulse: Total pulse in forward direction
R: Total pulse: Total pulse in reverse direction
Flow rate (%): Percentage of analog output to the range
Flow rate: Instantaneous flow rate

If flow rate is selected, select the unit of flow rate from the following.

L/s, L/min, L/h, L/d, kL/d, ML/d
m^3/s, m^3/min, m^3/h, m^3/d, km^3/d, Mm^3/d
BBL/ s , BBL/min, BBL/h, BBL/d, kBBL/d, MBBL/d

*1) The unit of Total forward/Reverse forward is the unit of Total.
(See "4.4.9.1. Total unit.")

(2) Setting of decimal point position of numeric value display

Measurement data is displayed in the range of 10 (including decimal point).
The number of decimal places can be set arbitrarily within the display range.

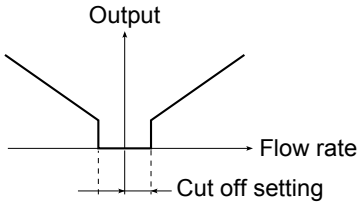
Operation (example)	When displaying instantaneous flow rate of display 1 in unit of m^3/h, and display 2 in unit of flow rate (%)	
Key operation	Description	Display
[FUNC] [DISP]	Display "1: DISPLAY KIND"	1: DISPLAY KIND FLOW RATE
[▼]	Select "1: DISPLAY UNIT"	1: DISPLAY UNIT m^3/h
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "m^3/h," and press ENTER.	2: DISPLAY KIND m^3/h
[▼]	Select "2: DISPLAY KIND"	2: DISPLAY KIND VELOCITY
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "FLOW RATE (%)," and press ENTER.	2: DISPLAY KIND FLOW RATE (%)
[ESC]	Display the measurement, reflecting the setting.	(Measurement display screen)

Operation (example)	When displaying display 1 up to the third decimal places, and not displaying the digits to the right of the decimal point of display 2	
Key operation	Description	Display
	Display "DISPLAY SETTING"	100.00% 112.63 m^3/h
[◄] or [►]	Display "◄, ►" on both sides of the value of display 1.	100.00% ◄ 112.63 ► m^3/h
[◄]	The value of display 1 shifts to left.	100.00% ◄ 112.639 m^3/h
[▲]	Display "◄, ►" on both sides of the value of display 2.	◄ 100.00 ►% 112.639 m^3/h
[►]	The value of display 2 shifts to right.	◄ 100 ►% 112.639 m^3/h
[ENTER]	Reflect the setting.	100% 112.639 m^3/h

4.4.8. Cut off

Description

The output can be cut when the flow rate is low.
This flowmeter may display flow rate even when the fluid within the pipe is moving due to convection, etc. even if the valve is closed. Set the cut off value as required.
(Setting range: 0 to 5 m/s in velocity. Enter absolute value.)



Operation (example)	When the cut off point is set to 10 m^3/h	
Key operation	Description	Display
FUNC CUT	Display "CUT OFF"	CUT OFF 0.28 m^3/h
ENTER 1 0 ENTER	Enter numeric value enter mode, enter "10" using ten keys, and press ENTER.	CUT OFF 10:00 m^3/h
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.9. Integration

4.4.9.1. Total unit

Description

The measurement value (flow rate) can be integrated as follows.
(1) Total unit
Select one from the following total units:
mL, L, m^3, km^3, Mm^3, mBBL, BBL, kBBL
Note: Set the total mode *1 to total stop state to make the setting.

Operation (example)	When starting integration using m^3 as total unit	
Key operation	Description	Display
FUNC TOTAL	Display "TOTAL MODE"	TOTAL MODE TOTAL STOP
▼	Select "TOTAL UNIT"	TOTAL UNIT mL
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "m^3," and press ENTER.	TOTAL UNIT m^3
ESC	Return to "TOTAL MODE"	TOTAL MODE TOTAL STOP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "TOTAL RESET," and press ENTER.	TOTAL MODE TOTAL RESET
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

*1) The following total modes are available.
TOTAL STOP: Stops integration. If integration is not stopped, setting cannot be changed.
TOTAL RUN: Starts integration. Used to start integration from stopped state.
TOTAL RESET: Starts integration, making the total value to total preset value.
If power is restored after power failure, etc., operation is started from the total mode state before the power failure.

4.4.9.2. Setting total pulse (Total rate, pulse width)

Description

The measurement value (flow rate) can be integrated in response to the total pulse output from an integrating meter, etc. as follows.

(1) Total rate: When the total volume reaches the value specified by the total rate, the total pulse value on the measurement screen is added, and 1 pulse is output for total pulse (volume).
(Setting range) 0 to 999999.999

(2) Pulse width: The pulse width can be selected with the connected counters DO1/DO2 and DO3.
Set the pulse width when "F: TOTAL PULSE" or "R: TOTAL PULSE" is used in status output setting.

- Pulse width 1: Pulse width of DO3 (relay contact). Select one from the following.
50 msec, 100 msec, 200 msec
- Pulse width 2: Pulse width of DO1/ DO2 (transistor open collector). Select one from the following.
0.5 msec, 1.0 msec, 2.0 msec, 5.0 msec, 10.0 msec, 20.0 msec, 50.0 msec, 100.0 msec, 200.0 msec

Note: If the total rate is set to "0," the total pulse is not output.
Note: Set the total pulse in a state where the total mode is in total stop state.

Limitation in setting

The following limitations are imposed on the total pulse output.

DO output port	Frequency range of pulse output (at full-scale flow rate)	Pulse width
DO1/DO2: Transistor open collector	1000 pulses/sec or lower	0.5 msec, 1.0 msec, 2.0 msec, 5.0 msec, 10.0 msec, 20.0 msec, 50.0 msec, 100.0 msec, 200.0 msec
DO3: Relay contact	1 pulse/sec or lower	50msec, 100 msec, 200 msec

The maximum output frequency is limited depending on the pulse width setting.
Set the total rate and the pulse width so that the following conditions 1 and 2 are satisfied.
Otherwise, proper operation may not be assured.

$$\text{Condition 1: } \frac{\text{Flow rate span}^{*1}\ [\text{m}^3/\text{s}]}{\text{Total rate}\ [\text{m}^3]} \leq \frac{1000\ [\text{Hz}]\ [\text{DO1 and DO2}]}{1\ [\text{Hz}]\ [\text{DO3}]}$$

$$\text{Condition 2: } \frac{\text{Flow rate span}^{*1}\ [\text{m}^3/\text{s}]}{\text{Total rate}\ [\text{m}^3]} \leq \frac{1000}{2 \times \text{Total pulse width}\ [\text{ms}]}$$

*1) Full scale 1 or full scale 2, whichever is larger, in the case of auto 2 range, bi-directional range, and bi-directional auto 2 range setting
The limitation of the maximum output frequency of each DO output port is applicable when the flow rate exceeds the set range. Consequently, if the setting is made so that the maximum frequency is obtained at 100% flow rate, the flow rate exceeding 100% does not allow the total pulse output to follow. If the over range continues for a long time, accurate total value may not be obtained. If there is a possibility that the flow rate may exceed 100%, review the range and the total rate, and make the setting so that the maximum frequency is kept below the limit.

Example of calculation

Find the total rate settable range under the following range and pulse width.
When the range and the pulse width settings are as follows:
Full scale: 36 [m^3/h] (=0.01 [m^3/s]), Pulse width: 50 [ms]

i) In the case of DO1/DO2
From condition 1

$$\text{Total rate} \geq \frac{\text{Flow rate span}^{*1}\ [\text{m}^3/\text{s}]}{\text{Total rate}\ [\text{m}^3]} = \frac{0.01\ [\text{m}^3/\text{s}]}{1000\ [\text{Hz}]} = 0.00001\ [\text{m}^3] = 0.01\ [\text{L}]$$

From the above: 0.01 [L] ≤ Total rate ..... A

From condition 2

Total rate ≥ Full scale [m^3/s] × $\frac{2 \times \text{Total pulse width [ms]}}{1000}$ = 0.01 [m^3/s] × $\frac{2 \times 50 \text{ [ms]}}{1000}$

= 0.001 [m^3] = 1 [L] .....B

The settable range of the total rate that satisfies both condition 1 and condition 2 is found to be as follows based on the result of calculations A and B.

1 [L] ≤ Total rate

ii) In the case of DO3

From condition 1

Total rate ≥ $\frac{\text{Full scale [m}^3/\text{s]}}{\text{1 [Hz]}}$ = $\frac{\text{0.01 [m}^3/\text{s]}}{\text{1 [Hz]}}$ = 0.01 [m^3] = 10 [L] C

Condition 2 is the same as the case of DO1 output in i) above.

Consequently, the settable range of the total rate is found to be as follows based on the result of calculations B and C.

10 [L] ≤ Total rate

Operation (example)	When starting integration with total rate set to 100 m^3 and pulse width 1 set to 100 msec.	
Key operation	Description	Display
FUNC TOTAL	Display "TOTAL MODE"	TOTAL MODE TOTAL STOP
▼	Select "TOTAL RATE"	TOTAL RATE 0.000 m3
ENTER 1 0 0 ENTER	Enter numeric value enter mode, enter "100" using ten keys, and press ENTER.	TOTAL RATE 100.000 m3
▲ or ▼	Select "PULSE WIDTH 1"	PULSE WIDTH 1 50 msec
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "100," and press ENTER.	PULSE WIDTH 1 100 msec
ESC	Return to "TOTAL MODE"	TOTAL MODE TOTAL STOP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "RESET," and press ENTER.	TOTAL MODE TOTAL RESET
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

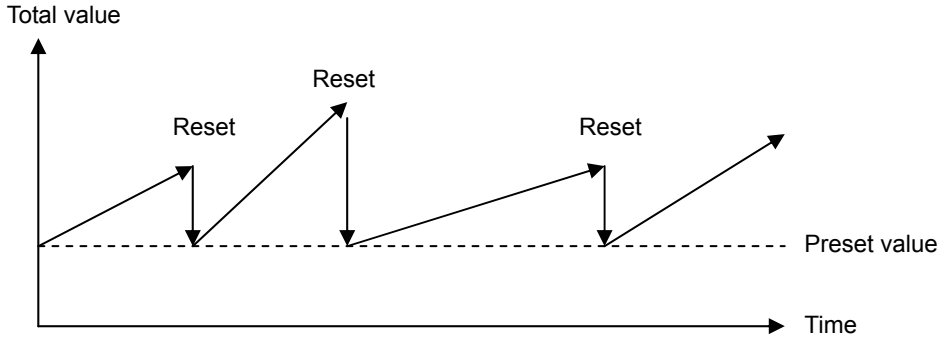
4.4.9.3. Total preset

Description

Total preset value can be set as follows.
Reset the total mode, and the preset value is restored.

- F: Total preset: Total preset value in forward direction
- R: Total preset: Total preset value in reverse direction
  (Setting range: 0 to 9999999999.999)

Note: Set the total preset value in a state where the total mode is set to stop.



Operation (example)	When setting forward direction to 1000m^3 and reverse direction to 2000m^3	
Key operation	Description	Display
[FUNC] [TOTAL]	Display "TOTAL MODE"	TOTAL MODE TOTAL STOP
[▲] or [▼]	Select "F: TOTAL PRESET"	F: TOTAL PRESET 0.000 m^3
[ENTER] [1] [0] [0] [0] [ENTER]	Enter numeric value enter mode, enter "1000" using ten keys, and press ENTER.	F: TOTAL PRESET 1000.000 m^3
[▼]	Select "R: TOTAL PRESET"	R: TOTAL PRESET 0.000 m^3
[ENTER] [2] [0] [0] [0] [ENTER]	Enter numeric value enter mode, enter "2000" using ten keys, and press ENTER.	R: TOTAL PRESET 2000.000 m^3
[ESC]	Return to "TOTAL MODE"	TOTAL MODE TOTAL STOP
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "TOTAL RESET," and press ENTER.	TOTAL MODE TOTAL RESET
[ESC]	Display the measurement, reflecting the setting.	(Measurement display screen)

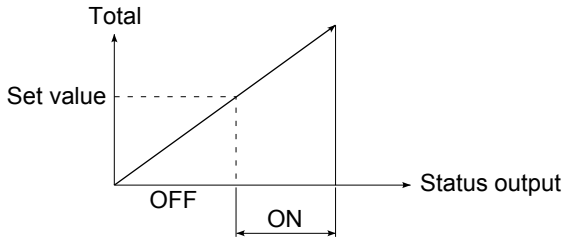
4.4.9.4. Total SW

Description

This is a function of providing contact output when the total value reaches the set value.
Set the total SW when selecting “F: TOTAL SW” or “R: TOTAL SW” in status output setting.

- F: Total SW: Total SW value in forward direction
- R: Total SW: Total SW value in reverse direction
  (Setting range: 0 to 9999999999.999)

Note: Set the total preset value in a state where the total mode is set to stop.



Operation (example)	When setting total switch setting in forward direction to 5000 m^3	
Key operation	Description	Display
[FUNC] [TOTAL]	Display “TOTAL MODE”	TOTAL MODE TOTAL STOP
[▲] or [▼]	Select “F: TOTAL SW”	F: TOTAL SW 0.000 m^3
[ENTER] [5] [0] [0] [0] [ENTER]	Enter numeric value enter mode, enter “5000” using ten keys, and press ENTER.	F: TOTAL SW 5000.000 m^3
[ESC]	Return to “TOTAL MODE”	TOTAL MODE TOTAL STOP
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select “TOTAL RESET,” and press ENTER.	TOTAL MODE TOTAL RESET
[ESC]	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.9.5. Determining how to dispose of total at error (BURNOUT)

Description

Output burnout is a function of setting the total output to hold when measurement state becomes abnormal. Set the duration until burnout processing is performed with the burnout timer.

(Setting contents)

- Hold: Holds the total value
- Not used: Burnout is not used.

Output burnout processing is performed as follows.

1. LCD .....Holds the total measurement value.
2. Total pulse output*[1] .....Stops output.
3. Internal calculation*[1] .....Stops integration.

Note: Set output burnout in a state where total mode is set to total stop.

*1) Integration is continued until output burnout processing is started.

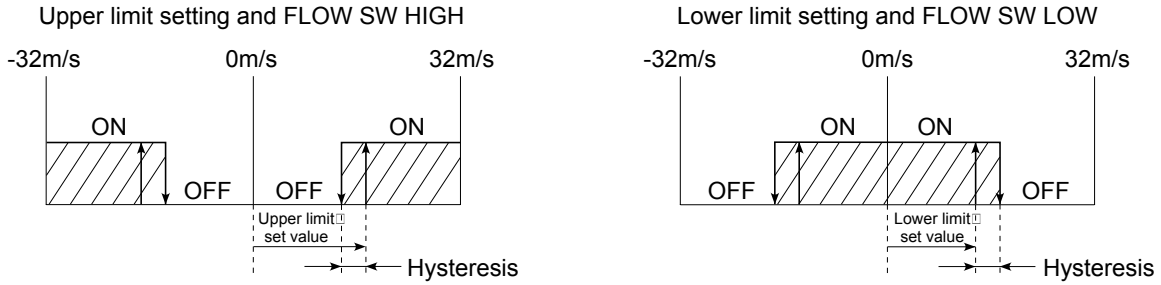
Operation (example)	When setting output burnout to hold and burnout timer to 30 sec.	
Key operation	Description	Display
FUNC TOTAL	Display "TOTAL MODE"	TOTAL MODE TOTAL STOP
▲ or ▼	Select "OUTPUT BURNOUT"	OUTPUT BURNOUT NOT USED
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "HOLD," and press ENTER.	OUTPUT BURNOUT HOLD
▼	Select "BURNOUT TIMER"	BURNOUT TIMER 10 sec
ENTER 3 0 ENTER	Enter numeric value enter mode, enter "30" using ten keys, and press ENTER.	BURNOUT TIMER 30 sec
ESC	Return to "TOTAL MODE"	TOTAL MODE TOTAL STOP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "TOTAL RESET," and press ENTER.	TOTAL MODE TOTAL RESET
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.10. Flow switch

Description

(1) The flow switch is actuated when the instantaneous flow rate exceeds the specified value. Set the flow switch high and low values when selecting “FLOW SW HIGH” or “FLOW SW LOW” in status output setting
Setting range: 0 to 32 m/s in velocity. Enter absolute value.

[Relation between status output and setting]



(2) Setting hysteresis
Switching hysteresis can be provided in the following range.
Set it in the range from 0 to 20% of the setting range. (Hysteresis is a ratio to the operation range.)

Operation (example)	When setting lower limit flow rate to 20 m^3/h, upper limit flow rate to 180 m^3/h, and hysteresis to 5%	
Key operation	Description	Display
FUNC FLOW SW	Display “”FLOW SW LOW”	FLOW SW LOW 0.00 m^3/h
ENTER 2 0 ENTER	Enter numeric value enter mode, enter “20” using ten keys, and press ENTER.	FLOW SW LOW 20.00 m^3/h
▼	Select “FLOW SW HIGH”	FLOW SW HIGH 112.64 m^3/h
ENTER 1 8 0 ENTER	Enter numeric value enter mode, enter “180” using ten keys, and press ENTER.	FLOW SW HIGH 180.00 m^3/h
▼	Select “FLOW SW HYS.”	FLOW SW HYS. 10%
ENTER 5 ENTER	Enter numeric value enter mode, enter “5” using ten keys, and press ENTER.	FLOW SW HYS. 5%
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.11. Status output

Description

(1) Output

Total pulse and status (measurement error or flow rate switch) output can be set as follows (common for DO1/DO2/DO3)

1.	NOT USED:	Contact output is not used.
2.	SIGNAL ERROR:	Outputs when measurement error occurs.
3.	F: TOTAL PULSE:	Outputs flow rate total pulse in forward direction.
4.	R: TOTAL PULSE:	Outputs flow rate total pulse in reverse direction.
5.	F: TOTAL ALARM:	Outputs when flow rate total alarm in forward direction is exceeded.
6.	R: TOTAL ALARM:	Outputs when flow rate total alarm in reverse direction is exceeded.
7.	F: TOTAL OVERFLOW:	Outputs when flow rata total value in forward direction overflows.
8.	R: TOTAL OVERFLOW:	Outputs when flow rate total value in reverse direction overflows.
9.	FLOW SW HIGH:	Outputs when the upper limit setting of the flow switch is exceeded.
10.	FLOW SW LOW:	Outputs when the flow rate becomes lower than the lower limit setting of the flow switch.
11.	FULL SCALE 2:	Outputs when analog output operation range is full scale 2.
12.	AO RANGE OVER:	Outputs when the value exceeds the upper limit setting or becomes lower than the lower limit setting of the range.
13.	PULSE RANGE OVER:	Outputs when the total pulse output exceeds the maximum output frequency value.
14.	R: FLOW DIRECTION:	Outputs when the flow is in reverse direction.
15.	DEVICE ERROR:	Outputs when devices become abnormal.

(2) Mode

The mode of status output pulse can be set as follows.

1.	NORMAL:	Normal off (DO1/DO2) or normal open (DO3)
2.	REVERSE	Normal on (DO1/DO2) or normal close (DO3)

⚠ CAUTION

- If the mode is set to REVERSE, DO output is provided when the power is turned on. Check if DO output can be modified before setting.

Note: DO output specifications

DO1/DO2: Transistor open collector, Contact capacity: 30V DC, 0.1A
When total pulse output is selected (Note: See 4.4.9.2.)
1000 pulse/s or lower (at full scale flow rate)
Pulse width: 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0, 100.0 or 200.0 ms

DO3: Relay contact, contact capacity: 220V AC/30V DC, 1A
Service life: 200,000 times (under rated load), Can be replaced if provided with a socket
When total pulse output is selected (Note: See 4.4.9.2.)
1 pulse/s or lower (at full scale flow rate)
Pulse width: 50, 100 or 200ms

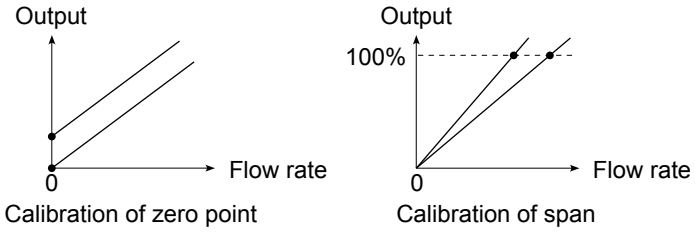
Operation (example)	When setting DO2 output to total pulse in forward direction and mode to reverse	
Key operation	Description	Display
FUNC STATUS	Display “SELECT STATUS”	SELECT STATUS DO.1
ENTER ▲ or ▼ ENTER	Select “DO.2” and press ENTER.	SELECT STATUS DO.2▲▼
ENTER	Display “OUTPUT DO.2”	OUTPUT DO.2 NOT USED
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “F: TOTAL PULSE,” and press ENTER.	OUTPUT DO.2 F: TOTAL PULSE
▲ or ▼	Display “MODE DO.2”	MODE DO.2 NORMAL
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “REVERSE,” and press ENTER.	MODE DO.2 REVERSE
ESC ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.12. Output calibration

Description

Measurement value can be calibrated arbitrarily.
Zero point and span adjustment can be made.
The adjustment range is as follows:
Zero point: ±5 m/s in velocity
Span: ±200%
Measurement value and analog output value can be calculated using the following expression.

$$\text{Output} = \frac{\text{Measurement value} \times [\text{Span setting \%}]}{100} + \text{Zero point}$$



Operation (example)	When adjusting zero point to –0.5 m^3/h and span to 105%	
Key operation	Description	Display
FUNC CAL	Display “CAL. ZERO”	CAL. ZERO 0.00 m^3/h
ENTER ± 0 . 5 ENTER	Enter numeric value enter mode, enter “±0.5” using ten keys, and press ENTER.	CAL. ZERO – 0.50 m^3/h
▲ or ▼	Select “CAL. SPAN”	CAL. SPAN 100.00%
ENTER 1 0 5 ENTER	Enter numeric value enter mode, enter “105” using ten keys, and press ENTER.	CAL. SPAN 105.00%
ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.13. Measurement unit

Description

Measurement unit can be selected from metric system and English system.
(Setting contents)

- Meter: Metric system
  Unit of length: .....mm
  Unit of velocity (S.V.): .....m/s
  Unit of flow rate: .....L/s, L/min, L/h, L/d, kL/d, ML/d, m^3/s, m^3/min, m^3/h, m^3/d, km^3/d, Mm^3/d, BBL/s, BBL/min, BBL/h, BBL/d, kBBL/d, MBBL/d
  Total unit: .....mL, L, m^3, km^3, Mm^3, mBBL, BBL, kBBL
  Unit of viscosity: .....$E^{-6}m^2/s$
  Unit of temperature: .....°C

Note: Set units in a state where the total mode is set to stop.

Operation (example)	When changing the unit system to metric system	
Key operation	Description	Display
FUNC SYSTEM	Display SYSTEM.	UNIT & LANGUAGE SKIP
ENTER ▲ or ▼	Select "SETTING"	UNIT & LANGUAGE SETTING▲▼
ENTER	Display system unit.	SYSTEM UNIT ENGLISH
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "METRIC," and press ENTER.	SYSTEM UNIT METRIC
ESC ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.14. System language selection

Description

The system language to be displayed at the time of setting can be selected from the following 5: English, Japanese, German, French, and Spanish.

Operation (example)	When selecting English	
Key operation	Description	Display
FUNC SYSTEM	Display SYSTEM.	UNIT & LANGUAGE SKIP
ENTER ▲ or ▼	Select “SETTING”	UNIT & LANGUAGE SETTING▲▼
ENTER	Display SYSTEM UNIT.	SYSTEM UNIT METRIC
▲ or ▼	Display SYSTEM LANGUAGE.	SYSTEM LANGUAGE JAPANESE
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “ENGLISH,” and press ENTER.	SYSTEM LANGUAGE ENGLISH
ESC ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.15. Setting serial communication (RS232C/RS485)

Description

Communication setting can be made as follows when using transmission function.
Setting contents
COM. SPEED, COM. PARITY, COM. STOP BIT, SERIAL METHOD, STATION NO.
Setting range
COM. SPEED: 9600bps, 19200bps, 38400bps
COM. PARITY: NONE, ODD, EVEN
COM. STOP BIT: 1 BIT, 2 BITS
SERIAL METHOD: RS232C or RS485
STATION NO.: 1 to 31
Note: See "8.1. External communication specifications" for details of communication specifications.

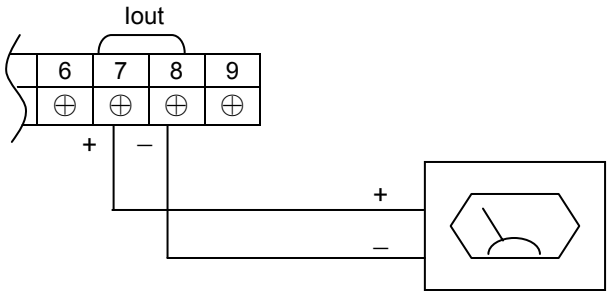
Operation (example)	When setting communication speed to 9600 bps, parity to even, stop bit to 2 bits, serial method to RS485, and station No. to "5"	
Key operation	Description	Display
[FUNC] [SYSTEM]	Display SYSTEM.	UNIT & LANGUAGE SKIP
[▲] or [▼]	Select "SERIAL COM."	SERIAL COM. SKIP
[ENTER] [▲] or [▼]	Enter select/enter mode and select "SETTING."	SERIAL COM. SETTING
[ENTER]	Display "COM. SPEED"	COM. SPEED 38400 bps
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "9600 bps," and press ENTER.	COM. SPEED 9600 bps
[▼]	Select "COM. PARITY"	COM. PARITY NONE
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "EVEN," and press ENTER.	COM. PARITY EVEN
[▼]	Select "COM. STOP BIT"	COM. STOP BIT 1 BIT
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "2 BITS," and press ENTER.	COM. STOP BIT 2 BITS
[▼]	Select "SERIAL METHOD"	SERIAL METHOD RS232C
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "RS485," and press ENTER.	SERIAL METHOD RS485
[▼]	Select "STATION NO"	STATION No. No. 1
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "5," and press ENTER.	STATION No. No. 5
[ESC]	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.16. Maintenance

4.4.16.1. Analog output adjustment and check

Description

Adjust the analog output so that the output becomes 4 mA when the flow rate is 0 and 20 mA when it is in full scale.
Check that each output value in the range from –20% to 120% becomes 0.8 mA to 23.2 mA.
Connect an ammeter to the IOUT terminal to perform the adjustment.



Operation (example)	Adjusting 4 mA and 20 mA outputs and checking 75% output (16 mA)	
Key operation	Description	Display
FUNC SYSTEM	Display SYSTEM.	UNIT & LANGUAGE SKIP
▲ or ▼	Select "MAINTENANCE"	MAINTENANCE SKIP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "AO.1," and press ENTER. Display 4 mA adjustment.	AO. 1 ADJUST 4 mA
▲ (Increase) or ▼ (Decrease)	Perform fine adjustment.	AO. 1 ADJUST 4 mA
▶ (Increase) or ◀ (Decrease)	Perform coarse adjustment. Adjust so that the ammeter indicates 4 mA.	
ENTER	Exit 4 mA adjustment and go to 20 mA adjustment.	AO. 1 ADJUST 20 mA
▲ (Increase) or ▼ (Decrease)	Perform fine adjustment.	AO. 1 ADJUST 20 mA
▶ (Increase) or ◀ (Decrease)	Perform coarse adjustment. Adjust so that the ammeter indicates 20 mA.	
ENTER	Exit 20 mA adjustment and go to "AO.1 CHECK"	AO. 1 CHECK 0%
ENTER 7 5 ENTER	Enter numeric value enter mode, enter "75" using ten keys, and press ENTER. [Check 75% (16 mA) output.]	AO. 1 CHECK 75%
ESC ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.16.2. Checking status output

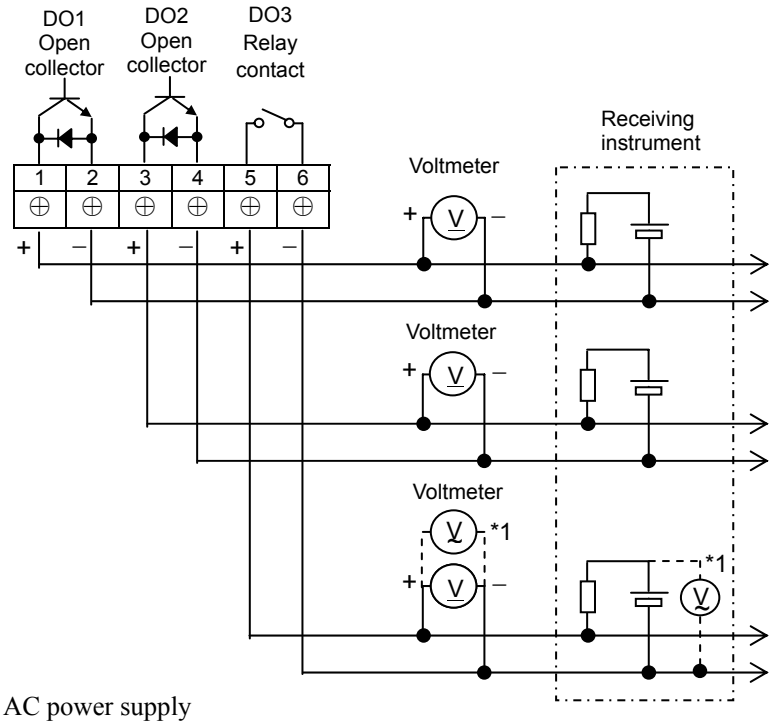
Description

Check the ON-OFF operation of the status output as follows.
Setting contents: ON: Closes the contact, OFF: Opens the contact.

⚠ CAUTION

- Check if DO output can be changed before operation.

Connect voltmeters to DO1, DO2, and DO3 terminals.
Note: Refer to "4.4.11. Status output" of DO output specifications.



*1): When used with AC power supply
Note: Relay may be disconnected and ON/OFF can be checked with a tester.

Operation (example)	When checking digital output DO.1	
Key operation	Description	Display
FUNC SYSTEM	Display SYSTEM.	UNIT & LANGUAGE SKIP
▲ or ▼	Select "MAINTENANCE"	MAINTENANCE SKIP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "DO.1," and press ENTER.	DO.1 CHECK OFF
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "ON," and press ENTER.	DO.1 CHECK ON
	[Check of status output DO. 1 ON *1]	
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "OFF," and press ENTER.	DO.1 CHECK OFF
	[Check of status output DO.1 OFF *1]	
ESC ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

*1) The status output is affected by "(2) Mode (Normal/Reverse)" of "4.4.11. Status output."

4.4.16.3. Calibrating temperature sensor

Description

The resistance of the wedge temperature measurement can be calibrated as follows.
(Setting contents)

Calibrate: Calibrates resistance value 100Ω (wedge temperature: 0°C) and resistance value 140Ω (wedge temperature: 100°C)

Clear: Displayed under uncalibrated state or when calibration error has occurred. (The uncalibrated state cannot be restored after calibration.)

Note: Temperature sensor specifications

Measurement range:	–40 to 100°C
Sensor:	Built into resistance bulb for wedge temperature measurement
Built-in resistor:	JIS C1604, Class B or equivalent
Transformer:	Built into resistance-temperature conversion circuit
Connection:	3-wire

Connect a resistor to temperature sensor terminals as shown below.

Note: Use a resistor having the accuracy of ±0.1%.

Operation (example)	When performing calibration of resistance of wedge temperature measurement	
Key operation	Description	Display
FUNC SYSTEM	Display SYSTEM.	UNIT & LANGUAGE SKIP
▲ or ▼	Select “MAINTENANCE”	MAINTENANCE SKIP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “WEDGE TEMP,” and press ENTER.	ADJUST TEMP. ADJUST
ENTER	Select “ADJUST” and press ENTER.	SET 100Ω
Set the resistor to 100Ω. ENTER	Set the resistor to 100 Ω and press ENTER Elapsed time is displayed on the lower row while adjustment is in progress.	ADJUSTING 100Ω ■■■■■■
	On completion of 100 Ω adjustment, a screen prompting you to perform 140 Ω adjustment appears.	ADJUSTING 100Ω ■■■■■■■■■
Set the resistor to 140Ω. ENTER	Set the resistor to 140 Ω and press ENTER. Elapsed time is displayed on the lower row while adjustment is in progress.	ADJUSTING 140Ω ■■■■■■■■■■■■■
	“ADJUST” is displayed if the adjustment is successfully completed, and “CLEAR” is displayed when the adjustment is unsuccessfully completed.	ADJUST TEMP. ADJUST
ESC ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.16.4. Checking temperature sensor

Description

Check the wedge temperature measurement as follows.
Connect a resistor to temperature sensor terminals as shown by the figure in 4.4.16.3.

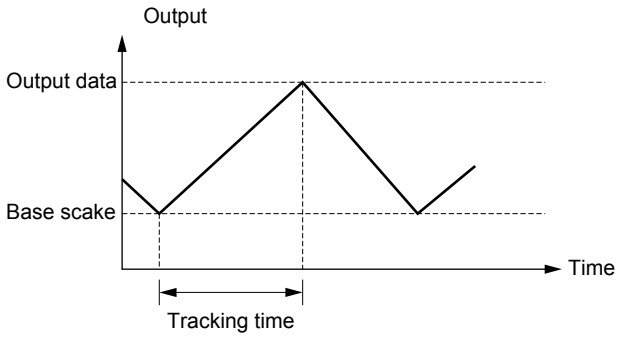
Operation (example)	When connecting 100 Ω resistor and checking that the wedge temperature becomes 0°C	
Key operation	Description	Display
FUNC SYSTEM	Display SYSTEM.	UNIT & LANGUAGE SKIP
▲ or ▼	Select "MAINTENANCE"	MAINTENANCE SKIP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select "WEDGE TEMP." and press ENTER.	ADJUST TEMP. ADJUST
▲ or ▼	Select "CHECK TEMP."	CHECK TEMP. 0.0°C
ENTER	Update the temperature display.	CHECK TEMP. 0.0°C
ESC	Display the measurement.	(Measurement display screen)

*1) About 4 seconds after the resistance value of the wedge temperature is changed, the temperature of the changed resistance value is displayed. The temperature display during that period is not constant.
*2) The accuracy of the wedge temperature is ±1.5°C. The accuracy depends also on the accuracy of the resistor.

4.4.16.5. Test mode

Description

In the test mode, flow rate is artificially input to check the state of integration and the operation of the flow rate switch, etc.
Set the target value as full scale, and the period until the target value is reached (tracking time) can be arbitrarily set.
Input data setting range: 0 to ±120%
Tracking time setting range: 0 to 900 sec.



⚠ CAUTION

- By performing the operation, the output of analog outputs, DO1, DO2, and DO3, varies depending on the setting. Check if each output can be changed beforehand.
- Be sure to return the setting to "NOT USE" after the test is completed. If not, the state of output of input value is held until the power is turned off.
- If "START/RESET" is selected as TOTAL MODE, the total value also changes. Select "STOP" not to make the total value change.

Operation (example)	When setting target value to 100% and making it to be reached in 15 seconds	
Key operation	Description	Display
[FUNC] [SYSTEM]	Display SYSTEM.	UNIT & LANGUAGE SKIP
[▲] or [▼]	Select "MAINTENANCE"	MAINTENANCE SKIP
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "TEST MODE," and press ENTER.	TEST MODE NOT USE
[ENTER] [▲] or [▼]	Enter select/enter mode, select "SETTING," and press ENTER.	TEST MODE SETTING
[ENTER]	Display INPUT DATA.	INPUT DATA 0%
[ENTER] [1] [0] [0] [ENTER]	Enter numeric value enter mode, enter "100" using ten keys, and press ENTER.	INPUT DATA 100%
[▲] or [▼]	Select "TRACKING TIME"	TRACKING TIME 0 sec
[ENTER] [1] [5] [ENTER]	Enter numeric value enter mode, enter "15" using ten keys, and press ENTER.	TRACKING TIME 15 sec
[ESC]	Artificially enter the flow rate to be measured in "SETTING" of the test mode.	TEST MODE SETTING
[ESC]	Display the measurement by artificial input.	(Measurement display screen)

4.4.17. LCD backlight

Description

The LCD backlight of the displayed screen can be selected from ON, OFF, and AUTO. If AUTO is selected, the backlight is set to ON when values are entered from the keyboard, and it is set to OFF on the measurement display screen.
If the setting is changed from OFF to ON/AUTO, the backlight is set to ON when the change is made. If the setting is changed from ON/AUTO to OFF, the backlight is set to OFF when the change is made.

Operation (example)	When setting the backlight to AUTO	
Key operation	Description	Display
FUNC SYSTEM	Display SYSTEM.	UNIT & LANGUAGE SKIP
▲ or ▼	Select “DISPLAY BACKLIGHT”	DISPLAY BACKLIGHT ON
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “AUTO,” and press ENTER.	DISPLAY BACKLIGHT AUTO
ESC	Set the backlight to OFF when the measurement display screen appears.	(Measurement display screen)

4.4.18. Key lock

Description

A password can be set for the input on the setting screen.
Select a 4-digit numeric value as a password. "." entered 4 times as a password is regarded as a valid password.
Note: If you forget the password, enter "." 4 times to reset the key lock.

Operation (example)	When enabling the key lock and setting "1234" as a password

Key operation	Description	Display
[FUNC] [SYSTEM]	Display SYSTEM.	UNIT & LANGUAGE SKIP
[▲] or [▼]	Select "KEY LOCK"	KEY LOCK OFF
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "ON," and press ENTER.	KEY LOCK ON
[▼]	Select "PASSWORD"	PASSWORD SKIP
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "SETTING," and press ENTER.	SET PASSWORD 0000
[ENTER] [1] [▶]	Enter numeric value enter mode, enter "1" using ten keys, and move to the second digit.	PASSWORD 1000
[2] [▶]	Enter "2" and move to the third digit.	PASSWORD 1200
[3] [▶]	Enter "3" and move to the fourth digit.	PASSWORD 1230
[4] [ENTER]	Enter "4" and press ENTER.	PASSWORD 1234
[ESC] [ESC]	Display the measurement.	(Measurement display screen)

Operation (example)	When resetting the key lock set as shown above (To go back to [FUNC] [SYSTEM])

Key operation	Description	Display
[FUNC]	Display password input screen.	_ _ _ _ (Measurement display screen)
[1]	Enter "1"	* _ _ _ (Measurement display screen)
[2]	Enter "2"	* * _ _ (Measurement display screen)
[3]	Enter "3"	* * * _ (Measurement display screen)
[4] *1	Enter "4"	(Measurement display screen)
[SYSTEM]	Enter "SYSTEM" to display SYSTEM.	UNIT & LANGUAGE SKIP

*1) If a wrong password is entered, the initial screen appears.

4.4.19. Checking system name

Description

The system name can be displayed.

Operation (example)	Check the system name as follows.	
Key operation	Description	Display
FUNC SYSTEM	Display SYSTEM.	UNIT & LANGUAGE SKIP
▲ or ▼	Select “SYSTEM NAME” Check the system name.	SYSTEM NAME FSH****
ESC ESC	Display the measurement	(Measurement display screen)

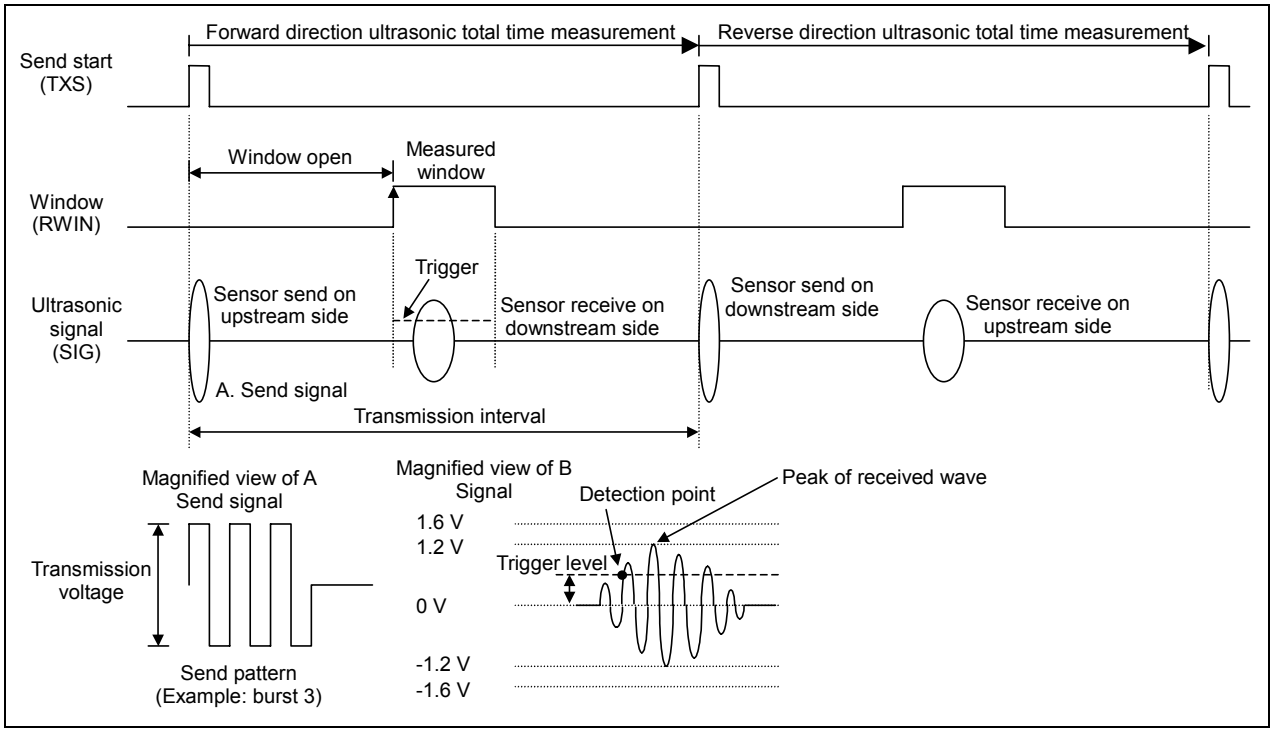
4.4.20. Details of measurement

4.4.20.1. Transit time

Description

The data required for time difference measurement can be set as follows.

[Signal processing outline drawing]



Note: Make the setting, following the description in "6.3. Checking received waveforms."

⚠ CAUTION

- This parameter is intended for our service personnel.
- Do not change the setting, since the parameter affects the flow rate measurement. If the setting is changed, measurement may be disabled.
- Make the setting when the factory-set value poses problems in flow rate measurement. If no problem arises with the factory-set value, the setting is not necessary.

Enter data for each item (see the following table) according to the display.

Item	Input method	Function and range or menu
Transmission count	Selection	The number of transmission of ultrasonic signals per flow rate signal output*[1] (Factory-set value: 128) • 8, 16, 32, 64, 128, 256
Trigger control	Selection	Control method setting of the trigger level (detection point) of ultrasonic signals (Factory-set value: AUTO) • AUTO • MANUAL
	Numeric value	Select the detection point according to the rate against the peak of receiving wave regarded as 100%. • Trigger level: 10% to 90%

Item	Input method	Function and range or menu
Window control	Selection	Setting of control method of measurement window that takes in signals (Factory-set value: AUTO) • AUTO • MANUAL
	Numeric value Numeric value	Set the time of starting taking in signals (period from the start of transmission until the startup of window signals) • Open time (F): 1 μs to 16383 μs • Open time (R): 1 μs to 16383 μs Note: (F): Forward direction, (R): Reverse direction Select (F) and (R) in manual mode.
Saturation	Numeric value	The number of times that the amplitude of received signals fluctuates and exceeds ±1.6V (saturation) per 1 flow rate signal output*[1]. Used as a threshold value for judgment of signal error. A signal error occurs if the specified number of times are exceeded. (Factory-set value: 32 times) • 0 to 256
Measurement method	Selection	Setting of measurement method for measuring transit time (Factory-set value: Method 2) • Method 1: method strong against interference • Method 2: Controls triggers on the plus side of the direction of voltage of received signals. • Method 3: Controls triggers on the minus side of the direction of voltage of received signals.
Signal balance	Numeric value	Setting of threshold value used for judging the existence of transit time. A signal error occurs if the specified value is exceeded. (Factory-set value: 25%) • 0% to 100% Note: Set to 50% or higher for Method 1.
Transmission pattern	Selection	Setting of transmission pattern of ultrasonic signals (Factory-set value: Burst 3) • Burst 1, Burst 2, Burst 3, Burst 4, Burst 5, Chirp 4, Chirp 8
AGC gain	Selection	Setting of control method of signal AGC gain (Factory-set value: Auto) Signal peak is controlled to be kept at 2.4Vpp. • AUTO • MANUAL
	Numeric value	Make the setting so that the signal peak in both forward and reverse directions is kept at 2.4 Vpp. • Gain in forward direction: 1.00% to 99.00% • Gain in reverse direction: 1.00% to 99.00%
Signal peak		Setting of signal peak threshold value per 1 flow rate signal output*[1]. Used as the threshold value for judging the error status of signals. A signal error occurs if the value becomes lower than the specified value. (Factory-set value: 3071) • 5120: $1.0V_{0P}$ or equivalent • 4096: $0.8V_{0P}$ or equivalent • 3071: $0.6V_{0P}$ or equivalent • 2048: $0.4V_{0P}$ or equivalent
TRANS. WAIT TIME	Numeric value	Setting of transmission interval of ultrasonic signals • 1 to 30 msec

*1) Forward-direction signals are taken in with forward total time measurement, while reverse-direction signals are taken in with reverse total time measurement. They are conducted alternately for the transmission count. Forward and reverse signal data is added for the transmission count and averaged. The result is 1 output of signal in forward/reverse direction.

Operation (example)	When setting window control of line 2 to manual, open time (F/R) to 150μs, and measurement method to method 1

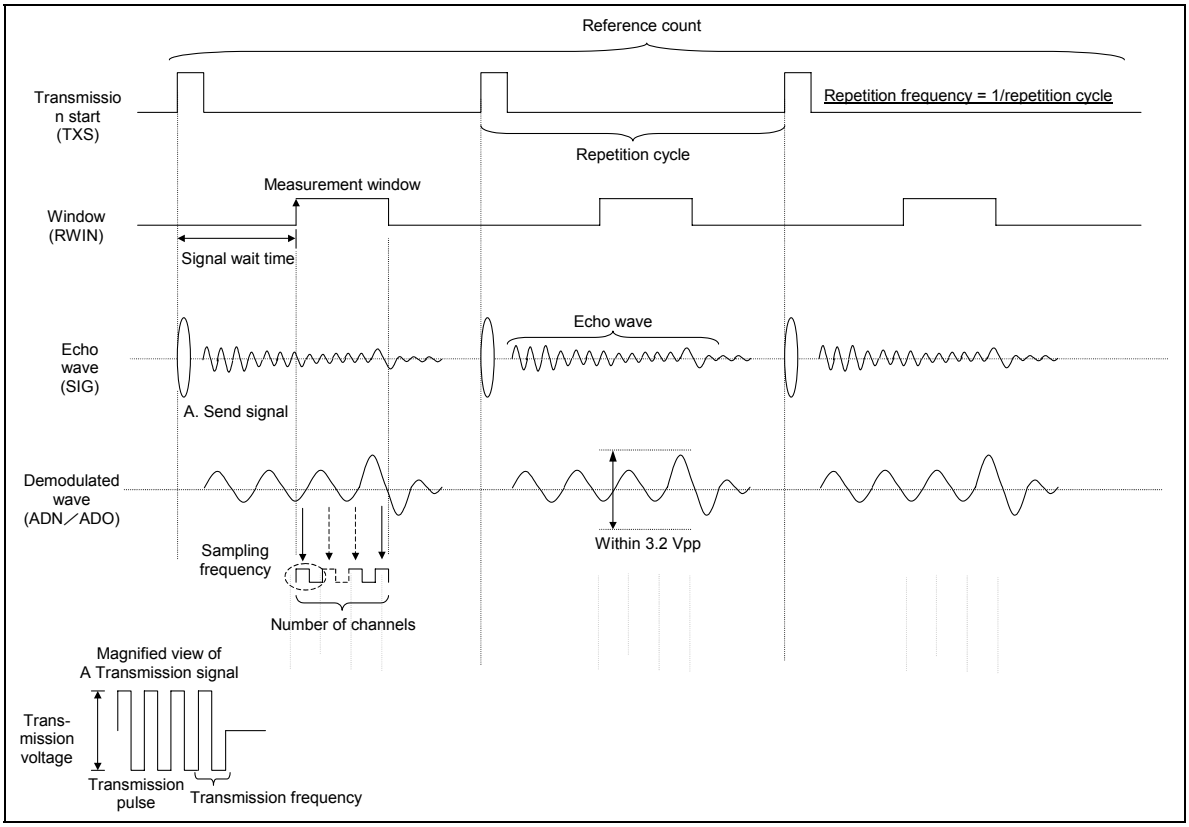
Key operation	Description	Display
FUNC DETAIL	Display VERSION INF.	VERSION INF. SKIP
▲ or ▼	Select “TRANSIT TIME”	TRANSIT TIME SKIP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “SETTING,” and press ENTER.	LINE SELECT NO. LINE 1
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “LINE 2,” and press ENTER.	2: TRANS. COUNT 128
▲ or ▼	Select “2: WINDOW CONTROL”	2: WINDOW CONTROL AUTO
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “MANUAL,” and press ENTER.	2: WINDOW CONTROL MANUAL
▼	Select “2: OPEN TIME (F)”	2: OPEN TIME (F) 0 us
ENTER 1 5 0 ENTER	Enter numeric value enter mode, enter “150” using ten keys, and press ENTER.	2: OPEN TIME (F) 150 us
▼	Select “2: OPEN TIME (R)”	2: OPEN TIME (R) 0 us
ENTER 1 5 0 ENTER	Enter numeric value enter mode, enter “150” using ten keys, and press ENTER.	2: OPEN TIME (R) 150 us
▲ or ▼	Select “2: MEAS. METHOD”	2: MEAS. METHOD METHOD 2
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “METHOD 1,” and press ENTER.	2: MEAS. METHOD METHOD 1
ESC ESC ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.20.2. Pulse Doppler

Description

The data required for pulse Doppler measurement can be set as follows.

[Outline drawing of signal processing]



Note: Make the setting, following the description in “6.3. Checking received waveform.”

⚠ CAUTION

- This parameter is intended for our service personnel.
- Do not change the setting, since the parameter affects the flow rate measurement. If the setting is changed, measurement may be disabled.
- Make the setting when the factory-set value poses problems in flow rate measurement. If no problem arises with the factory-set value, the setting is not necessary.

Enter data for each item (see the following table) according to the display.

Item	Input method	Function and range or menu
Wedge sound velocity	Selection Numeric value	Setting of wedge sound velocity of the sensor (Factory-set value: AUTO) • AUTO • MANUAL • WEDGE S.V.: 1000m/s to 3700m/s
Pipe sound velocity	Selection Numeric value	Setting of pipe sound velocity (Factory-set value: AUTO) • AUTO • MANUAL • PIPE S.V.: 1000m/s to 3700m/s

Item	Input method	Function and range or menu
Lining sound velocity	Selection Numeric value	Setting of pipe sound velocity (Factory-set value: AUTO) • AUTO • MANUAL • PIPE S.V.: 1000m/s to 3700m/s
Transmission frequency	Selection Numeric value	Setting of transmission frequency of the sensor (Factory-set value: AUTO) • AUTO • MANUAL • Transmission frequency: 0.100MHz to 5.000MHz Note: The transmission frequency setting range varies depending on the sensor. FSW12: 1.59 MHz to 2.25 MHz (Fundamental frequency: 2.0 MHz) FSW21: 0.81 MHz to 1.23 MHz (Fundamental frequency: 1.0 MHz) FSW40/FSW50: 0.45 MHz to 0.55 MHz (Fundamental frequency: 0.5 MHz)
Transmission pulse No.	Selection	Setting of transmission pulse of the sensor (Factory-set value: 4) • 0, 1, 2, 4, 8, 16, 32, 64
Sampling frequency	Selection Numeric value	Setting of control method of sampling frequency for taking in demodulated waves (Factory-set value: AUTO) • AUTO • MANUAL Set sampling frequency. • Sampling frequency: 31.3 kHz to 8000 kHz
Receipt wait time	Selection Numeric value	Setting of control method of measurement window for taking in modulated waves (Factory-set value: AUTO) • AUTO • MANUAL Set the time to start taking in demodulated waves (time from the start of transmission to the startup of window signals). • Receipt wait time: 0.12 μs to 2104.75 μs
Repetition frequency	Selection Numeric value	Setting of frequency control method in intervals of send/receive of reference count (Factory-set value: AUTO) • AUTO • MANUAL Set repetitive frequency. • Repetitive frequency: 100 Hz to 8000 Hz
Reference count	Selection	Setting of number of times of taking in per 1 flow rate signal output *[1] (Factory-set value: 256) • 4 to 512
No. of channels	Selection Numeric value	Setting of number of division (number of channels) of transmission path (Factory-set value: AUTO) • AUTO • MANUAL Set the number of channels. • Number of channels: 16, 32, 48, 64, 80, 96, 112, 128
Measurement range	Selection	Setting of measurement range within pipe (Factory-set value: F radius) • F radius: Radius farther viewed from the sensor that has made transmissions • N radius: Radius nearer viewed from the sensor that has made transmissions • Diameter: Total area on diameter of transmission path
Phase angle shift	Selection	Setting of measurement range of Doppler shift (phase angle) (Factory-set value: NORMAL 2) • NORMAL 1: Flow in positive/negative direction ($-\pi$ to 0 to π) • NORMAL 2: Flow in positive/negative direction (-3π to 0 to 3π) • POSITIVE: Flow in positive direction (0 to 2π) • NEGATIVE: Flow in negative direction (-2π to 0)

Item	Input method	Function and range or menu
Gain	Selection	Setting of control method of demodulated wave gain (Factory-set value: AUTO) The peak of demodulated waves within measurement window is controlled not to exceed 3.2 Vpp. • AUTO • MANUAL
	Numeric value	Make the setting so that the peak of demodulated waves within measurement window does not exceed 3.2 Vpp. START GIN ≤ END GAIN • START GAIN: 0 to 18 • END GAIN: 0 to 18
Fluid sound velocity	Selection	Setting of fluid sound velocity (Factory-set value: AUTO) • AUTO • MANUAL
	Numeric value	• PIPE S.V.: 500 m/s to 2500 m/s
Power	Numeric value	Setting of threshold value of echo wave power (Factory-set value: 4.0 E^4) A measurement error occurs if the value becomes lower than the threshold. The power measured in "6.1.2.3 Measurement data information" can be checked. • 0.00 to 99.99 E^4
Deviation	Numeric value	Setting of threshold value of standard deviation of Doppler shift (Factory-set value: 0.5) A success rate error occurs if the threshold is exceeded. (The deviation measured in "6.1.2.3 Measurement data information" can be checked.) • 0.00 to 1.00
Success rate	Numeric value	Setting of success rate of power and standard deviation per 1 flow rate signal output (Factory-set value: 70%) A success rate error occurs if the value becomes lower than the threshold. The success rate can be checked, following the description in "6.1.2.3. Measurement data information." • 0% to 100%

*1) A sensor transmits ultrasonic waves, and the same sensor receives the echo waves coming from the reflector. The transmission path is divided, Doppler shift (fluctuation of frequency) of the reflector that runs through each area (channel) is measured by performing send/receive for two or more times (reference count), and the flow velocity distribution is found based on the transmission speed of each part.

Operation (example)	When setting repetition frequency to 3500Hz manually and the success rate of line 1-F and line 1-R to 65%	
Key operation	Description	Display
FUNC DETAIL	Display VERSION INF.	VERSION INF. SKIP
▲ or ▼	Select “PULSE DOPPLER”	PULSE DOPPLER SKIP
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “SETTING,” and press ENTER.	WEDGE S.V. AUTO
▲ or ▼	Select “REPETITION FREQ.”	REPETITION FREQ. AUTO
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “SETTING,” and press ENTER.	REPETITION FREQ. MANUAL
▼	Select “REPETITION FREQ.”	REPETITION FREQ. 2000 Hz
ENTER 3 5 0 0 ENTER	Enter numeric value enter mode, enter “3500” using ten keys, and press ENTER.	REPETITION FREQ. 3500 Hz
▲ or ▼	Select “LINE SELECT”	LINE SELECT LINE 1-F
ENTER ▲ or ▼ ENTER	Enter select/enter mode, select “LINE 1-F,” and press ENTER.	1-F: POWER 4.00 E^4
▲ or ▼	Select “1-F: SUCCESS RATE”	1-F: SUCCESS RATE 70.00%
ENTER 6 5 ENTER	Enter numeric value enter mode, enter “65” using ten keys, and press ENTER.	1-F: SUCCESS RATE 65.00%
ESC ENTER ▲ or ▼ ENTER	Press “ESC,” enter select/enter mode, select “LINE 1-R,” and press ENTER.	1-R: POWER 4.00 E^4
▲ or ▼	Select “1-R: SUCCESS RATE”	1-R: SUCCESS RATE 70.00%
ENTER 6 5 ENTER	Enter numeric value enter mode, enter “65” using ten keys, and press ENTER.	1-R: SUCCESS RATE 65.00%
ESC ESC ESC	Display the measurement, reflecting the setting.	(Measurement display screen)

4.4.20.3. Initializing setting parameters

Description

Setting parameters stored in a memory can be initialized as follows.
(Setting contents)

- NOT INITIALIZE: Does not initialize the parameter.
- INITIALIZE: Initializes the parameter.
- FACTORY SETTING: Initializes those other than the adjusted values (such as current output, sensor calibration, etc.)

⚠ CAUTION

- This parameter is intended for our service personnel.
- Do not attempt to initialize the setting parameters. Otherwise measurement is disabled.

Operation (example)	When setting parameters to factory-set values	
Key operation	Description	Display
[FUNC] [DETAIL]	Display "VERSION INF."	VERSION INF. SKIP
[▲] or [▼]	Select "SETTING DATA"	SETTING DATA NOT INITIALIZE
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode and then select "FACTORY SETTING," and the converter is reset.	SETTING DATA FACTORY SETTING
	Display the measurement.	(Measurement display screen)

4.4.20.4. Confirmation of software version

Description

The software version of the measurement board and control board can be displayed.

Operation (example)	The software version can be checked as follows.	
Key operation	Description	Display
[FUNC] [DETAIL]	Display "VERSION INF."	VERSION INF. SKIP
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select "CHECK," and press ENTER.	VERSION INF. CHECK
	Check the version of "MEASUREMENT BOARD"	MEASUREMENT BOARD FSH1MES********
[▲] or [▼]	Select "." Check the version of "CONTROL BOARD"	CONTROL BOARD FSH1MMI***
[ESC] [ESC]	Display the measurement.	(Measurement display screen)

5. MAINTENANCE AND INSPECTION

5.1. Daily inspection

Visually check the following.

- Check the screw of the flow transmitter cover for looseness.
  ⇒ Fasten.
- Check the cable gland for looseness.
  ⇒ Fasten.
- Check the stainless belt of the detector for sag.
  ⇒ Stretch.
- Check the LCD for error display (measurement error).
  ⇒ Check that the state of detector mounting or wiring is normal. Check that the pipe is filled with fluid. Decrease air bubbles or foreign substances, if contained in the fluid too much.

5.2. Periodic inspection

5.2.1. Checking zero point

Stop the flow of the fluid, fill the pipe with fluid, and check zero point.

⇒ Refer to 4.4.6. Zero adjustment

5.2.2. Calibrating current output circuit

Adjust the 4 mA and 20 mA analog outputs.

⇒ Refer to 4.4.16.1. Analog output adjustment and check

5.2.3. Calibrating temperature sensor circuit

Adjust the resistances (100 Ω and 140 Ω) of wedge temperature measurement.

⇒ Refer to 4.4.16.3. Calibrating temperature sensor

5.2.4. Measuring insulation resistance

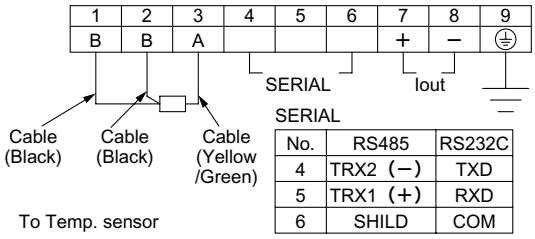
⚠ CAUTION

Be sure to turn off the power before opening the cover of the flow transmitter.
The power terminals (N, L) and the output terminals (Iout, SERIAL, DO1 to DO3) are provided with an arrester as standard. To measure the insulation resistance between the power terminal and the grounding terminal, remove the earth plate of the power terminal block as shown by the following figure. To measure the insulation resistance between each output terminal described above and the grounding terminal, remove the ground wire of the measurement board terminal block and the control board terminal block.
The insulation resistance performance of the equipment is 100 MΩ/500 V DC.

Be sure to return the earth plates and ground wire in position after the measurement is completed.

[Measurement method]
(1) Between power terminal and grounding terminal
In the case of AC power: Between L, N (batch) and outer earth terminal
In the case of DC power: Between +, – (batch) and outer earth terminal
(2) Between output terminal and grounding terminal
Between Iout (+,–) (batch) and outer earth terminal
Between SERIAL (batch) and outer earth terminal
Between DO1 (+,–) (batch) and outer earth terminal
Between DO2 (+,–) (batch) and outer earth terminal
Between DO3 (+,–) (batch) and outer earth terminal
Refer to 3.3.5 for the outer earth terminal.

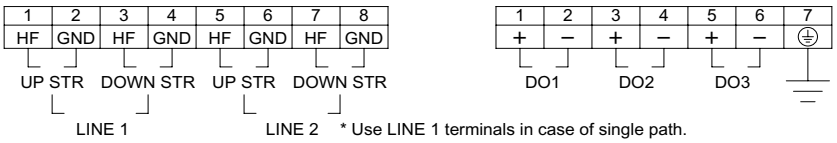
[Control board terminal block]



SERIAL

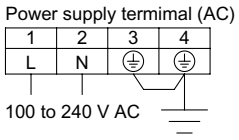
No.	RS485	RS232C
4	TRX2 (–)	TXD
5	TRX1 (+)	RXD
6	SHILD	COM

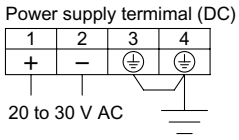
[Measurement board terminal block]

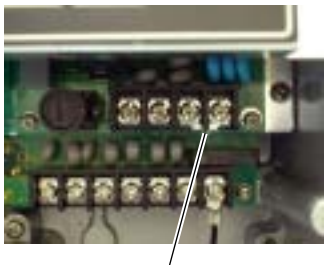


* Use LINE 1 terminals in case of single path.

[Power supply board terminal block]







5.3. Replacing fuse

⚠ CAUTION

- Be sure to turn off the power before replacing the fuse.
  The specifications of the fuse is as follows:
  (1) AC power supply (100 V and 200 V): 5.2 mm (diameter) × 20 mm (length), 250 V 2A
  (such as UL CSA FGMT 250 V 2 A by Fuji Tanshi Kougyo)
  (2) DC power supply: 5.2 mm (diameter) × 20 mm (length), 250 V 3A
  (such as UL CSA FGMT 250 V 3 A by Fuji Tanshi Kougyo)

(1) Turn off the power and open the cover.
Loosen the 4 screws on the front face of the flow transmitter, and open the cover.
(2) Replacement of fuse
Remove the fuse holder on the left side of the terminal block of the power supply board using a flat-blade screwdriver, and replace the fuse. Then return the fuse holder back in position.
(3) Close the cover.
Close the cover and fasten the 4 screws.

⚠ CAUTION

- Be sure to close the cover before turning on the power.

5.4. Replacing relay

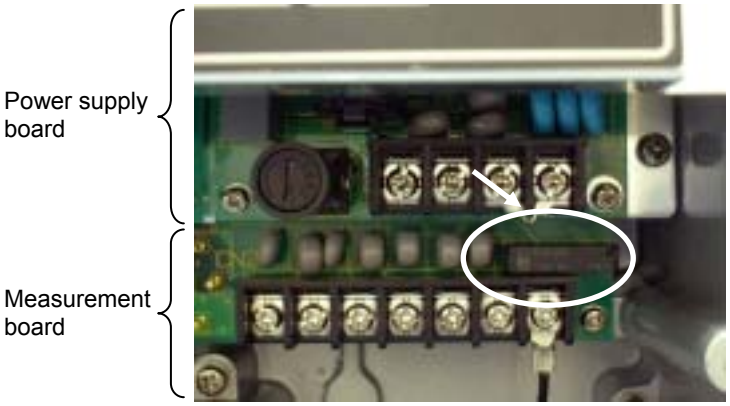
DO3 is a relay contact, whose service life is 200,000 times (under rated load).
Replace the relay before its service life expires, paying attention to the number of times of contact operation.
Card relay type: RB104-DY (Fuji Electric)

[Replacement procedure]

(1) Turn off the power and open the cover.
(2) As shown by the following photo, pull out the card relay on the measurement board located under the power supply board from the socket.
(3) Set a new card relay into the socket. Push the card relay securely until the nail of the relay engages in position.
(4) Close the cover and turn on the power.
(5) Check the ON/OFF operation in status output check in maintenance. (Refer to "4.4.16.2. Checking status output.")

⚠ CAUTION

- The unit has high-voltage section. Be sure to turn off the cover before opening the cover.



5.5. Replacing LCD

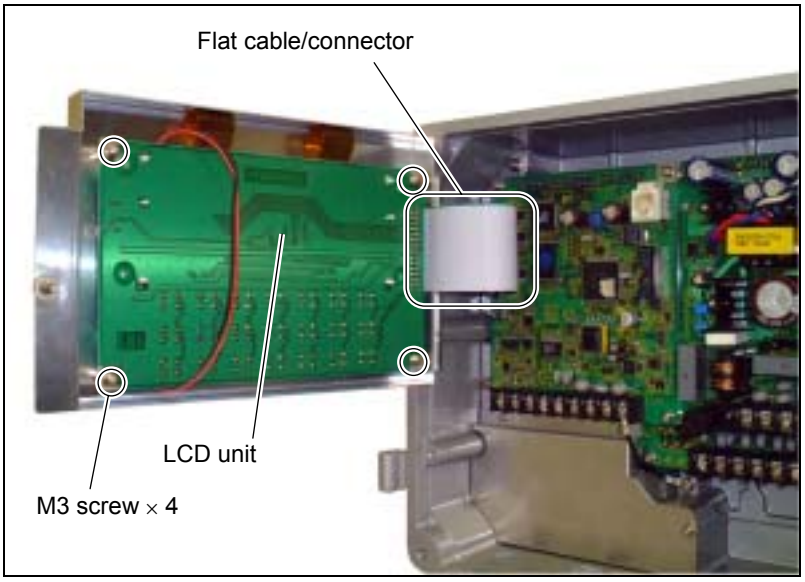
The nominal service life of the LCD is 10 years. The contrast gradually deteriorates with time. Replace the LCD when 5 to 6 years have passed since the start of use.

[Replacement procedure]

(1) Turn off the power and open the cover.
(2) Open the setting section of the display unit.
(3) Remove the flat cable connector.
(4) Remove the screws fastening the LCD unit (4 positions).
(5) Mount a new LCD unit (see parts list). Insert the operation key into the hole of the cover properly, paying attention not to let the operation key to be pressed against or caught by the cover.
(6) Insert the flat cable connector. (Insert it securely.)
(7) Close the cover and turn on the power.
(8) Check that the LCD display and key operation are normal.

⚠ CAUTION

- The unit has high-voltage section. Be sure to turn off the power before opening the cover.

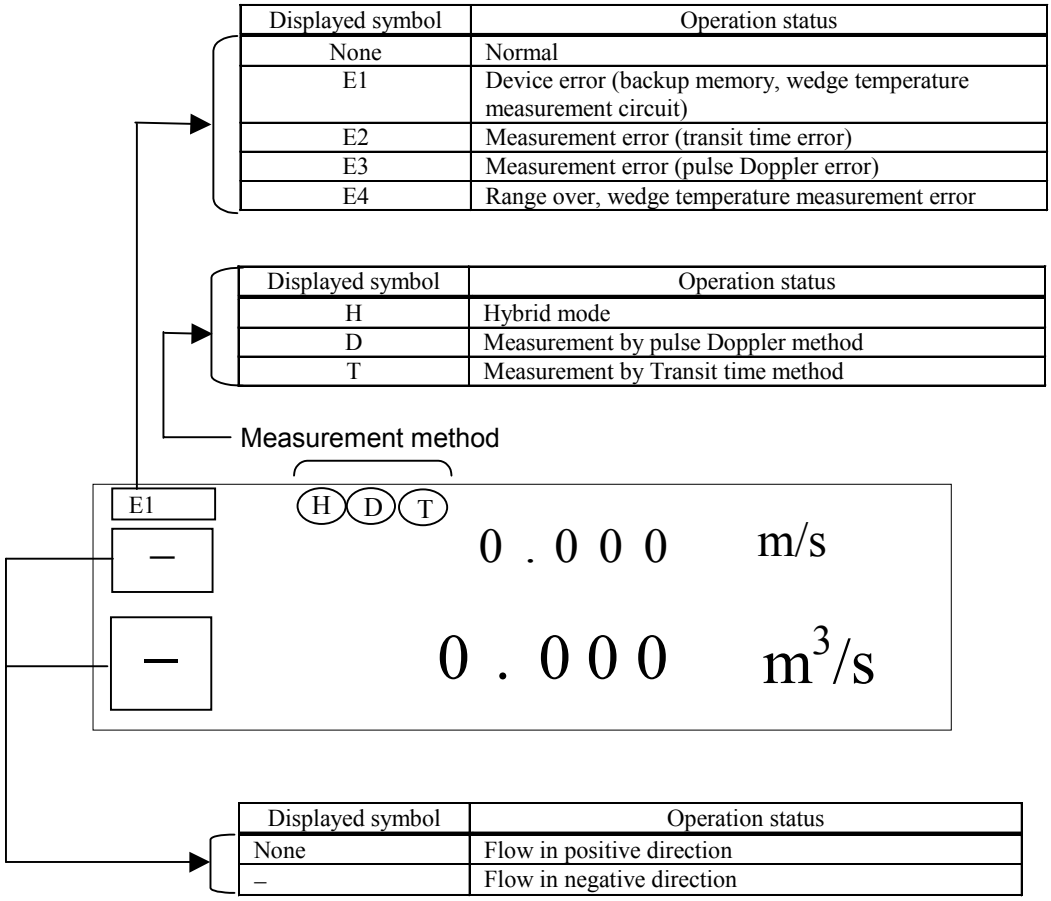


6. TROUBLESHOOTING

6.1. How to confirm normal operation

6.1.1. Checking on LCD

If the following display does not appear, press the [ESC] key.



6.1.2. Checking measurement status information

6.1.2.1. Define “RAS”

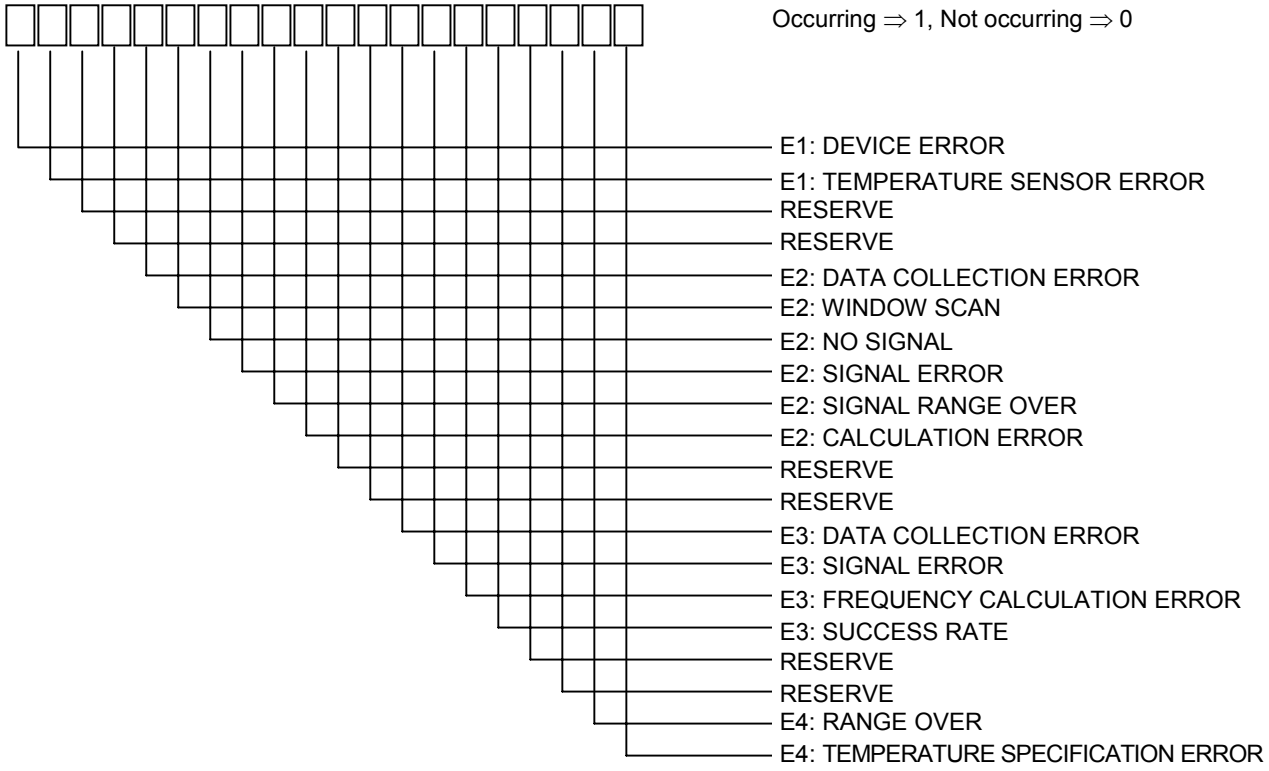
Description

Check the details of error status.
The following table lists the RAS information displayed on the upper-left corner of the measurement screen.
If an error is detected, take measures according to “6.2. Fault and remedies.”

Displayed symbol	RAS information	Displayed contents	Major cause
E1	E1: Device error	• Backup memory error • Measurement circuit error	• Hardware error
	E1: Temperature sensor error	• Check cable connection. • Temperature circuit error	• Break of cable • Hardware error
E2	E2: Data collection error	• Check sensor type. • Turn on the power again. OFF → OFF	• Hardware error
	E2: Window scan	• Signals are being detected.	• Signals are being detected.
	E2: No signal	• Check receive sensitivity. • Check pipe input data. • Check sensor mounting dimensions. • Check sensor type. • Check cable connection. • Check that the pipe is filled with fluid.	• Ultrasound waves cannot be propagated into pipe.
	E2: Signal error	• Check receive sensitivity. • Check mixing in of air bubbles. • Check mixing in of foreign substances. • Check zero point status.	• Receive sensitivity is low. • Receive signal waveform is improper.
	E2: Signal range over	• Check pipe input data. • Check sensor mounting dimensions.	• Receive signals do not fall within measurement window.
	E2: Calculation error	• Check pipe input data. • Check receive sensitivity. • Turn on the power again. OFF → ON	• Improper pipe specifications
E3	E3: Data collection error	• Check sensor type. • Turn on the power again. OFF → ON	• Parameter setting error • Hardware error
	E3: Signal error	• Check cable connection. • Check receive sensitivity.	• No echo waves from reflector.
	E3: Frequency calculation error	• Check pipe input data. • Check sensor type.	• The difference in flow rate measured with the reverse-direction sensor and the forward-direction sensor is large.
	E3: Success rate	• Check receive sensitivity.	• Sensitivity of echo wave from reflector is low.
E4	E4: Range over	• Check range setting. • Check integration setting.	• Flow rate range over
	E4: Temperature specification range over	• Sensor temperature error	• Fluid temperature range over

Operation (example)	E2: In case of no signals	
Key operation	Description	Display
FUNC CHECK	Display RAS information in CHECK.	RAS INFORMATION*1 0000001 0000000000000 E2: NO SIGNAL
(◀ or ▶)	(Select multiple error items, if any, by pressing ◀ or ▶.)	
ENTER	Check the contents of the error selected. If multiple error items are selected, ▲▼ is displayed.	RAS INFORMATION E2: NO SIGNAL PIPE IN-DATA CHECK
▲ or ▼	Check contents.	RAS INFORMATION E2: NO SIGNAL SENSOR MOUNT CHECK▲▼
ESC ESC	Display the measurement.	(Measurement display screen)

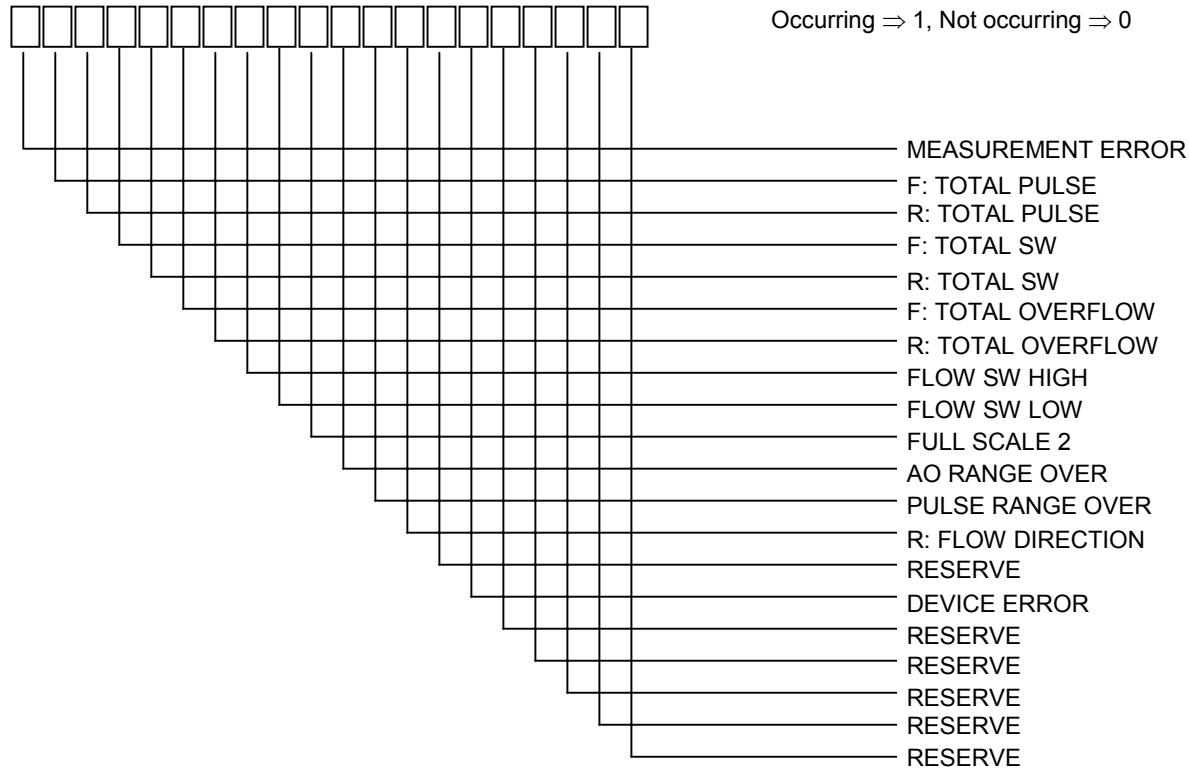
*1) Composition of RAS information



6.1.2.2. Status information

Description

Check the operation status in STATUS.
The composition is shown below.



Operation (example)	In case of range over	
Key operation	Description	Display
[FUNC] [CHECK]	Display RAS information in CHECK.	RAS INFORMATION 0000000000000000000
[▼]	Display status information in CHECK.	STATUS INFORMATION 10000000000000000000 MEASUREMENT ERROR
([◀] or [▶])	(Select multiple error items, if any, by pressing [◀] or [▶].)	
[ESC]	Display the measurement.	(Measurement display screen)

6.1.2.3. Measurement data information

Description

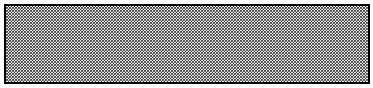
The information of data measured by time difference and pulse Doppler methods can be checked.
The following table lists the data information.

Time difference			Pulse Doppler		
Wedge S.V. [m/s]		(Theoretical value)	Wedge S.V. [m/s]		(Theoretical value)
Wedge angle [°]		(Theoretical value)	Wedge angle [°]		(Theoretical value)
Pipe S.V. [m/s]		(Theoretical value)	Pipe S.V. [m/s]		(Theoretical value)
Angle in pipe [°]		(Theoretical value)	Angle in pipe [°]		(Theoretical value)
Lining S.V. [m/s]		(Theoretical value)	Lining S.V. [m/s]		(Theoretical value)
Angle in lining [°]		(Theoretical value)	Angle in lining [°]		(Theoretical value)
Fluid S.V. [m/s]		(Theoretical value)	Fluid S.V. [m/s]		(Theoretical value)
Wedge temperature [°C]			Wedge temperature [°C]		
Angle in fluid [°]		(Theoretical value)	Angle in fluid [°]		(Theoretical value)
Total time [μs]		(Theoretical value)	Transmission frequency [MHz]		
Window open [μs]		(Theoretical value)	Sampling frequency [kHz]		
Line 1	1: Total time [μs]		Receive wait time [μs]		
	1: Forward time [μs]		Repetition frequency [Hz]		
	1: Reverse time [μs]		Transmission pulse No.		
	1: Time difference [ns]		Reference count		
	1: Delay time [μs]		No. of channels		
	1: Fluid S.V. [m/s]		Measurement range		
	1: Angle in fluid [°]		Phase angle shift		
	1: Raynolds No.		Start gain		
	1: K		End gain		
	1: Velocity [m/s]		Start distance [mm]		
	1: Signal power (F) [%]		Channel width [mm]		
	1: Signal power (R) [%]		Start channel No.		
	1: Trigger level (F) [%]		End channel No.		
	1: Trigger level (R) [%]		Velocity coefficient		
	1: Signal peak (F)		Line 1-F	Power [E^4]	
	1: Signal peak (R)			Deviation	
Line 2: Same as Line 1				Success rate [%]	
			Line 1-R: Same as Line 1-F		
			Line 2-F: Same as Line 1-F		
			Line 2-R: Same as Line 1-F		
			MAX RANGE [m/s]		

Operation (example)	When checking the signal power of line 2 in Transit time method When checking the success rate of line 1-R in pulse Doppler method	
Key operation	Description	Display
[FUNC] [CHECK]	Display RAS information in CHECK.	RAS INFORMATION 00000000000000000000
[▲] or [▼]	Select “TRANSIT TIME”	TRANSIT TIME SKIP
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select “CHECK,” and press ENTER.	WEDGE S.V. 2500 m/s
[▲] or [▼]	Select “LINE SELECT NO.”	LINE SELECT NO. LINE 1
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select “LINE 2,” and press ENTER.	2: TOTAL TIME 89.256 us
[▲] or [▼]	Select “SIGNAL POWER (R)” and check the data.	2: SIGNAL POWER (R) 56.23%
[ESC] [ESC]	Go back to “TIME DIFFERENCE”	TIME DIFFERENCE SKIP
[▲] or [▼]	Select “PULSE DOPPLER”	PULSE DOPPLER SKIP
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select “CHECK,” and press ENTER.	WEDGE S.V. 2500 m/s
[▲] or [▼]	Select “LINE SELECT NO.”	LINE SELECT NO. LINE 1-F
[ENTER] [▲] or [▼] [ENTER]	Enter select/enter mode, select “LINE 1-R,” and press ENTER.	1-R: POWER 5.24 E^4
[▲] or [▼]	Select “SUCCESS RATE” and check the data.	1-R: SUCCESS RATE 95.77%
[ESC] [ESC] [ESC]	Display the measurement.	(Measurement display screen)

6.2. Faults and remedies

6.2.1. Display error

State	Cause
 Nothing is displayed.	• Power is not turned on. • Power supply voltage is low. • Blown fuse • LCD failure ⇒ To "6.3.4. Measures against hardware failure" • Reverse polarity of DC power supply
 Left or right side appears black.	• Power supply voltage is low. • Reverse polarity of DC power supply • LCD failure ⇒ To "6.3.4. Measures against hardware failure"
 Random display	• Effect of noise from outside ⇒ Ground the grounding terminal on the flow transmitter case. • Hardware failure ⇒ To "6.3.4. Measures against hardware failure"
 Pale display	• Ambient temperature is low (less than –20°C) ⇒ Increase temperature • When temperature cannot be increased ⇒ Adjust the contrast of the LCD. • The LCD has come to the end of its service life. ⇒ Replace the LCD.
 The entire display appears black.	• Ambient temperature is high (50°C or higher) ⇒ Decrease temperature. • When temperature cannot be decreased. ⇒ Adjust the contrast of the LCD.

6.2.2. Key failure

State	Cause
Nothing happens if key entry is made.	• Hardware failure ⇒ To "6.3.4. Measures against hardware failure"
Specific keys do not respond. Keys do not operate according to definition.	

6.2.3. Measurement value error

<table>
<tr><th>State</th><th>Cause</th><th>Remedy</th></tr>
<tr><td rowspan="2">The reading appears with “–” (minus).</td><td>• Connection between main unit and sensor (Upstream sensor and downstream sensor are reversed.)</td><td>→ Connect properly</td></tr>
<tr><td>• The fluid is flowing as shown by the reading.</td><td></td></tr>
<tr><td rowspan="3">The reading fluctuates abnormally even if the flow rate is kept constant.</td><td>• The length of linear pipe section is insufficient.</td><td>→ Move the sensor to the place where the length of 10D can be assured on upstream side and 5D on downstream side.</td></tr>
<tr><td>• There is an object nearby that interferes with the flow such as a pump or valve.</td><td>→ Mount the sensor keeping the distance of at least 30D.</td></tr>
<tr><td>• The flow is actually pulsing.</td><td>→ Increase the response time by damping setting.</td></tr>
<tr><td>The reading does not change even if the flow rate changes. (Error display on LCD)</td><td colspan="2">Ultrasound waves cannot be transmitted, which causes the measurement to be held.
1. Improper installation
• Improper piping specifications
• Sensor is mounted on welded section.
• Improper sensor spacing
• Insufficient filling of silicon at the time of sensor mounting
• Improper connection of sensor cable
→ Check and remove the sensor, apply silicon filling material again, and mount the sensor in a position slightly deviated from the original position.
Improper sensor mounting
• Spacing
• The sensor is coming off the pipe.
→ • Mount the sensor, allowing sufficient sensor unit spacing, in parallel with the pipe.
• Attach the sensor firmly on the pipe.
2. Problem of piping and fluid
○ Pipe is not filled with fluid.
→ Find a place in the same piping line where the pipe is filled with fluid, and attach the sensor there.
• Mount the sensor at the place lowest in the piping line.
○ Air bubbles are mixed in.
If the reading becomes normal when the fluid is stopped, the cause is mixing in of air bubbles.
→ Prevent air bubbles from mixing in.
• Increase the level of the pump well.
• Check the sealing of pump shaft.
• Fasten the negative piping flange.
• Take measures to prevent the fluid from falling down into the pump well.
If the sensor is mounted immediately after the valve, cavitation induces the same phenomenon as mixing in of air bubbles.
Move the sensor to a place where the fluid does not contain air bubbles.
• Inlet side of the pump
• Upstream side of the valve</td></tr>
</table>

State	Cause	Remedy
	○ Turbidity is high Inflow of wastewater or turbidity higher than that of return sludge →	
	○ Pipe is old and scale is attached on inner side. →	• Move the sensor to a place in the same line where pipe diameter is shorter.
	○ Thick lining Mortar lining of thickness of several 10 mm →	• Move the sensor to other places or to different piping.
	○ Peeling of lining There is a gap between the lining and the pipe. →	
	○ Sensor is attached to flow elbow or taper tube. →	Mount it to a straight pipe.
	3. Effect of noise from outside →	• Keep the cable between the main unit and the sensor as short as possible • Ground the main unit and the piping.
	• There is a radio broadcast station nearby. • Measurement is taken near the place where traffic is heavy (cars and trains).	
	4. Hardware failure →	Refer to "6.3.4. Measures against hardware failure"
The reading does not appear as "0" even if the flow is stopped.	• Convection of fluid within pipe →	Normal
	• Zero adjustment is performed. →	• Perform zero adjustment in a state the flow is completely stopped.
	• If the flow is stopped, the fluid does not fill the pipe or the pipe becomes empty. →	Normal
The reading error is observed.	• Entered piping specifications differ from actual specifications →	Difference of internal diameter of 1% causes 3% error. • Enter properly.
	• The pipe is old and scale is attached →	• Enter scale as lining.
	• Insufficient linear pipe length (10D or more for upstream and 50D or more for downstream) →	Find another mounting place. (Mount it upstream of an object causing interference.)
		Make sure that there is no object that interferes with the flow within 30D upstream of the sensor. Make sure that no pumps, valves, or junction pipes nearby.
		• Mount the sensor in various angle against the cross-sectional area of the pipe, and find a place where average value is obtained.
	• The pipe is not filled with fluid or sediment has accumulated within the pipe. →	The smaller the cross-sectional area, the larger the sedimentation. • Move the sensor to a straight piping section.

6.2.4. Analog output error

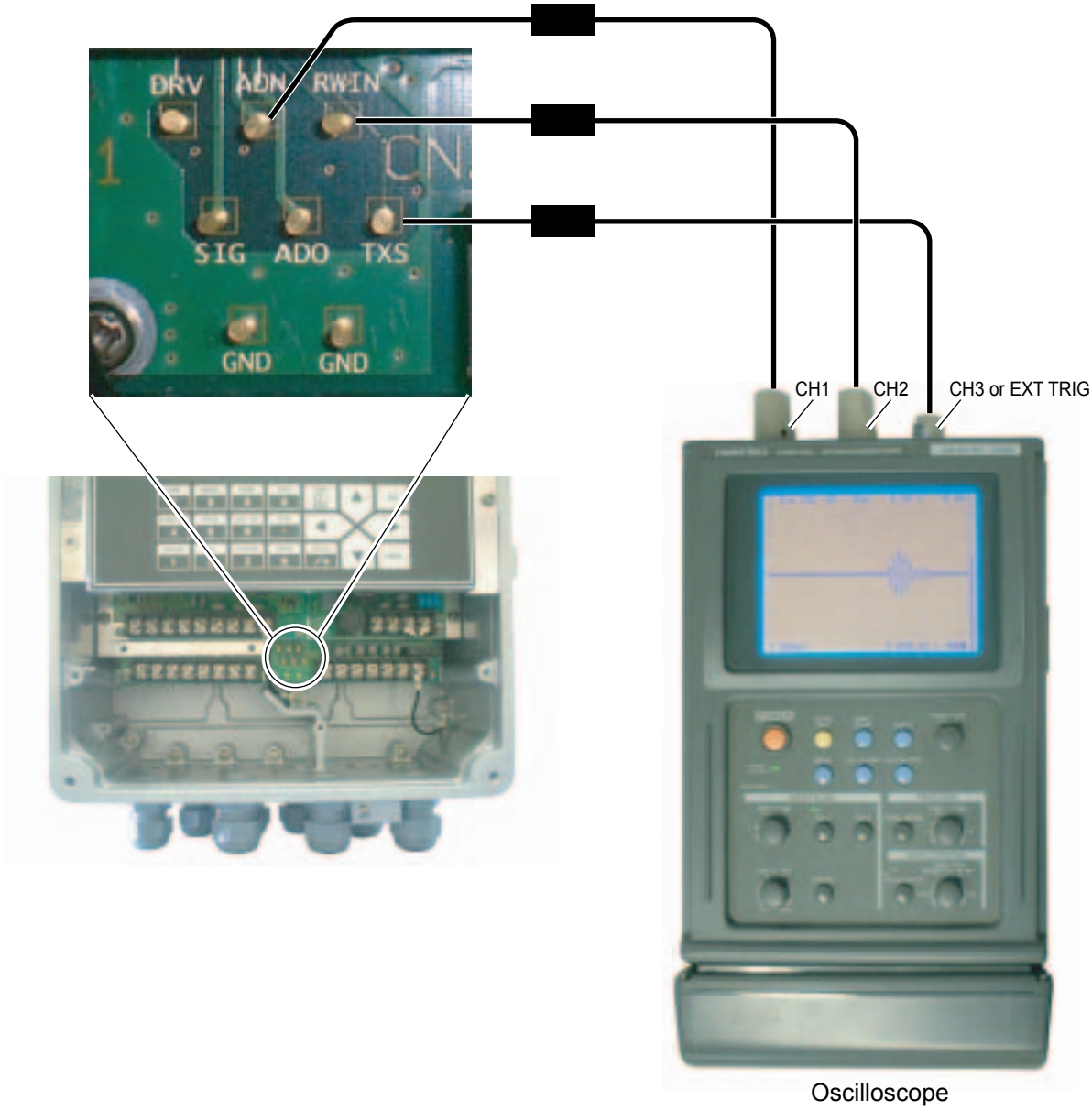
State	Cause	Remedy
Specified current output cannot be obtained.	Improper range setting	• Set the range properly.
Even if the reading is 0, the output does not become 4 mA.	Analog output calibration deviation	• Perform analog output calibration.
The output is 0 mA.	Break of the cable	
The output exceeds 20 mA	"OVER FLOW" appears on the LCD.	Range over • Set the analog output range data once again.
The output becomes lower than 4 mA.	"UNDER FLOW" appears on the LCD.	Reverse flow • Set upper/lower stream properly.
The reading changes but the analog output stays the same.	The output load is 1 kΩ or more.	• Set it to lower than 1 kΩ.
The reading and the analog output do not coincide.	Analog output calibration deviation	• Perform analog output calibration.
The output dies not change even if analog output adjustment is performed.	Hardware failure	• Contact us.

6.3. Checking received waveform

The unit has high-voltage part. Be sure to ask our service personnel for the work described below.

6.3.1. Method by oscilloscope

Open the cover, and connect an oscilloscope to the check pin on the printed board according to the following figure.
The unit has high-voltage part. Be careful not to touch the parts other than those specified below.

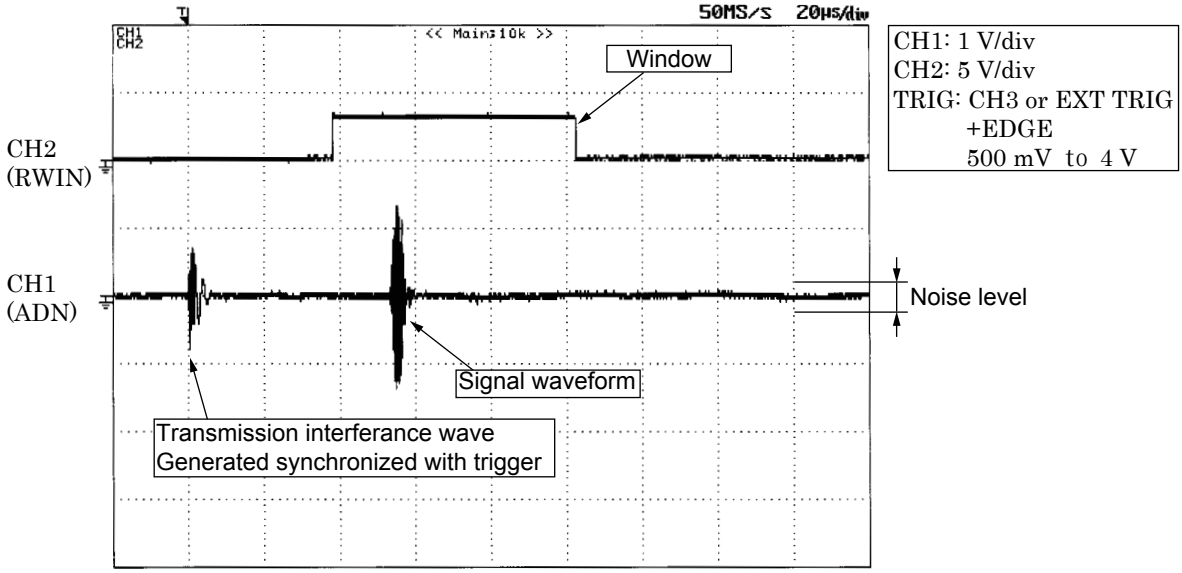


Oscilloscope

6.3.2. Checking signal waveform (TRANSIT TIME)

Monitor signals and check the state of signals.

Window and signals

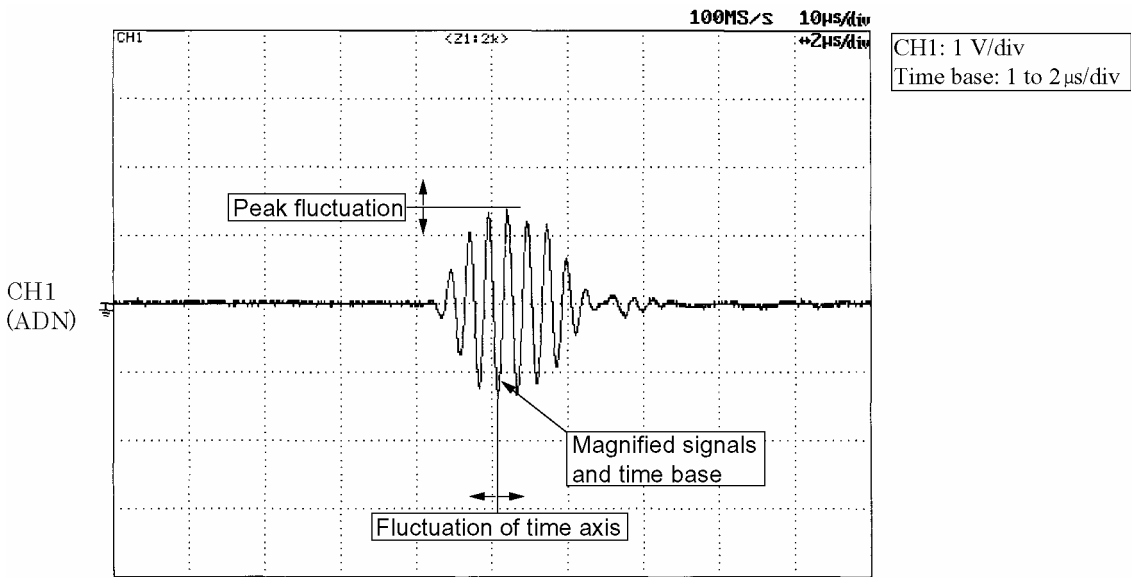


Point

1. Check that signals exist within the HIGH zone (window) of RWIN of CH2. If it is found to deviate, check piping parameters.
2. The amplitude of signals is about 2.4 Vpp.
   (1) When it is smaller than 2.4 Vpp: Receive sensitivity is low. Take measures, referring to the section that "The reading does not change even if the flow rate changes" (error display on LCD) of "6.2.3. Measurement value error.
   (2) When it is larger than 2.4 Vpp: The flow transmitter may be defective. Inform us of the details of the error.
3. Check that overall noise level is kept at 0.48 Vpp or lower. If the noise level is higher than that value, possible causes are as follows.

<Cause>	<Check>
Failure of dedicated cable	Check continuity and insulation resistance.
Reverse polarity of terminals connected	Check connection.
Detector mounting failure (degradation of S/N)	Take measures by referring to the section that "The reading does not change even if the flow rate changes" (error display on LCD) of "6.2.3. Measurement value error."
Effect of noise from outside	
Mounting surface of the detector is insecure.	Remove the detector and remount it securely.
Imperfect wiring work	Check that the dedicated signal cable runs through metal conduit tube, and that it does not run through the tube together with power cables and power lines.
Contact failure	

Magnified view of signals



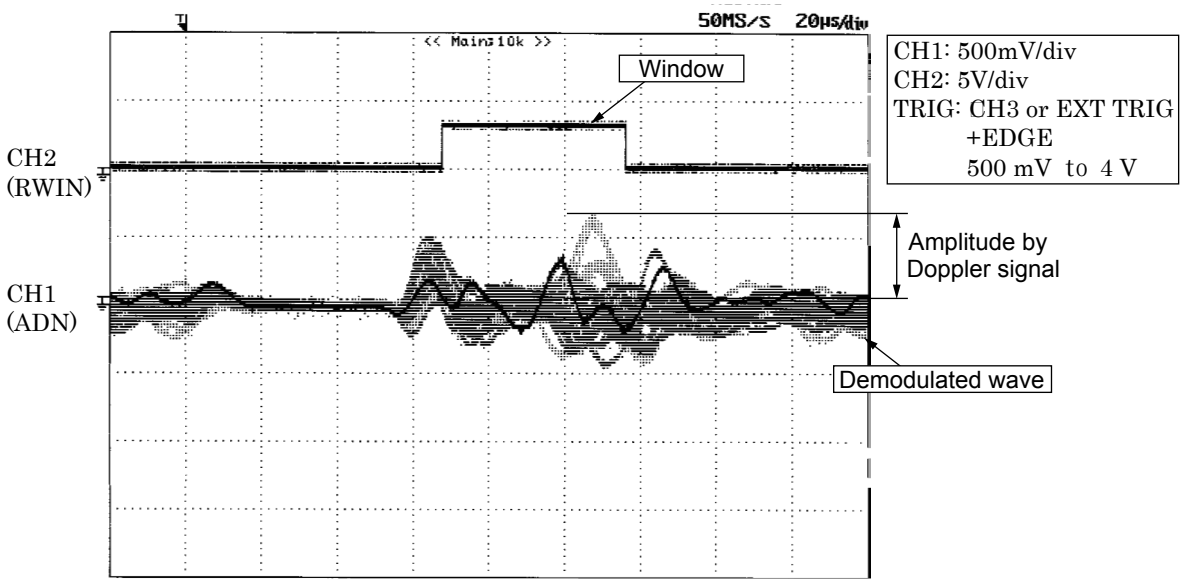
Point

1. Startup is kept within 3 to 5 waves. If startup of signals is not good, piping parameters may not be entered properly, or the mounting status of the detector may not be good. Check piping parameters and the mounting status of the detector by referring to the section that "The reading does not change even if the flow rate changes" (error display on LCD) of 6.2.3. Measurement value error.
2. The peak (amplitude) does not fluctuate. If the peak fluctuates vertically, air bubbles may be mixed in. Take measures by referring to the part of "mixing in of air bubbles" in the section that "The reading does not change even if the flow rate changes" (error display on LCD).
3. The time base does not fluctuate. If the time base fluctuates, the signals may be affected by turbulent flow or drift current. Take measures by referring to the section that "The reading fluctuates abnormally even if the flow rate is kept constant" of 6.2.3. Measurement value error.

6.3.3. Checking demodulated waves (Pulse Doppler)

Monitor the waveforms and check the state of demodulated waves.

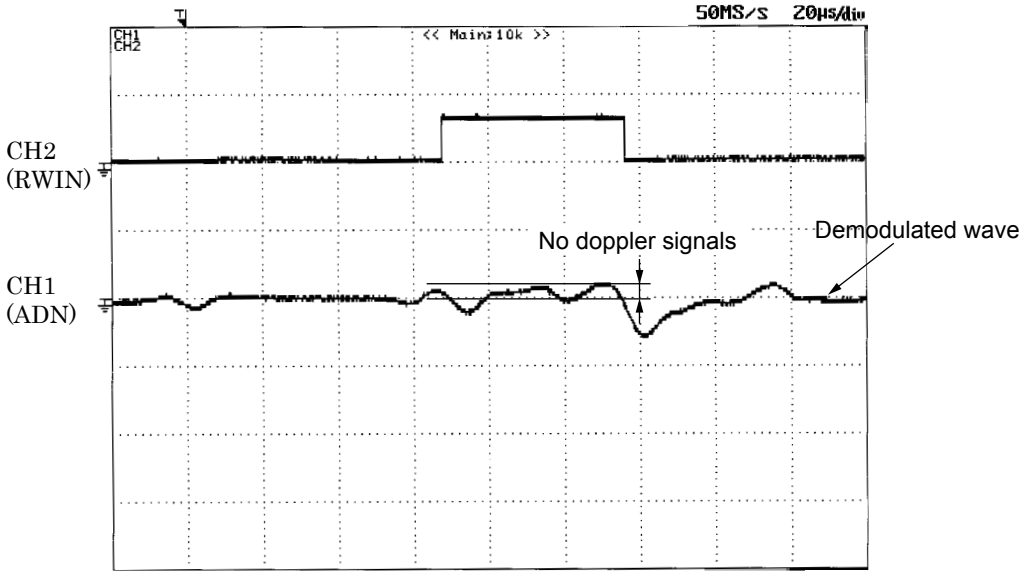
Window and demodulated wave



Point

1. The amplitude of demodulated wave (amplitude due to Doppler signals) within the HIGH zone (window) of RWN of CH2 is kept within 3.2 Vpp.
   (1) When amplitude is small: Echo sensitivity is low. See the following figure.
   (2) When amplitude is larger than 3.2 Vpp: The flow transmitter may be defective. Inform us of the details of the error.

When there are no Doppler signals



If there are no reflectors such as air bubbles and particles within the measured fluid, sufficient amount of Doppler signals cannot be obtained, resulting in measurement error.

6.3.4. Measures against hardware failure

If hardware failure is detected by performing maintenance and inspection and troubleshooting in Chapters 5 and 6, inform us of the details of the failure and the messages in RAS information.

7. PC LOADER SOFTWARE

7.1. Copyright of this software

The copyright of this software belongs to Fuji Electric Systems Co., Ltd. No part of this software may be reproduced or transmitted in any form.

7.2. Outline

Using this software, you can set, read and display relevant graphs of the hybrid ultrasonic flow meter on your PC with ease. Your data can be easily edited with Microsoft Excel because you can save your data in CSV file format.
Note: Microsoft Excel is the registered Trademark of the Microsoft Corporation in the United States.

7.3. PC to be used

7.3.1. Computer

AT compatible-type with CPU Pentium IV 1 GHz/Celeron 1 GHz or more installed, display resolution of 1024 × 768, and use of small font recommended.

7.3.2. Memory capacity

128 MB or more (256 MB or more recommended) [52 MB memory or more for free space required]

7.3.3. Interface

RS232C port or RS485 port

7.3.4. OS

Microsoft Windows2000 Professional (SP6a or more) or Microsoft WindowsXP Professional (SP1 or more)

7.4. Installing of Software

(1) Insert the setup disk into the drive, and double-click “Duosonics_ENG.msi”.

Fig. 3 <File Installation>

(2) Setting wizard will start up. Click the [Next] button. Click the [Cancel] button to cancel the installation.

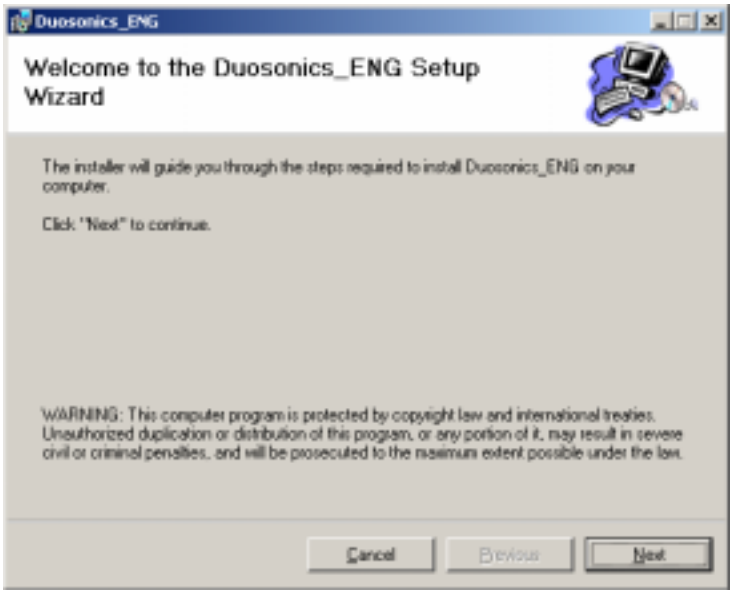


Fig. 4 <Setup wizard screen>

(3) There is a query about selection of installation folder. Click the [Next] button to install the software in that folder. To specify a folder click the [Browse] button and select, or enter directly. To return to the previous screen, click the [Previous] button. Click the [Cancel] button to cancel the installation.

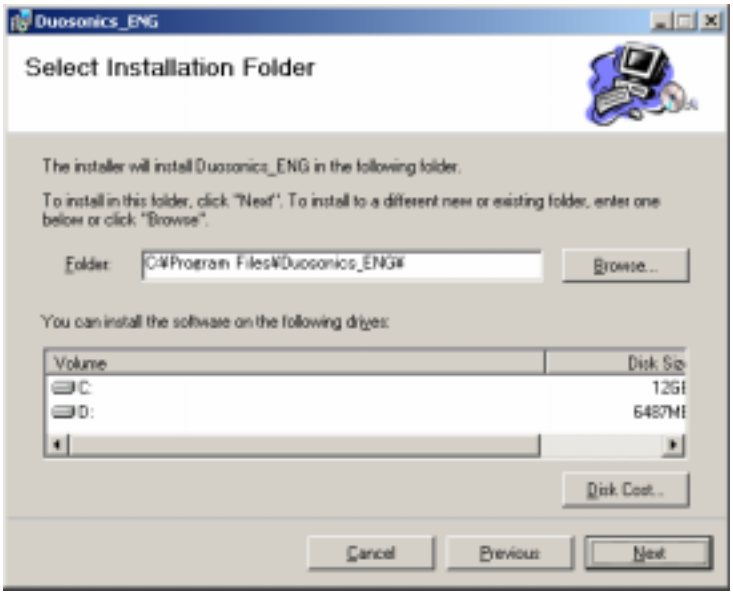


Fig. 5 <Select installation folder screen>

(4) Screen is displayed to confirm installation. Click the [Next] button to execute the installation. Click the [Previous] button to return to the previous screen. Click the [Cancel] button to cancel the installation.

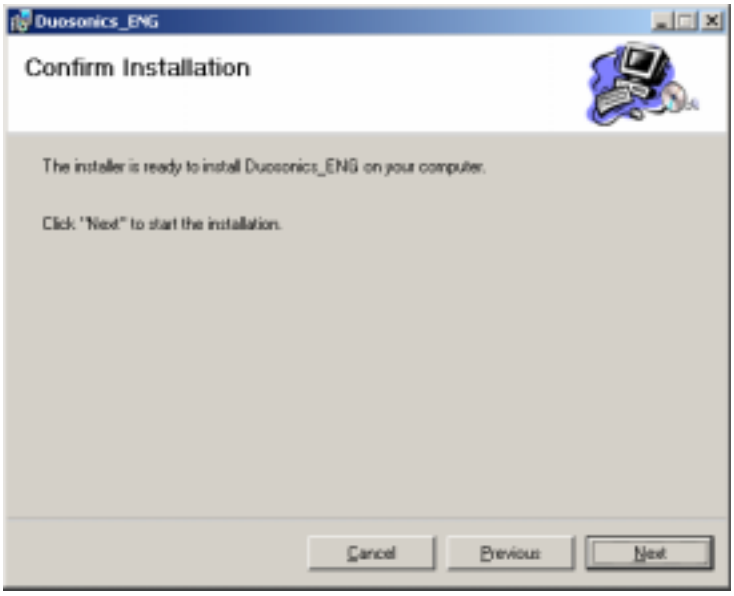


Fig. 6 <Installation confirmation screen>

(5) Execution of Installation

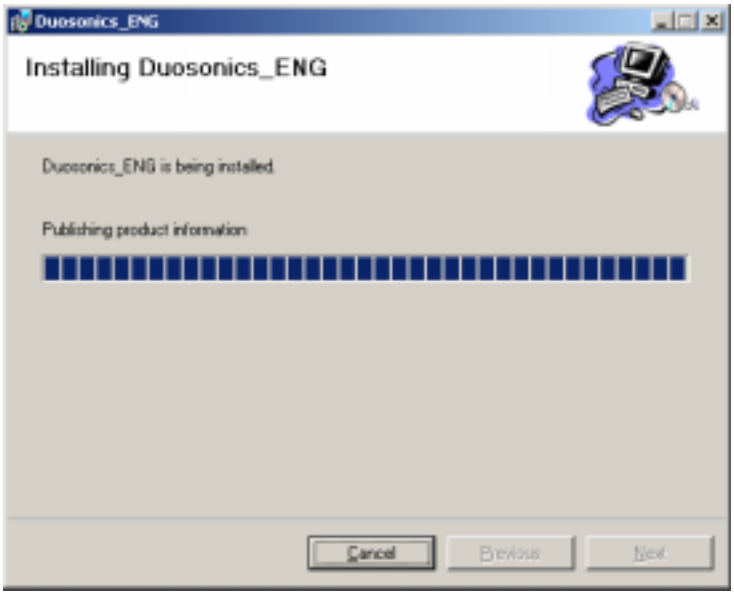


Fig. 7 <Installing screen>

(6) The Installation Complete screen is displayed. Click the [Close] button to exit the installation screen.

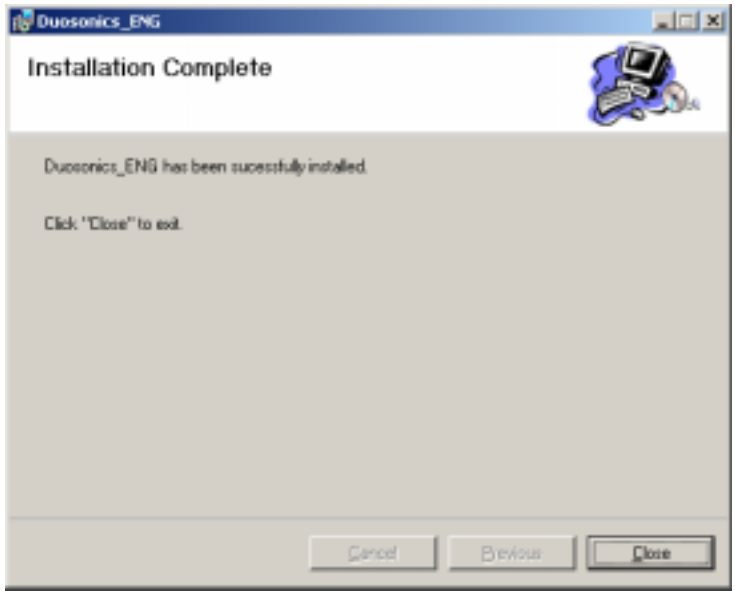


Fig. 8 <Installation complete screen>

(7) After installation, the start menu and the application ("Duosonics_ENG") that has been installed in the disktop are created.

7.5. Startup Method

Start “Duosonics_ENG” from the start menu to start up the loader.

Fig. 9 <Start screen>

Information related to system name, measuring method, language and unit can be obtained by communicating with the flow transmitter.
If error occurs during communications, an error message is displayed to continue communication, select [Continue]. To stop communication, select [Cancel] on the menu screen that appears, check the setting for “Communication.”

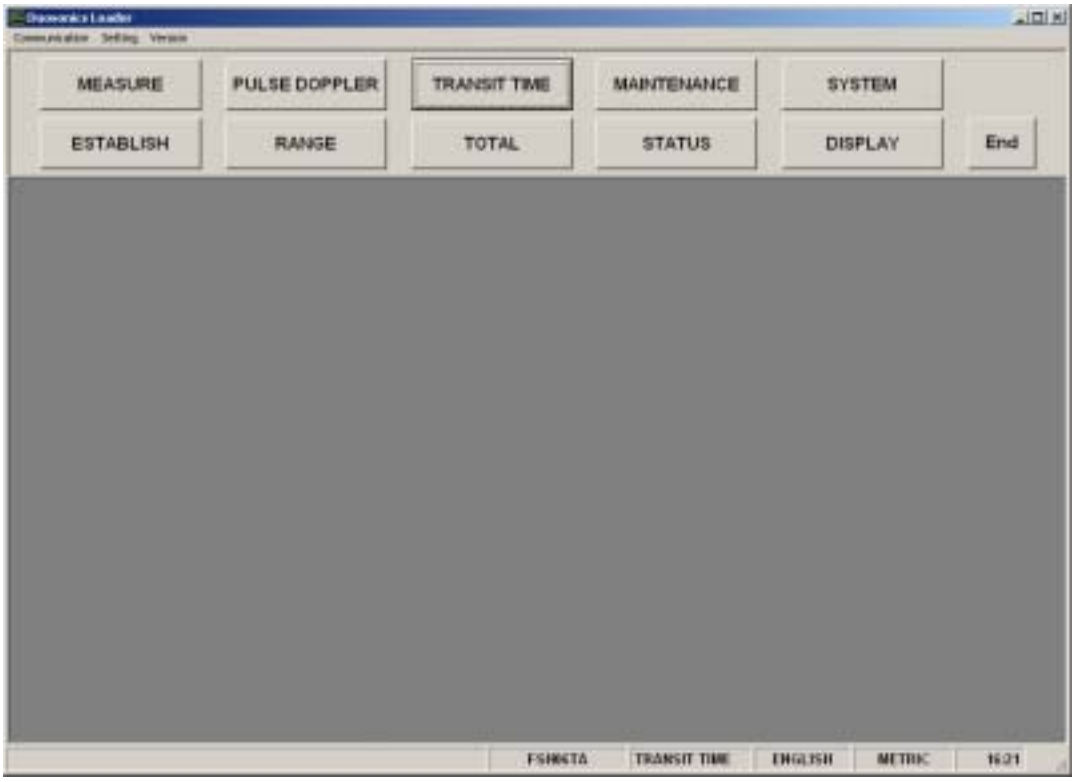


Fig. 10 <Menu screen>

Click the menu bar and each function button to execute a desired function.

7.5.1. Communications

Click “Communication” on the menu bar on the Menu screen, and the following setup screen appears.

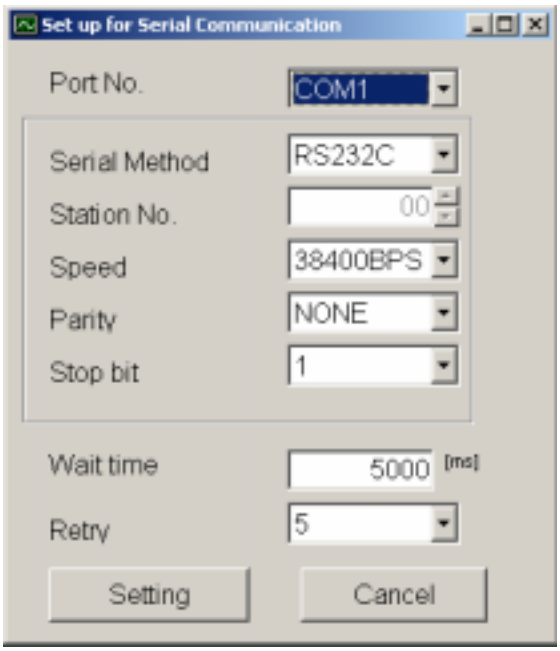


Fig. 11 <Serial communication setup screen>

Click the [Setting] button, and setting content is reflected; communications are executed with the flow transmitter and information related to system name, measurement method, language and unit is obtained. Click the [Cancel] button to invalidate the setting.

Table 2 <Measurement and Detailed Setting>

Item	Content
Port No.	Select either from COM1, COM2, COM3, COM4 and COM5.
Serial Method	Select either RS232C or RS485.
Station No.	Select one from 01 to 31. If communication method is RS232C, no selection is allowed (fixed with 00).
Speed	Select one from 9600BPS, 19200BPS and 38400BPS.
Parity	Select one from NONE, EVEN and ODD.
Stop Bit	Select either 1-bit or 2-bit.
Wait time	Specify in the range from 1 to 65535. (Unit: msec)
Retry	Specify in the range from 0 to 5.

7.5.2. Setting

Click “Setting” on the menu bar on the Menu screen, and either “Save setting” or “Read setting” can be selected.

7.5.2.1. Save setting

Click “Save setting”, and the following screen appears. Specify saving location and file name, and setting content is saved by clicking [Save] button. Click the [Cancel] button not to save the setting. File format is ini file.

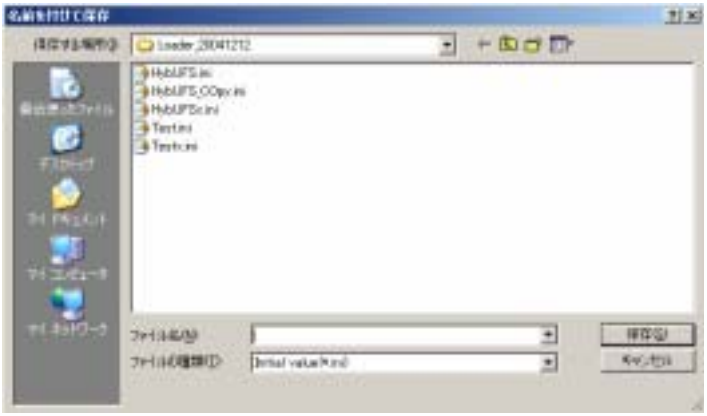


Fig. 12 <Save setting: select save file screen>

* Note: Please be careful not to rewrite the setting file for loader (Hybrid USF.ini).

7.5.2.2. Read setting

Click “Read setting”, and the following screen appears. Specify the location and the name of the file saved previously. Click the [Open] button to read the setting. Click the [Cancel] button not to read the setting. File format is ini file.

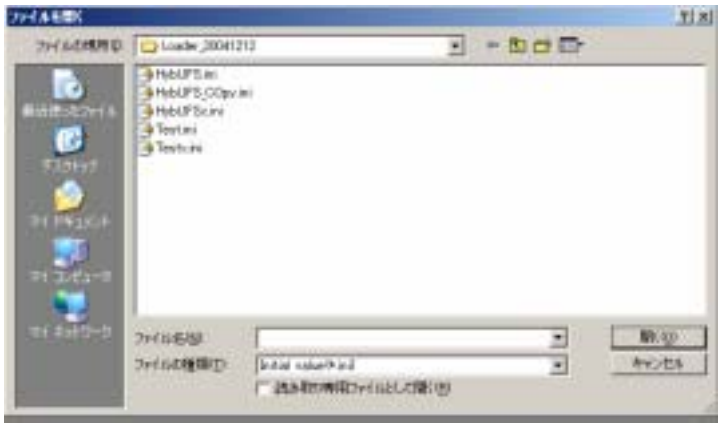


Fig. 13 <Read setting: select read file screen>

7.5.3. Version

Click “Version” on the menu bar on the Menu screen, and the following screen appears.

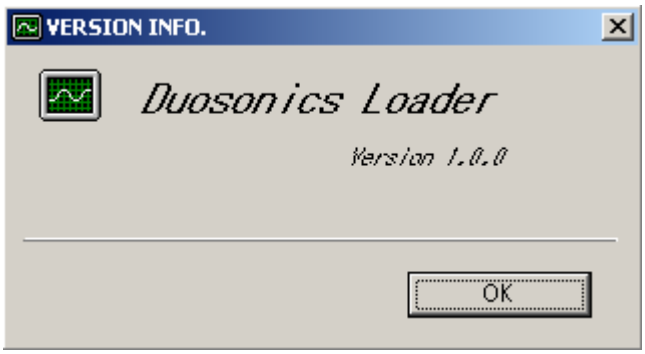


Fig. 14 <Version screen>

Click the [OK] button to close the screen.

7.6. Structure of Function

Functions with loader are as follows:

Function	Outline
ESTABLISH	Sets piping specifications, sensor type, etc.
RANGE	Sets range-related matters.
TOTAL	Sets total-related matters.
STATUS	Sets status output-related matters.
DISPLAY	Sets LCD display-related matters.
SYSTEM	Sets system related to language, etc.
MEASURE	Displays trend of flow rate, etc.
PULSE DOPPLER	Displays graphs on Pulse Doppler detailed setting and operation information and flow rate distribution, etc.
TRANSIT TIME	Displays graphs on detailed setting of transit time difference, operation information and received waveform, etc.
MAINTENANCE	Executes AO adjustment, AO and DO tests, etc.

7.7. Establish Setting

Click the “ESTABLISH” button on the Menu screen, and the following screen appears.

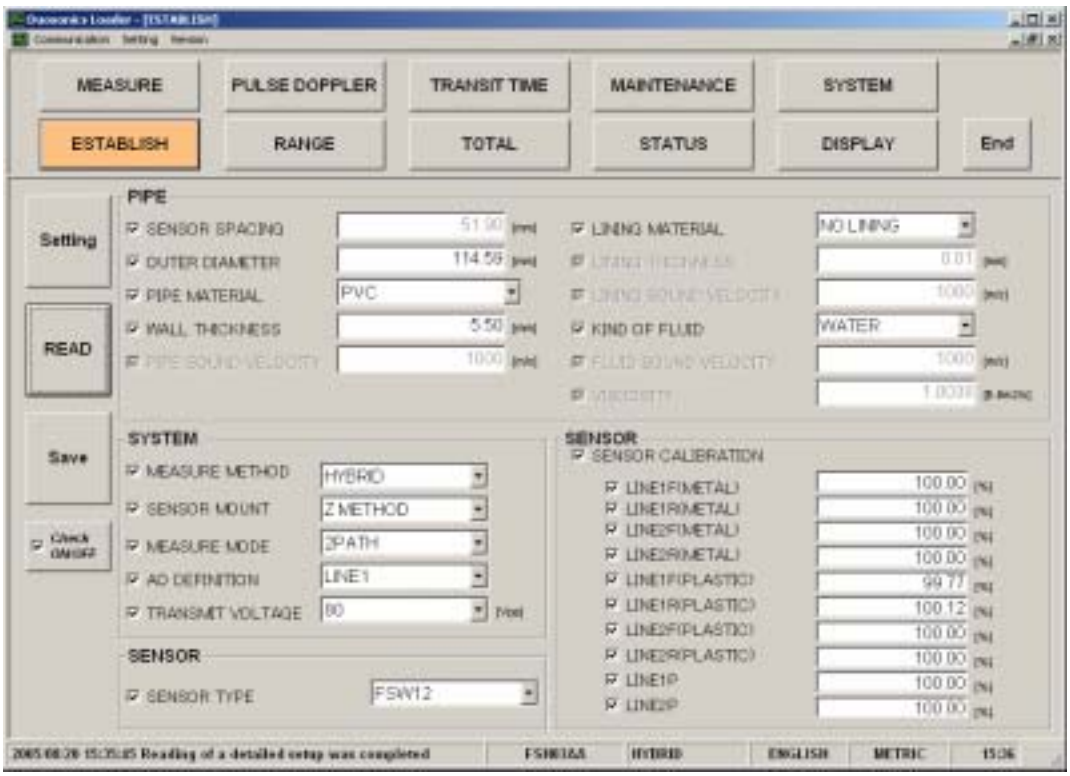


Fig. 15 <Establish setting screen>

To select an item to be set or read, set the relevant check box to ON (☑). Not to select (or to reset the selection), set the relevant check box to OFF (☐). If “Other” is selected as pipe material, pipe sound velocity becomes valid. If “Other” is selected as fluid type, fluid sound velocity and dynamic viscous coefficient become valid.

[Setting] ..... Sends the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[READ] ..... Reads the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[Save] ..... Reflects the setting sent by pressing the [Setting] button on the flow transmitter.

[Check ON/OFF] ..... Set the check box to ON to select all the items (to set all the check boxes to ON (☑)). Set the check box to OFF (☐) to release the selection of all the items (to set all the check boxes to OFF. (☐))

Table 3 <Piping Specifications>

Item	Content
OUTER DIAMETER	Enter in the range from 10.00 to 6200.00 mm.
PIPE MATERIAL	Select from carbon steel, stainless steel, PVC, Copper, Cast iron, aluminum, FRP, ductile iron, peek, PVDF, acrylic and others.
PIPE SOUND VELOCITY	Enter in the range from 1000 to 3700 m/s (if piping material is “Others”.).
WALL THICKNESS	Enter in the range from 0.10 to 100.00 mm.
LINING MATERIAL	Select from no lining, tar epoxy, mortar, rubber, Teflon, pyrex, glass, PVC and others.
LINING SOUND VELOCITY	Enter in the range from 1000 to 3700 m/s (if lining material is “Others”.).
LINING THICKNESS	Enter in the range from 0.01 to 100.00 mm (if lining material is other than “No Lining”.).
KIND OF FLUID	Select for water, seawater, dist. water, ammonia, alcohol, benzene, bromide, ethanol, glycol, kerosene, milk, methanol, toluol, lube oil, fuel oil, petrol and others.
FLUID S.V.	Enter in the range from 500 to 2500 m/s (if fluid type is “Others”).
VISCOSITY	Enter in the range from 0.0010 to 999.9999 $\times 10^{-6}$ m^2/s (if fluid type is “Others”).
SENSOR SPACING	[Read] only is valid.

Table 4 <System>

Item	Content
MEASURE METHOD	Select from hybrid and transit time.
SENSOR MOUNT	Select from Z method and V method.
MEASURE MODE	Select from 1 path and 2 paths.
AO DEFINITION	Select from average, line 1 and line 2. Line 1 only when 1 path is selected as measurement mode.
TRANSMIT VOLTAGE	Select from 20, 40, 80 and 160Vpp.

Table 5 <Sensor>

Item	Content	
SENSOR TYPE	Select from FLW11, FLW41, FLW12, FLD12, FLD22, FLW32, FLW51, FSW12, FSW21, FSW40 and FSW50.	
SENSOR CALIB.	LINE 1F (METAL)	Enter in the range from 0.00 to 300.00.
	LINE 1R (METAL)	Enter in the range from 0.00 to 300.00.
	LINE 2F (METAL)	Enter in the range from 0.00 to 300.00.
	LINE 2R (METAL)	Enter in the range from 0.00 to 300.00.
	LINE 1F (PLASTIC)	Enter in the range from 0.00 to 300.00.
	LINE 1R (PLASTIC)	Enter in the range from 0.00 to 300.00.
	LINE 2F (PLASTIC)	Enter in the range from 0.00 to 300.00.
	LINE 2F (PLASTIC)	Enter in the range from 0.00 to 300.00.
	LINE 1P	Enter in the range from 0.00 to 300.00.
	LINE 2P	Enter in the range from 0.00 to 300.00.

7.8. Range Setting

Click the “RANGE” button on the Menu screen, and the following screen appears.

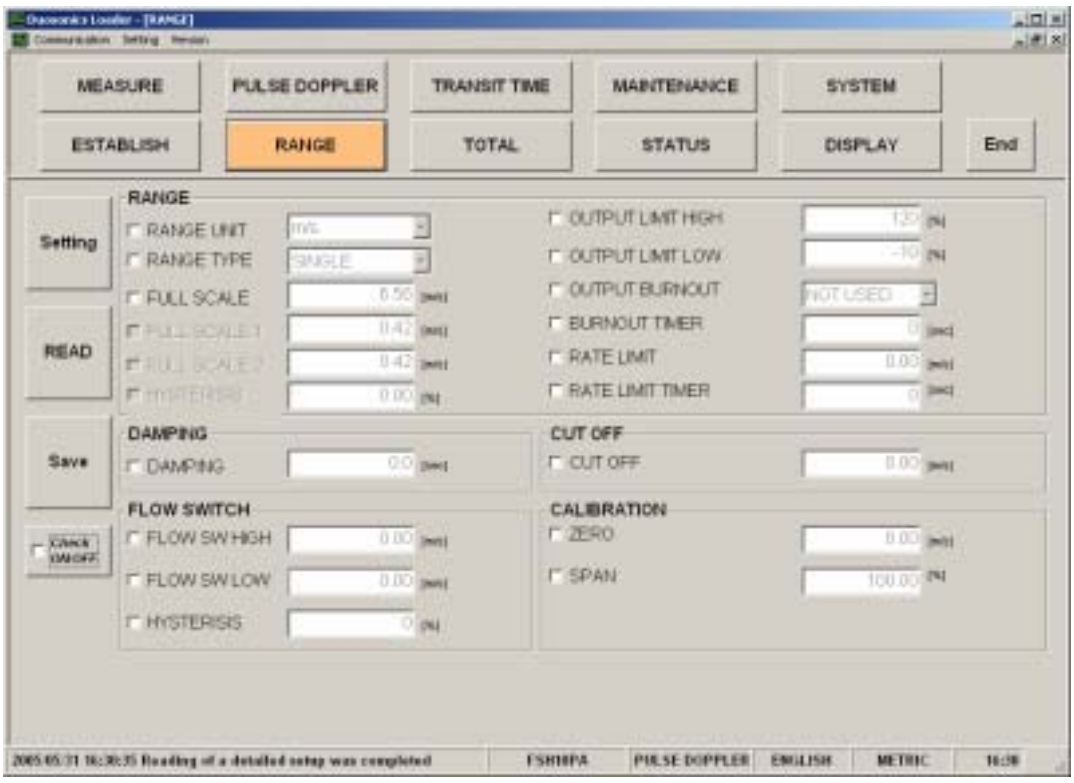


Fig. 16 <Range setting screen>

To select an item to be set or read, set the relevant check box to ON (☑). Not to select (or to reset the selection), set the relevant check box to OFF (☐).

- Type: in case of single range;
  Display Valid Full scale
  Display Invalid Full scale 1, full scale 2 and histeresis

- Type: in case of automatic 2-range, forward and reverse range, forward and reverse automatic 2-range
  Display Valid Full scale 1, full scale 2 and histeresis
  Display Invalid Full scale
  [Setting]..... Sends the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.
  [READ] ..... Reads the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.
  [Save] ..... Reflects the setting sent by pressing the [Setting] button on the flowmeter flow transmitter.
  [Check ON/OFF]..... Set the check box to ON to select all the items (to set all the check boxes to ON (☑)). Set the check box to OFF (☐) to release the selection of all the items (to set all the check boxes to OFF. (☐))

Table 6 <Range Setting>

Item	Content
RANGE UNIT	Select from m/s, L/s, L/min, L/h, L/d, kL/d, ML/d, m^3/s, m^3/min, m^3/h, m^3/d, km^3/d, Mm^3/d, BBL/s, BBL/min, BBL/h, BBL/d, kBBL/d, MBBL/d [ft/s, ft^3/s, ft^3/h, ft^3/d, kft/d, Mft^3/d, gal/s, gal/min, gal/h, gal/d, kgal/d, Mgal/d, BBL/s, BBL/min, BBL/h, BBL/d, kBBL/d, MBBL/d] * Of which [ ]: unit is in case of inch system.
RANGE TYPE	Select from SINGLE, AUTO 2, BI-DIR, BI-DIR AUTO 2.
FULL SCALE	Enter 0, ±0.3 to 32 m/s fitting value (comply with range unit).
FULL SCALE 1	Enter 0, ±0.3 to 32 m/s fitting value (comply with range unit).
FULL SCALE 2	Enter 0, ±0.3 to 32 m/s fitting value (comply with range unit).
HYSTERISIS	Enter in the range of 0 to 20%.
OUTPUT LIMIT LOW	Enter in the range of -20 to 0%.
OUTPUT LIMIT HIGH	Enter in the range of 100 to 120%.
OUTPUT BURNOUT	Select from NOT USED, HOLD, UPPER, LOWER, ZERO.
BURNOUT TIMER	Enter in the range of 0 to 900sec.
RATE LIMIT	Enter 0 to 5 m/s fitting value (comply with range unit).
RATE LIMIT TIMER	Enter in the range of 0 to 900 sec.

Table 7 <Damping>

Item	Content
DAMPING	Enter in the range of 0.0 to 100.0 sec.

Table 8 <Low Flow Rate Cut>

Item	Content
CUT OFF	Enter 0 to 5 m/s fitting value (comply with range unit).

Table 9 <High and Low Limit Switch>

Item	Content
FLOW SW LOW	Enter 0 to 32 m/s fitting value (comply with range unit).
FLOW SW HIGH	Enter 0 to 32 m/s fitting value (comply with range unit).
HYSTERESIS	Enter in the range of 0 to 20%.

Table 10 <Output Correction>

Item	Content
ZERO	Enter 0 to 5 m/s fitting value (comply with range unit).
SPAN	Enter in the range of 0 to 200%.

7.9. Total Setting

Click the “TOTAL” button on the Menu screen, and the following screen appears.

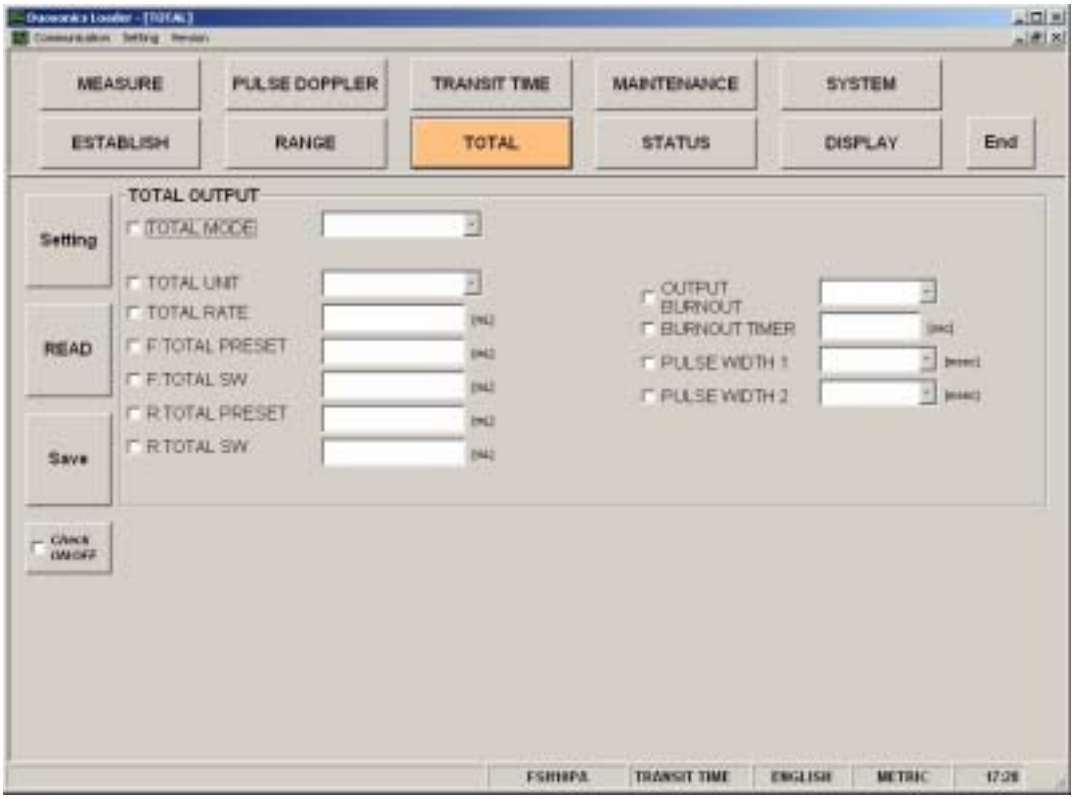


Fig. 17 <Total setting screen>

To select an item to be set or read, set the relevant check box to ON (☑). Not to select (or to reset the selection), set the relevant check box to OFF (☐).

[Setting] .....Sends the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting. Note that only when “STOP” mode is selected, the setting of other items is reflected.

[READ].....Reads the setting of the selected item (check box set to ON (☑)), reflecting the response value together with the unit on the setting.

[Save].....Reflects the setting sent by pressing the [Setting] button on the flowmeter flow transmitter.

[Check ON/OFF] .....Set the check box to ON (☑) to select all the items (to set all the check boxes to ON (☑)). Set the check box to OFF (☐) to release the selection of all the items (to set all the check boxes to OFF (☐)).

Table 11 <Total Setting>

Item	Content
TOTAL MODE	Select from TOTAL STOP, TOTAL RUN, TOTAL RESET.
TOTAL UNIT	Select from mL, L, m^3, km^3, Mm^3, mBBL, BBL and kBBL, [ft^3, kft^3, Mft^3, kgal, gal, mBBL, BBL, kBBL and ACRf] * Of which [ ]: unit is in case of inch system.
TOTAL RATE	Enter in the range of 0 to 999999.999.
F: TOTAL PRESET	Enter in the range of 0 to 9999999999.999.
F: TOTAL SW	Enter in the range of 0 to 9999999999.999.
R: TOTAL PRESET	Enter in the range of 0 to 9999999999.999.
R: TOTAL SW	Enter in the range of 0 to 9999999999.999.
OUTPUT BURNOUT	Select from NOT USED and HOLD.
BURNOUT TIMER	Enter in the range of 0 to 900 sec.
PULSE WIDTH 1	Select from 50 msec, 100 msec and 200msec.
PULSE WIDTH 2	Select from 0.5 msec, 1 msec, 2 msec, 5 msec, 10 msec, 20 msec, 50 msec, 100 msec, 200 msec.

Note) When unit is changed, each unit indication of constant, F: total preset, F: total switch, R: total preset, R: total switch are changed if [Read] is executed.

Note) When setting is changed, it should be executed with the mode stop.

7.10. Status Output Setting

Click the “STATUS” button on the Menu screen, and the following screen appears.

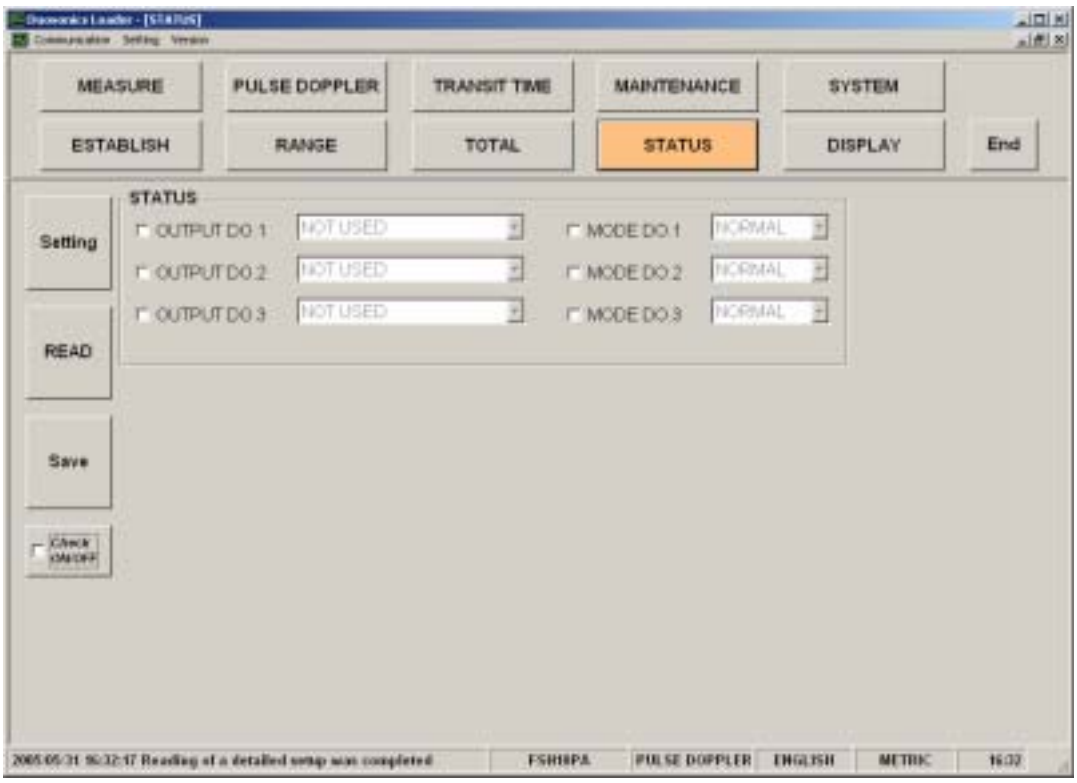


Fig. 18 <Status output setting screen>

To select an item to be set or read, set the relevant check box to ON (☑). Not to select (or to reset the selection), set the relevant check box to OFF (☐).

[Setting] ..... Sends the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[READ] ..... Reads the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[Save] ..... Reflects the setting sent by pressing the [Setting] button on the flowmeter flow transmitter.

[Check ON/OFF] ..... Set the check box to ON to select all the items (to set all the check boxes to ON (☑)). Set the check box to OFF (☐) to release the selection of all the items (to set all the check boxes to OFF. (☐))

Table 12 <Status output setting>

Item	Content
OUTPUT DO 1	Select from NOT USED, SIGNAL ERROR, F: TOTAL PULSE, R: TOTAL PULSE, F: TOTAL SW, R: TOTAL SW, F: TOTAL OVERFLOW, R: TOTAL OVERFLOW, FLOW SW HIGH, FLOW SW LOW, FULL SCALE 2, AO RANGE OVER, PULSE RANGE OVER, R: FLOW DIRECTION and DEVICE ERROR.
OUTPUT DO 2	Same as above
OUTPUT DO 3	Same as above
MODE DO 1	Select either NORMAL or REVERSE.
MODE DO 2	Same as above
MODE DO 3	Same as above

7.11. Display Setting

Click the “DISPLAY” button on the Menu screen, and the following screen appears.

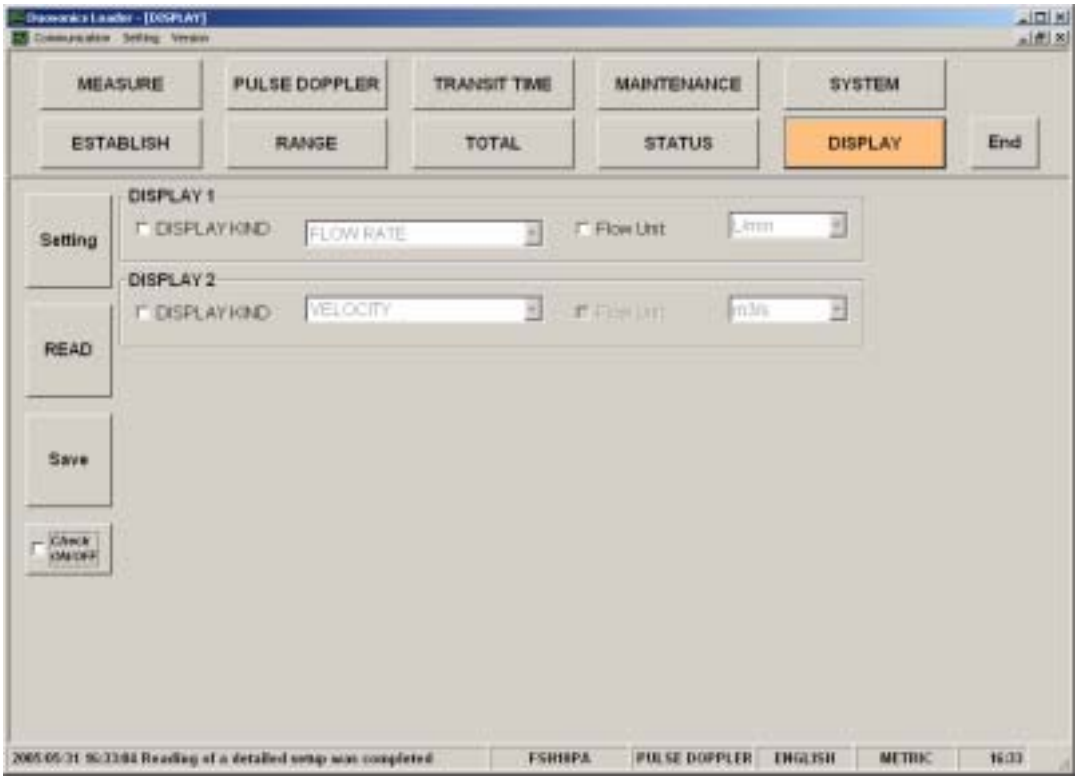


Fig. 19 <Display setting screen>

To select an item to be set or read, set the relevant check box to ON (☑). Not to select (or to reset the selection), set the relevant check box to OFF (☐). If “Flow rate” is select in the selection items, flow rate unit becomes valid.

[Setting] ..... Sends the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[READ] ..... Reads the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[Save] ..... Reflects the setting sent by pressing the [Setting] button on the flowmeter flow transmitter.

[Check ON/OFF] ..... Set the check box to ON to select all the items (to set all the check boxes to ON (☑)). Set the check box to OFF (☐) to release the selection of all the items (to set all the check boxes to OFF. (☐))

Table 13 <Display Setting>

Item		Content
DISPLAY 1	DISPLAY KIND	Select from VELOCITY, FLOW RATE, TOTAL FORWARD, TOTAL REVERSE, F: TOTAL PULSE, R: TOTAL PULSE, FLOW RATE (%).
	Flow Unit	Select from L/s, L/min, L/h, L/d, kL/d, ML/d, m^3/s, m^3/min, m^3/h, m^3/d, km^3/d, Mm^3/d, BBL/min, BBL/h, BBL/d, kBBL/d, MBBL/d [ft/s, ft^3/s, ft^3/min, ft^3/h, ft^3/d, kft^3/d Mft^3/d, gal/s, gal/min, gal/h, gal/d, kgal/d, Mgal/d, BBL/s, BBL/h, BBL/d, kBBL/d, MBBL/d] * Of which [ ]: unit is in case of inch system.
DISPLAY 2	DISPLAY KIND	Same as the selection of DISPLAY 1
	Flow Unit	Same as the unit of DISPLAY 1

7.12. System Setting

Click the “SYSTEM” button on the Menu screen, and the following screen appears.

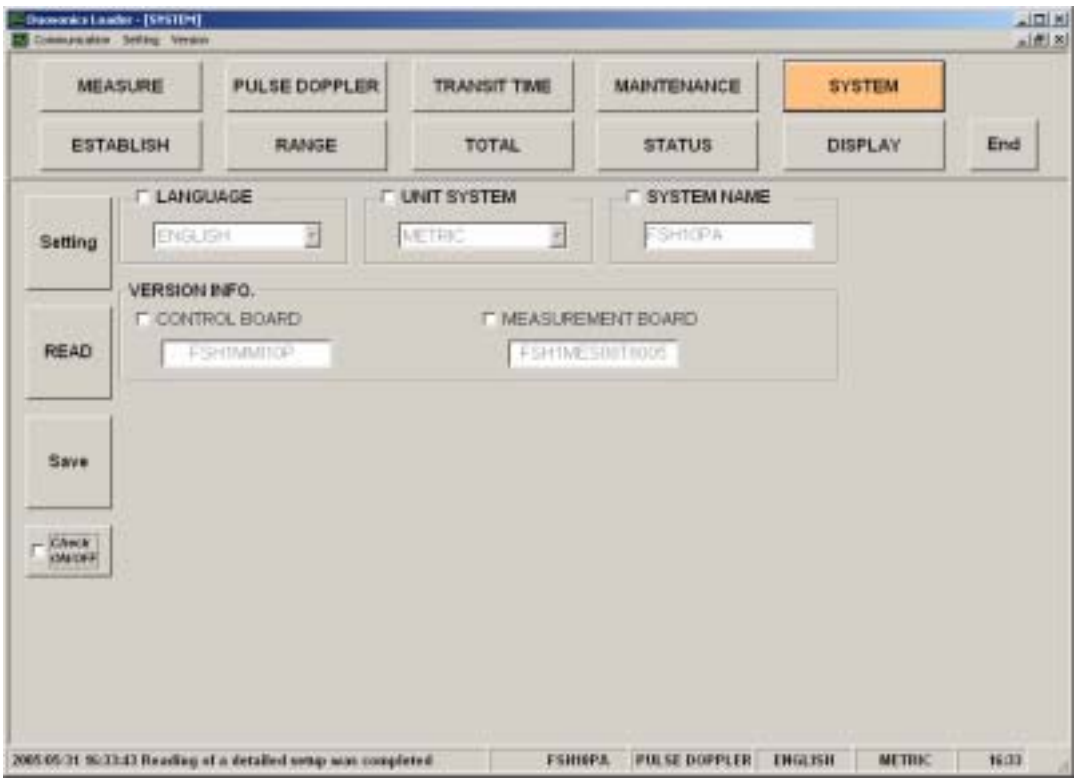


Fig. 20 <System setting screen>

To select an item to be set or read, set the relevant check box to ON (☑). Not to select (or to reset the selection), set the relevant check box to OFF (☐). However, system name and version information can only be read.
* When changing unit, restart the loader to reflect the unit change.

[Setting] ..... Sends the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.
[READ] ..... Reads the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.
[Save] ..... Reflects the setting sent by pressing the [Setting] button on the flowmeter flow transmitter.
[Check ON/OFF] ..... Set the check box to ON to select all the items (to set all the check boxes to ON (☑)). Set the check box to OFF (☐) to release the selection of all the items (to set all the check boxes to OFF. (☐))

Table 14 <System Setting>

Item		Content
LANGUAGE		Language is available in JAPANESE, ENGLISH, GERMAN, FRENCH and SPANISH.
UNIT SYSTEM		Select from METRIC and ENGLISH.
SYSTEM NAME		Read only
VERSION INFO.	CONTROL BOARD	Read only
	MEASUREMENT BOARD	Read only

7.13. Measurement

Click the “MEASURE” button on the Menu screen, and the following screen appears.

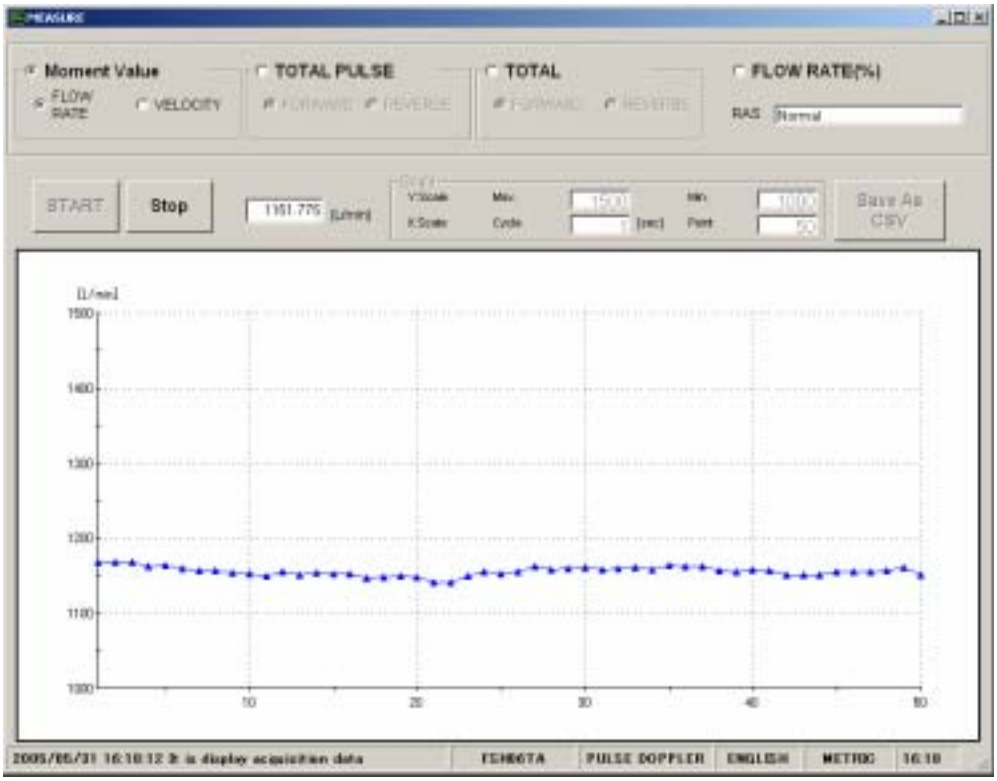


Fig. 21 <Measure screen>

Select one from instantaneous value, total pulse, total value, or flow rate % first. Next, in case of moment value, select either flow rate or flow velocity. In case of total pulse, select either normal direction or reverse direction. In case of total value, select either normal direction or reverse direction.

In case of trend, the read measurement value and RAS columns are updated in specified cycles. Also, it is displayed in trend (X axial displays collection time. The oldest is deleted and time is shifted to make the latest value to be seen when specified points are reached. The vertical axial it displays with Y scale specifed. The grid line represents Pulse Doppler in blue and transit time difference in green.

[Start]..... Starts measuring.
[Stop]..... Stops measuring.
[Save as CSV] ..... Saves the measurement result in a file in CSV format. Click the button, and you are prompted to enter the name of a file to which the data is to be saved. Specify the destination to save and enter the file name, and a CSV file is created.

Table 15 <Measurement and Detailed Setting>

Item		Content
Moment Value		Select either FLOW RATE or VELOCITY.
TOTAL PULSE		Select either FORWARD or REVERSE.
TOTAL		Select either FORWARD or REVERSE.
FLOW RATE %		-
SCALE	Y: Scale	Enter Max and Min.
	X: Scale	Enter Cycle and Point.

7.14. Pulse Doppler Measurement

Click the “PULSE DOPPLER” button on the Menu screen, and the following screen appears. Click detailed setting tab, flow speed distribution tab and/or operation information tab when necessary.
* The detailed setting tab and flow speed distribution tab are optional functions.

7.14.1. Detailed setting (optional function)

⚠ CAUTION

- Do not change the setting by yourself. Otherwise measurement may be disabled.
- Make the detailed setting only when a problem should arise in flow rate measurement with factory default settings. The setting need not be made in other cases.

Click “Detailed setting”, and the following screen appears.

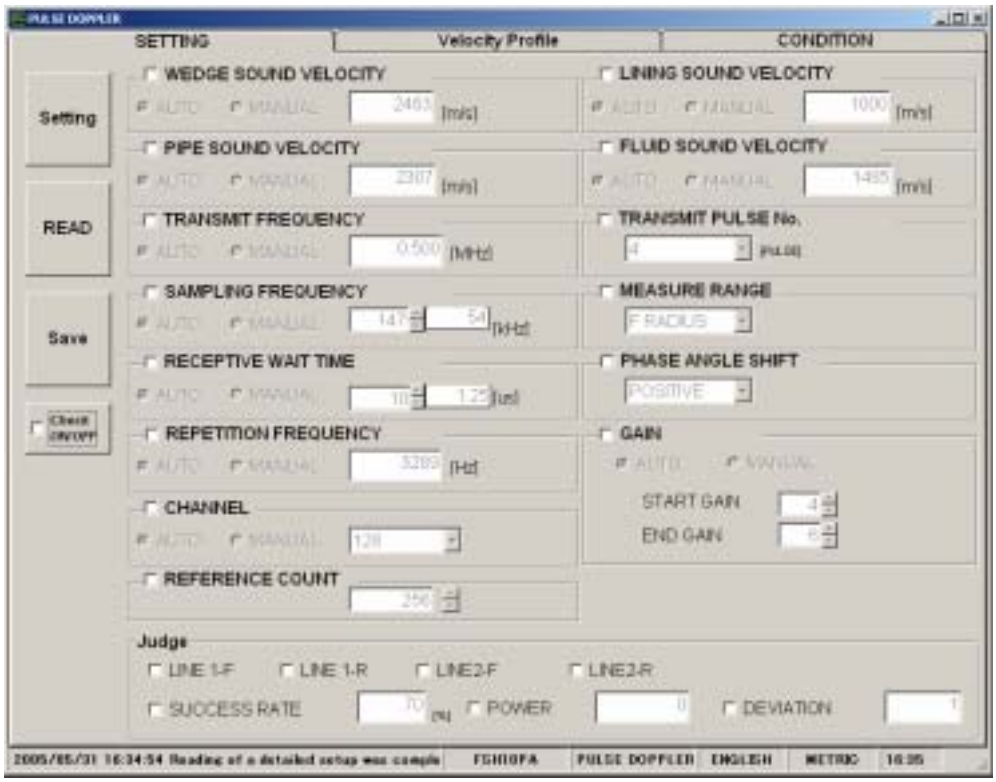


Fig. 22 <Detail setting screen>

To select an item to be set or read, set the relevant check box to ON (☑). Not to select (or to reset the selection), set the relevant check box to OFF (☐). As to judgment, it can obtain with setting success ratio set, power and deviation while setting ON with check box of setting lateral-line. However, when read it, disregard selection of multiple lateral-lines.

[Setting] ..... Sends the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[READ] ..... Reads the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[Save] ..... Reflects the setting sent by pressing the [Setting] button on the flowmeter flow transmitter.

[Check ON/OFF] ..... Set the check box to ON to select all the items (to set all the check boxes to ON (☑)). Set the check box to OFF (☐) to release the selection of all the items (to set all the check boxes to OFF. (☐))

Table 16 <Pulse and Doppler Measurement Detailed Setting>

Item	Content
WEDGE SOUND VELOCITY	With selection of AUTO/MANUAL, in case of MANUAL, input right side column in the range of numeric 1000 to 3700 m/s.
PIPE SOUND VELOCITY	With selection of AUTO/MANUAL, in case of MANUAL, input right side column in the range of numeric 1000 to 3700 m/s.
LINING SOUND VELOCITY	With selection of AUTO/MANUAL, in case of MANUAL, input right side column in the range of numeric 1000 to 3700 m/s.
FLUID SOUND VELOCITY	With selection of AUTO/MANUAL, in case of MANUAL, input right side column in the range of numeric 500 to 2500 m/s.
TRANSMIT FREQUENCY	With selection of AUTO/MANUAL, in case of MANUAL, input right side column in the range of numeric 0.1 to 5 MHz.
SAMPLING FREQUENCY	With selection of AUTO/MANUAL, in case of MANUAL, select numeric at right side column.
RECEPTIVE WAIT TIME	With selection of AUTO/MANUAL, in case of MANUAL, select numeric at right side column.
REPETITION FREQUENCY	With selection of AUTO/MANUAL, in case of MANUAL, input right side column in the range of numeric 100 to 8000 Hz.
CHANNEL	With selection of AUTO/MANUAL, in case of MANUAL, select from numeric 16, 32, 48, 64, 80, 96, 112 and 128 at right side column.
REFRENCE COUNT	Select numeric.
TRANSMIT PULSE NO.	Select from 0, 1, 2, 4, 8, 16, 32 and 64.
MEASUREMENT RANGE	Select from F RADIUS, N RADIUS and DIAMETER.
PHASE ANGLE SHIFT	Select from NORMAL 1, NORMAL 2, POSITIVE and NEGATIVE.
GAIN	With selection of AUTO/MANUAL, in case of MANUAL, select numeric 0 to 18 in each column of START GAIN/END GAIN.

Table 17 <Pulse and Doppler Measurement Judgment Setting>

Item	Content
SUCCESS RATIO	Enter in the range of 0 to 100%.
POWER	Enter in the range of 0.00 to 100.00.
DEVIATION	Enter in the range of 0.00 to 1.00.

7.14.2. Flow velocity profile (optional function)

Click “Flow Rate Distribution”, and the following screen appears.

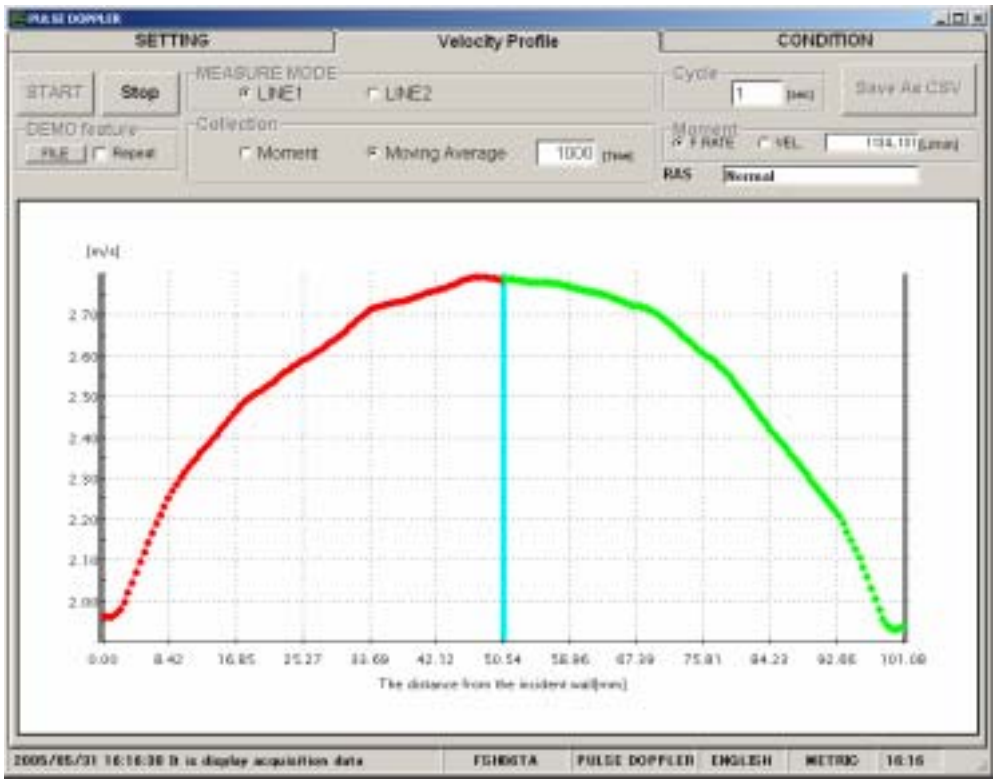


Fig. 23 <Flow Rate Distribution screen>

Select either Moment or Moving Average first and then enter the range for reading from 1 to 60 sec. If Moving-average is selected, set the number of times. Then, select either Line 1 or Line 2.
The line displays flow velocity distribution measured by upper flow side sensor in green, and flow speed distribution measured by down flow side sensor in red.

Collection

Moment.....Displays data by each read

Moving Average.....Displays data in moving average with the number of times set by channel in each read data.

Moment

Flow velocity/flow rate.....Displays flow velocity or flow rate with each read

RAS.....Displaying RAS with each read

Demonstration function ....Displays read flow velocity distribution with [Save As CSV] file
Displays repeatedly by setting check box to ON (☑)

[Start].....Starts reading in indicated cycle.

[Stop].....Stops reading.

[Save As CSV].....Saves measurement results in file with CSV format. Click the button, and you are prompted to enter the file name to which the data is to be saved.

Fig. 24 < Flow Velocity Distribution screen >

7.14.3. Operation Information

Click “Operation Information”, and the following screen appears.
* Execute this operation with Pulse doppler setting in the measurement method.

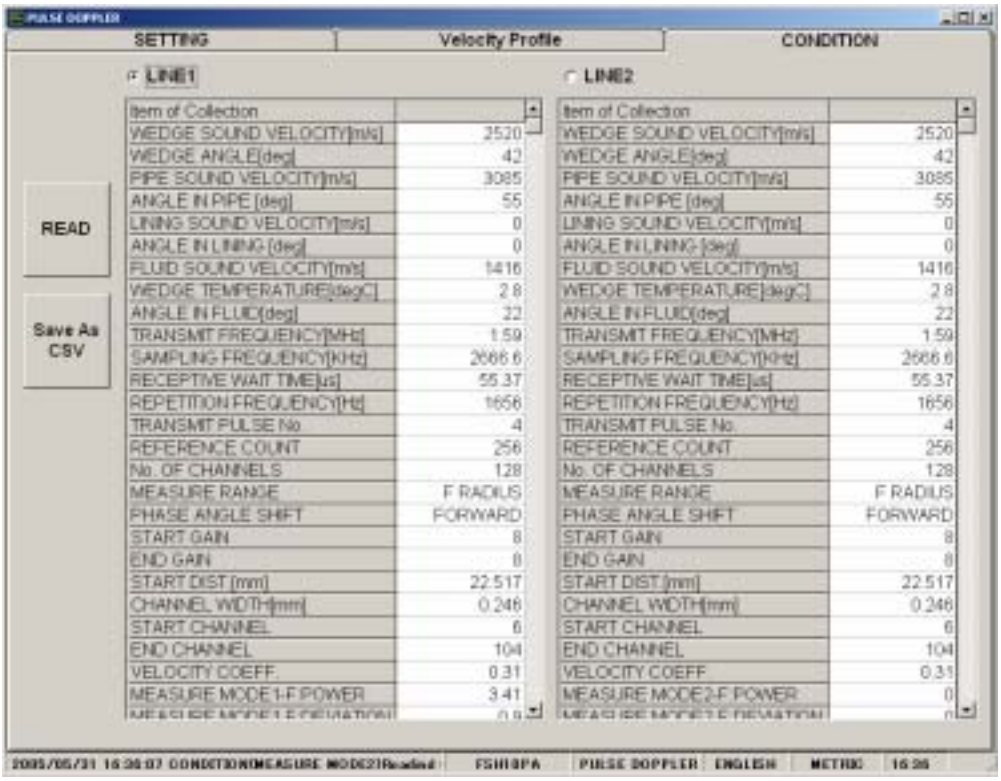


Fig. 25 <Operation Information screen>

Select either Line 1 or Line 2 first.

[READ] ..... Reads operation information in batch.
[Save As CSV]..... Saves the measurement result in a CSV format file. Click the button, and you are prompted to enter the name of a file to which the data is to be saved. Specify the destination to save and enter the file name, and a CSV file is created.

Table 18 <Operation Information>

"Y" becomes "1" with Line 1 and "2" with Line 2.

Item	Content
WEDGE SOUND VELOCITY	m/s [ft/s]
WEDGE ANGLE	°
PIPE SOUND VELOCITY	m/s [ft/s]
ANGLE IN PIPE	°
LINING SOUND VELOCITY	m/s [ft/s]
ANGLE IN LINING	°
FLUID SOUND VELOCITY	m/s [ft/s]
WEDGE TEMPERATURE	°C [°F] displaying with "–" in case of measurement abnormal
ANGLE IN FLUID	°
TRANSMIT FREQUENCY	MHz
SAMPLING FREQUENCY	kHz
RECEPTIVE WAIT TIME	μs
REPETITION FREQUENCY	Hz
TRANSMIT PULSE No.	
REFERENCE COUNT	
No. OF CHANNELS	
MEASURE RANGE	F RADIUS, N RADIUS, DIAMETER
PHASE ANGLE SHIFT	NORMAL1, POSITIVE, NEGATIVE
START GAIN	
END GAIN	
START DIST.	mm [inch]
CAHNNEL WIDTH	mm [inch]
START CHANNEL	0 to 128
END CHANNEL	0 to 128
VEROCITY COEFF.	
MEASURE MODE1-F: POWER	[10^4]
MEASURE MODE1-F: DEVIATION	
MEASURE MODE1-F: SUCCESS RATE	[%]
MEASURE MODE1-R: POWER	[10^4]
MEASURE MODE1-R: DEVIATION	
MEASURE MODE1-R: SUCCESS RATE	[%]

7.15. Transit Time Difference Measurement

Click the [TRANSIT TIME] button on the Menu screen, and the following screen appears. Click detailed setting tab, receiving waveform tab and operation information tab when necessary.
* Detailed Setting tab and Receiving Waveform tab are optional functions.

7.15.1. Detailed Setting (optional function)

⚠ CAUTION

- Do not change the setting by yourself. Otherwise measurement may be disabled.
- Make the detailed setting only when a problem should arise in flow rate measurement with factory default settings. The setting need not be made in other cases.

Click “SETTING”, and the following screen appears.

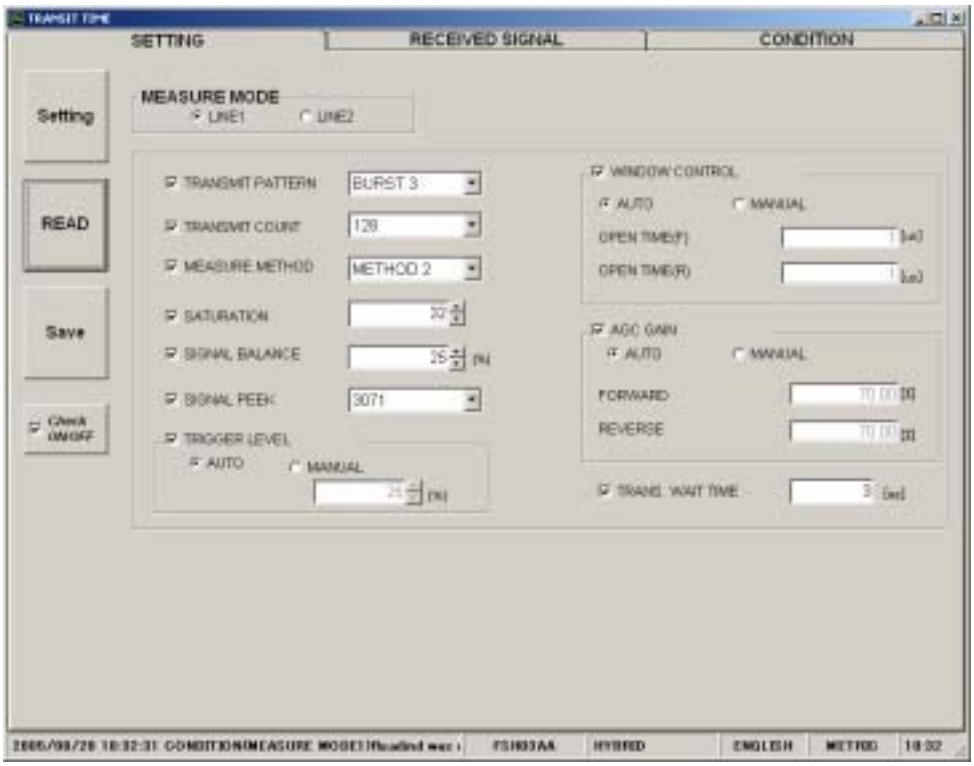


Fig. 26 <Detailed information screen>

Select either Line 1 or Line 2 first. As to selected Lateral-line, select the items to be set and read. Set the check box items to be set to (☑). Set the check box of the items not to be selected to reset the selection to OFF. (☐).

[Setting] ..... Sends the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[READ] ..... Reads the setting of the selected item (check box set to ON (☑)), reflecting the response value on the setting.

[Save] ..... Reflects the setting sent by pressing the [Setting] button on the flowmeter flow transmitter.

[Check ON/OFF] ..... Set the check box to ON to select all the items (to set all the check boxes to ON (☑)). Set the check box to OFF (☐) to release the selection of all the items (to set all the check boxes to OFF. (☐))

Table 19 <Detailed Setting>

Item	Content
TRANSMIT PATTERN	Select from BURST 1, BURST 2, BURST 3, BURST 4, BURST 5, CHIRP 4 and CHIRP 8.
TRANSMIT COUNT	Select from 8, 16, 32, 64, 128 and 256.
MEASURE METHOD	Select from METHOD 1, METHOD 2 and METHOD 3.
SATURATION	Enter in the range of numeric 0 to 256.
SIGNAL BALANCE	Enter in the range of numeric 0 to 100%.
SIGNAL PEEK	Select from 2048, 3071, 4096 and 5120.
TRIGGER LEVEL	With selection of AUTO/MANUAL, in case of MANUAL, input range of numeric 10.00 to 90.00% at right column.
WINDOW CONTROL	With selection of AUTO/MANUAL, in case of MANUAL, input range of numeric 1 to 16383 in each column of OPEN TIME (F)/OPEN TIME (R).
AGC GAIN	With selection of AUTO/MANUAL, in case of MANUAL, input range of numeric 0.00 to 100.00% in each column of FORWARD/REVERSE.
TRANS. WAIT TIME	Enter in the range of numeric 1 to 30 msec.

7.15.2. Received Signal (optional function)

Click “RECEIVED SIGNAL”, and the following screen appears.

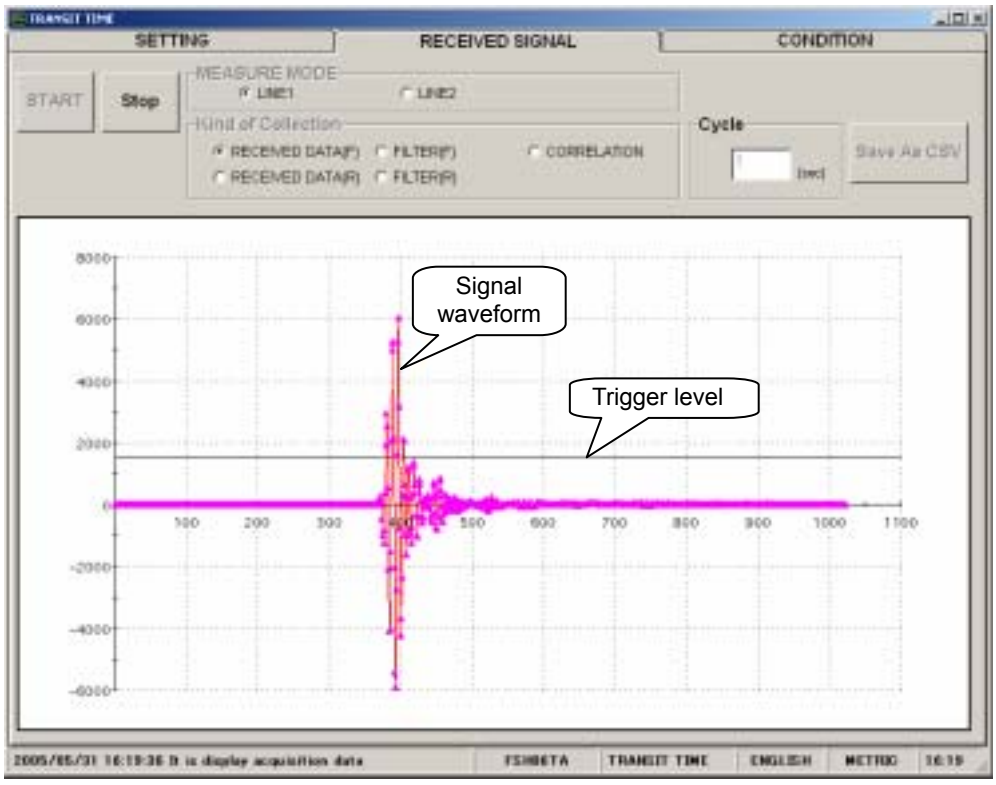


Fig. 27 <Received signal screen>

Select either Line 1 or Line 2 first. Then, select one from forward direction received wave, reverse direction received wave, forward direction filter, reverse direction filter and correlation waveform. Depending on measurement method (method 1, method 2 and method 3), items which can be selected vary as shown below. Trigger level is also displayed.

Left-click the mouse while pressing the shift key to specify the screen range, and the selected range is magnified. Press the R key to return to original status.

- Method 1: One from forward direction, reverse direction and correlation waveform can be selected.
- Method 2: One from forward direction, reverse direction, forward direction filter and reverse direction filter can be selected.
- Method 3: One from forward direction, reverse direction, forward direction filter and reverse direction filter can be selected.

[Start] ..... Starts reading in idicated cycle.
[Stop] ..... Stops reading
[Save As CSV] ..... Saves the measurement result in a file in CSV format. Click the button, and you are prompted to enter the name of a file to which the data is to be saved. Specify the destination to save and enter the file name, and a CSV file is created.

7.15.3. Operation Information

Click “CONDITION”, and the following screen appears.

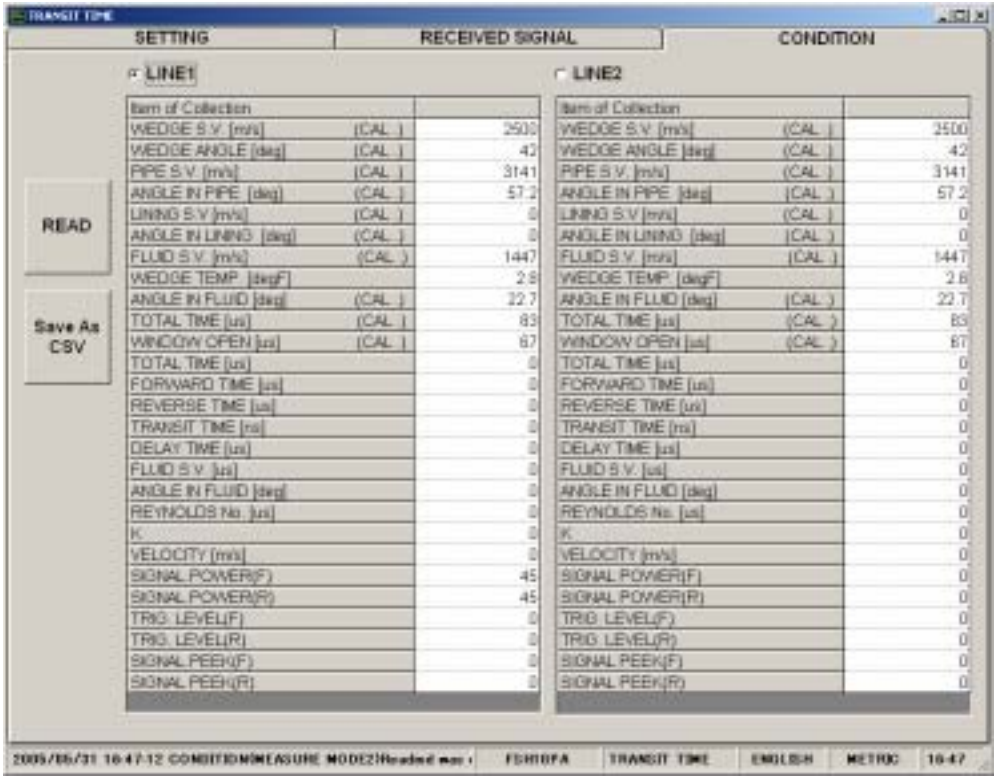


Fig. 28 <Operation Information screen>

Select either Line 1 or Lline 2 first.

[Read]..... Reads operation information in a batch.
[Save As CSV] ..... Saves Operation Information in file with CSV format. Click the button, and you are prompted to enter the name of a file to which the data is to be saved. Specify the destination to save and enter the file name, and a CSV file is created.

Table 20 <Operation Information>

Item	Content
WEDGE SOUND VELOCITY	m/s [ft/s]
WEDGE ANGLE	°
PIPE SOUND VELOCITY	m/s [ft/s]
ANGLE IN PIPE	°
LINING SOUND VELOCITY	m/s [ft/s]
ANGLE IN LINING	°
FLUID SOUND VELOCITY	m/s [ft/s]
WEDGE TEMPERATURE	°C [°F] displaying with "–" in case of measurement abnormal
ANGLE IN FLUID	°
TOTAL TIME	μs
WINDOW OPEN	μs
TOTAL TIME	μs
FORWARD TIME	μs
RESERVE TIME	μs
TRANSIT TIME	ns
DELAY TIME	μs
FLUID SOUND VELOCITY	μs
ANGLE IN FLUID	°
REINOLDS No.	μs
K	
VELOCITY	m/s [ft/s]
SIGNAL POWER (F)	
SIGNAL POWER (R)	
TRIG. LEVEL (F)	
TRIG. LEVEL (R)	
SIGNAL PEEK (F)	
SIGNAL PEEK (R)	

7.16. Maintenance

Click the “MAINTENANCE” button on the Menu screen, and the following screen appears.

Note) If [Setting] and [Read] are executed on this screen, the instrument is in the Maintenance mode for flow rate measurement. Be sure to reset the Maintenance mode of flow meter by clicking the [Release] button.

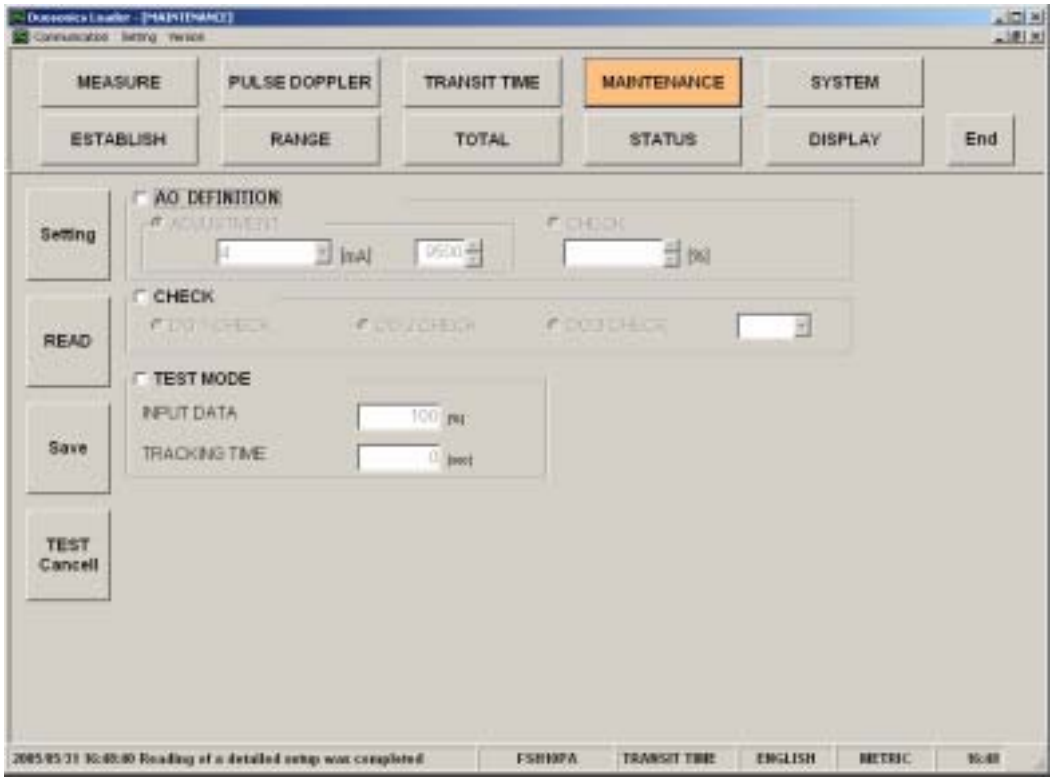


Fig. 29 <Maintenance screen>

(1) Analog output

There are two options: 4 to 20 mA adjustment and confirmation. Select one by pressing the option button.

- Adjustment
  (1) Select either “4 mA” or “”20 mA”, read current setting at right column by clicking the [READ] button once. Then, set value (1 to 65535) at right column and click the [Setting] button, and then click the [Save] button. When setting is completed, setting value is redisplayed at right column. Click the [READ] button, and selected setting values of “4 mA” and “20 mA” appear on the right column.

- Confirmation
  (2) Selecting a value in the range from -20 to 120, and click the [Setting] button, when setting is completed, and setting value is redisplayed: Click the [READ] button, and the setting value appears.

(2) DO output

Select one from the following option buttons: DO1 output confirmation, DO2 output confirmation and DO3 output confirmation.

- DO1 output confirmation
  (1) Set [DO1 Output Confirmation] check box to ON. Then select either ON or OFF from setting combo box, and click the [Setting] button to change the selected value of DO1 output. Click the [READ] button, and the setting value appears.

- DO2 output confirmation
  (2) Set [DO2 Output Confirmation] check box to ON. Then select either ON or OFF from setting combo box, and click the [Setting] button to change to the selected value of DO2 output. Click the [READ] button, and the setting value appears.

- DO3 output confirmation
  (3) Set [DO3 Output Confirmation] check box to ON. Then select either ON or OFF from setting combo box, and click the [Setting] button to change the selected value of DO3 output. Click the [READ] button, and setting value is displayed.

(3) Test mode

Set input data and tracking time and click the [Setting] button, and you can enter the test mode.
Click the [Read] button to read the values in each column of the test mode.

[Release] button ..... Resets analog output, each DO output and Test mode.
* Note: Make sure to press the [Release] button when maintenance is completed.

7.17. End

Click the [End] button on the Menu screen, and the following screen appears.

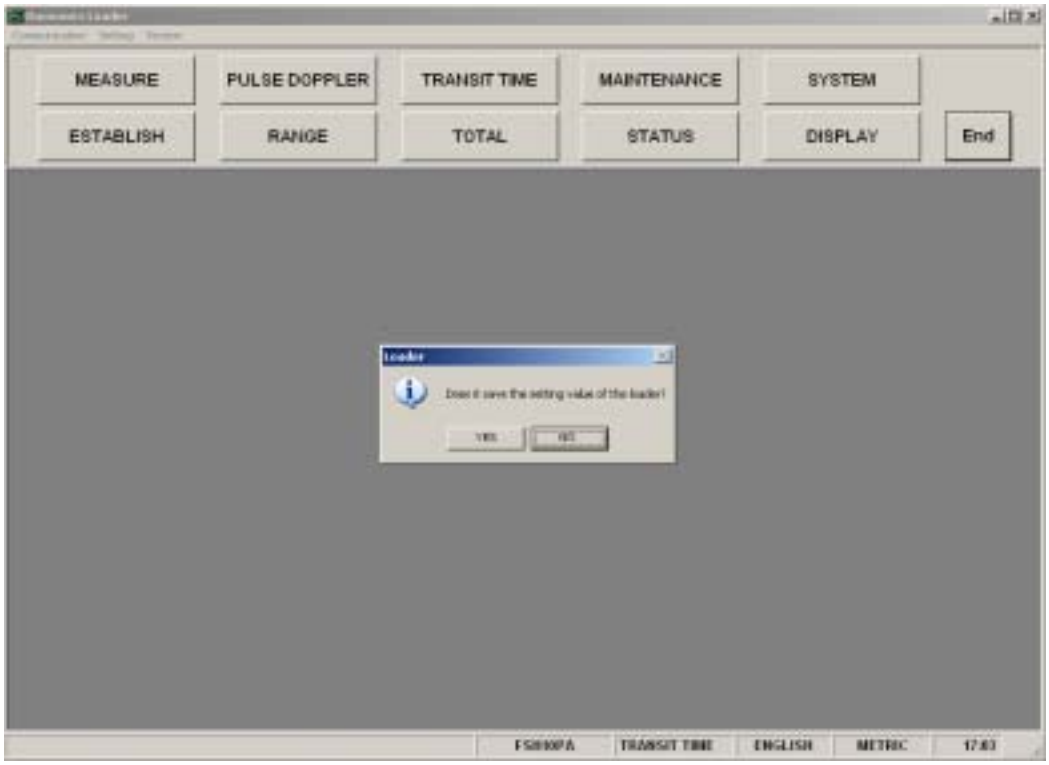


Fig. 30 <Menu screen

Click either the [End] button or the (☒) button, and a message asking you whether you want to save the loader setting appears. To save setting value, select “Yes”. On the file designation window that appears, select a file, and the setting is saved in the file. Then the loader is terminated. Not to save setting value, select “No”, and the loader is terminated without saving the setting.

7.18. Uninstalling of Software

Select “Addition and Deletion of Application” from “Control Panel” of Windows, and click [Change and Deletion] to uninstall the software.

8. APPENDIX

8.1. External communication specifications

8.1.1. Communication specifications

Item		Specifications	
Communication interface		RS-232C	RS-485
Communication distance		15 m	1 km
Communication method		Half-duplex start-stop synchronization system	
Communication procedure		Message system	
Communication speed		9600, 19200, 38400bps	
Communication mode		ASCII mode	
Data format	Start bit	1 bit	
	Data	Hexadecimal ASCII representation (8 bits)	
	Parity	None, Odd, Even	
	Stop bit	1, 2 bits	
BCC		Even horizontal parity	
Station		01 to 31	
Number of connected units		31 max./system (including other devices)	

8.1.2. Message configuration

8.1.2.1. Receiving

Configuration	Byte count	Note
Start mark	1	STX (02h)
Station No. (SLV)	2	01 to 31
Mode/type	2	Measurement “U”/Polling system “P”
Function code (F_CD)	4	Refer to the function code table.
Error check	2	BCC
End mark	1	CR (0Dh)
	1	LF (0Ah)

8.1.2.2. Response

Configuration	Byte count	Note
Start mark	1	STX (02h)
Station No. (SLV)	2	01 to 31
Mode/type	2	Measurement “U”/Polling system “P”
Function code (F_CD)	4	Refer to the function code table.
Data	#	Refer to the function code table.
Error check	2	BCC
End mark	1	CR (0Dh)
	1	LF (0Ah)

8.1.2.3. Error response

Configuration	Byte count	Note
Start mark	1	STX (02h)
Station No. (SLV)	2	01 to 31
Mode/type	2	Measurement “U”/Polling system “P”
Function code (F_CD)	4	Refer to the function code table.
Error Data (ERR)	#	Refer to the error data table
Error check	2	LRC
End mark	1	CR (0Dh)
	1	LF (0Ah)

Receive format	STX	SLV	U P	F_CD	BCC	CR	LF	
Response format	STX	SLV	U P	F_CD	Data	BCC	CR	LF
Error response format	STX	SLV	U P	F_CD	ERR	BCC	CR	LF

8.1.3. Error check

EX-OR (even horizontal parity) from STX side of each byte excluding STX, BCC, CR, and LF.
Operation is performed by bytes, and the result of operation is transmitted/received as 2-digit ASCII code BCC data.

[BCC creation procedure]
(1) EX-OR operation is performed with the data after the start mark (STX).
(2) The result of the operation is converted to ASCII representation (=BCC).
Example: When the result of operation if 05h: → ASCII representation: 30h, 35h

8.1.4. Function code table

No.	Name		F code	Response data part			
				Item		Data type (No. of bytes)	Note
1	Instantaneous value	Velocity	0000	1	Instantaneous velocity	MDV (11)	Number of decimal places: 3. m/s
				2	Measurement method	H (2)	Time difference (1), Pulse Doppler (2)
				3	Error information	H (20)	
				4	Status information	H (20)	
2		Flow rate	0001	1	Instantaneous velocity	MDV (11)	Number of decimal places: 3. When range unit is flow rate: Range unit Other cases: m/s
				2	Measurement method	H (2)	Time difference (1), Pulse Doppler (2)
				3	Error information	H (20)	
				4	Status information	H (20)	
3	Total pulse	Forward direction	0002	1	Number of forward-direction total pulse	MDV (11)	No decimal point
				2	Measurement method	H (2)	Time difference (1), Pulse Doppler (2)
				3	Error information	H (20)	
				4	Status information	H (20)	
4		Reverse direction	0003	1	Number of reverse direction total pulse	MDV (11)	No decimal point
				2	Measurement method	H (2)	Time difference (1), Pulse Doppler (2)
				3	Error information	H (20)	
				4	Status information	H (20)	
5	Total value	Forward direction	0004	1	Forward flow rate integration	MDV (15)	Number of decimal places: 3. Total unit
				2	Measurement method	H (2)	Time difference (1), Pulse Doppler (2)
				3	Error information	H (20)	
				4	Status information	H (20)	
6		Reverse direction	0005	1	Reverse flow rate integration	MDV (15)	Number of decimal places: 3. Total unit
				2	Measurement method	H (2)	Time difference (1), Pulse Doppler (2)
				3	Error information	H (20)	
				4	Status information	H (20)	
7	Flow rate %		0006	1	Flow rate %	MDV (11)	Number of decimal places: 3.
				2	Measurement method	H (2)	Time difference (1), Pulse Doppler (2)
				3	Operation range	H (2)	Single range (0), Auto 2 range (1), Bi-directional range (2), Bi-directional auto 2 range (3)
				4	Error information	H (20)	
				5	Status information	H (20)	
8	Status information		0007	1	Status information	H (20)	
9	Error information		0008	1	Error information	H (20)	

*1) Data type

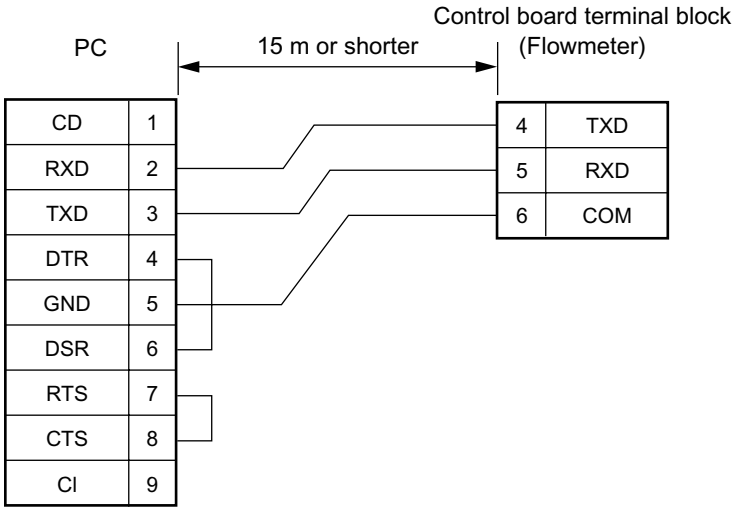
MDV: Data type that represents positive/negative numeric values with decimal point.
"+" or "–" is used as a leading character, which is followed by a numeral (ASCII), with decimal point included in between in some cases.

H: Hexadecimal (0 to 9, A to F) (ASCII) data. Decimal data in the case of numerals.

8.1.5. Error code table

Error data	Number of bytes	Note
BCC ERROR	9	BCC error: [BCC ERROR] (9 characters)
FORMAT ERROR	12	Format error: [FORMAT ERROR] (12 characters)
MANAGE ERROR	12	Management error: [MANAGE ERROR] (12 characters)
REQUEST ERROR	13	Request error: [REQUEST ERROR] (13 characters)

8.1.6. Cable connection specifications (RS-232C)



8.2. Specifications

Operational specifications

System configuration:
The system is composed of one/two detectors (Model: FSW) and one Flow transmitter (Model: FSH), realizing single-path/ two-path measurement. Hybrid mode or transit time mode is selectable. In case of hybrid mode, ether Pulse Doppler method or transit time method is automatically selected depending on conditions of measured liquid and magnitude of velocity.

Application: Uniform liquid in which ultrasonic waves can propagate.
Air bubble quantity:
Pulse Doppler method: 0.02 to 15% of volume at 1 m/s
Transit time method: 0 to 12% of volume at 1 m/s
Fluid temperature:
-40 to +100°C (FSW12)
-40 to 80°C (FSW21, FSW40, FSW50)
Type of flow:
Pulse Doppler method: Axisymmetric flow in a filled pipe.
Transit time method: Well-developed turbulent or laminar flow in a filled pipe.

Applicable flow pipe:
Material: Plastics (PVC, FRP, etc.) or Metals (carbon steel, SS, copper, aluminum, etc.)
Pipe size (Pipe internal dia.): Pulse Doppler method: 50 to 1000 mm
Transit time method: 13 to 6000 mm
Liner: Tar epoxy, mortar, etc.
Straight pipe length:
Upstream: 10D, Downstream: 5D
Refer to straight pipe conditions.
Note) The souce: JEMIS-032 (Japan Electric Measuring Instruments Manufacturers' Association standard)

Velocity:
Hybrid method: 0 to ±0.3 m/s…Maximum flow velocity (depending on pipe diameter)
Transit time method: 0 to ±0.3 … ±32 m/s

Power supply:
100 to 240 Vac + 10%/-15%, 50/60 Hz or 20 to 30 Vdc

Dedicated signal cable:
High-frequency coaxial cable and 3-wire shielded cable, up to 150m, Allowable temperature limit: 80°C
Single-path system:
2 coaxial cables + 3-wire cable for temperature sensor
2-path system:
4 coaxial cables + 3-wire cable for temperature sensor

Environment:
Non-explosive environment without direct sunlight, corrosive gas and heat radiation

Ambient temperature:
-10 to +50°C for flow transmitter, -20 to +80°C for detector

Ambient humidity:
95% RH or less for flow transmitter, 100% RH or less for detector

Grounding: Class D (less than 100 Ω)

Arrester:
Surge absorbers for outputs and power supply incorporated as standard

Performance specifications

Accuracy:
Pulse Doppler method:

Pipe size (inside diameter)	Velocity	Accuracy
ϕ50 mm to ϕ100 mm (Detector FSWS12)	1.5 m/s to Maximum flow velocity	±0.5% of rate
	0 m/s to 1 .5 m/s	±0.0075m/s
100 mm to ϕ1000 mm (Detector: FSWS21 40, 50)	1 m/s to Maximum flow velocity	±1.0% of rate
	0 m/s to 1 m/s	±0.01 m/s

Transit time method:

Pipe size (inside diameter)	Velocity	Accuracy
ϕ50 mm to ϕ300 mm or less	2 to 32 m/s	±1.0% of rate
	0 to 2 m/s	±0.02 m/s
ϕ300 mm to ϕ6000 mm	1 to 32 m/s	±1.0% of rate
	0 to 1 m/s	± 0.01 m/s

Response time:
Pulse Doppler method:
0.2 sec (depending on pipe measurement condition)
Transit time method: 0.5 sec

Power consumption: 20 W or less

Short-term thermal stability:
140°C, 30 min (FSWS12),
100°C, 30 min (FSWS21, FSWS40, FSWS50)

Functional specifications

Analog output:
4 to 20 mAdc (1 point)
Max. load resistance: 1 kΩ

Digital output:
+total, -total, alarm, acting range, flow switch or total switch -- arbitrarily selectable
Mechanical relay contact:
1 point with socket (replaceable)
Normally: Closed/open selectable
Capacity: 240 Vac/30 Vdc, 1 A
Total pulse: less than 1 p/s (Pulse width: 50, 100 or 200 ms selectable)
Transistor open collector: 2 points
Capacity: 30 Vdc, 0.1 A
Normally off/on selectable
Total pulse: less than 1000 p/s (Pulse width: 0.5, 1, 2, 5, 10, 20, 50, 100 or 200 ms selectable)

Communication interface:
RS-232C equivalent / RS-485 (selectable)
Number of connectable units: one (RS-232C)/up to 31 (RS-485)
Baud rate: 9600/19200/38400 bps selectable
Parity: none/odd/even selectable
Stop bit: 1 or 2 bits selectable
Distance: up to 15 m (RS-232C)/up to 1 km (RS-485)
Data: Velocity, flow rate, +total, -total, status, velocity profile (option)

Display device:
Graphic LCD (number of pixels: 240 × 64) with back light,

Display language:
Japanese, English, French, German or Spanish selectable

Velocity/flow rate display:
Instantaneous velocity, instantaneous flow rate display (The flow in reverse direction is displayed with minus "–.")
Data: Up to 10 digits (decimal point to be counted as 1 digit)
Unit: Metric/British system selectable

	Metric system	British system
Velocity	m/s	ft/s
Flow rate	L/s, L/min, L/h, L/d, kL/d, ML/d, m^3/s, m^3/min, m^3/h, m^3/d, km^3/d, Mm^3/d, BBL/s, BBL/min, BBL/h, kBBL/d, MBBL/d	ft^3/s, ft^3/min, ft^3/h, Mft^3/d, gal/s, gal/mm, gal/h, Mgal/d, BBL/s, BBL/min, BBL/h, BBL/d, kBBL/d, MBBL/d

Note: "gal" means US gal.

Total display: Display of forward or reverse total (The total in reverse direction is displayed with minus "–.")
Data: up to 10 digits (decimal point to be counted as 1 digit)
Unit: Metric/British system selectable

	Metric system	British system
Total	mL, L, m^3, km^3. Mm^3, mBBL, BBL, kBBL	ft^3, kft^3, Mft^3, gal, kgal, mBBL, BBL, kBBL, ACRf

Setting function: Settable with 20-point setting key

Zero adjustment: Set zero/Clear available. (transit time method)

Damping:
0 to l00 s (every 0.1 s) configurable for analog output and display

Low flow cut off: 0 to 5 m/s configurable

Alarm: Hardware fault/process fault can be tied to digital output

Burnout:
Analog output: Hold/Upper limit/Lower liinit/Zero/Not-used selectable
Total: Hold/Count selectable
Timer: 0 to 900 s (every 1 s) configurable

Bi-directional range:
Forward and reverse ranges configurable independently
Hysteresis: 0 to 20% of working range configurable
Working range applicable to digital output

Auto-2 ranges:
Forward 2 ranges configurable independently
Hysteresis: 0 to 20% of working range configurable
Working range applicable to digital output

Flow switch:
Lower and upper switching points configurable independently
Acting point applicable to digital output

Total switch:
+total switching point configurable
Acting point applicable to digital output

Physical specifications

Enclosure protection:
Flow Transmitter: IP67 (Water-tight type)
Detector: IP67 (Water-tight type)

Mounting:
Flow Transmitter: wall mount
Detector: Clamped on pipe surface

Acoustic coupler: Silicon compound (silicone grease or RTV)

Material:
Flow Transmitter: aluminum alloy
Detector: PBT for housing, aluminum alloy for frame and SS for fastening belt

Sensor cable (FLY6):
RF coaxial cable (double shielded)
External sheath: Black flame-resistant vinyl
External diameter: About 7.3 mm
Terminal treatment: Water-resistant BNC connector (detector side), M3.5 amplifier terminal (flow transmitter side)
Mass: About 90 g/m

Temperature sensor cable (FLY7):
3-core shield cable
External sheath: Gray flame-resistant vinyl
External diameter: About 6.9 mm
Terminal treatment: Round waterproof connector (detector side), M3.5 amplifier terminal (flow transmitter side)
Mass: About 56 g/m

Dimensions:
Flow Transmitter: H240 × W247 × Dl34 mm (FSH)
Detector:
H70 × W57 × D360 mm (FSWS12)
H72 × W57 × D540 mm (FSWS21)
H90 × W85 × D640 mm (FSWS40)
H82 × W71 × D258 mm (FSWS50)

Mass:
Flow Transmitter: 5 kg
Detector: 1.7 kg (FSWSl2), 1.9 kg (FSWS2l), 5 kg (FSWS40), 1.5 kg (FSWS50)

Support software

Loader software for PC
Equipped as standard.
Supported model: PC/AT-compatible model
The operation on PC98 series (NEC) cannot be guaranteed.
The operation on self-made PCs and shop-brand PCs cannot be guaranteed.
Major functions:
Makes various parameter settings/changes of the main unit.
The following functions cannot be used if "without flow velocity profile" is selected.
"Detailed setting" and "flow velocity profile display" of pulse Doppler measurement
"Detailed setting" and "signal waveform display" of time difference measurement
O/S: Windows 2000/XP
Memory: 128 MB or more
Disk device: Windows 2000/XP-capable CD-ROM drive
Hard disk capacity: Free space of 52MB or more

Note: PC loader communication cable (type ZZP*B TK4H6253) is separately required.

Detector frame mounting jig

A mounting jig is provided to facilitate positioning of the frame on the pipe.
Select from the following types according to the detector used.

Type	Applicable detector
ZZP*TK7M7071C1	FSWS12
ZZP*TK7M7071C2	FSWS21
ZZP*TK7M7071C3	FSWS40

Note: The mounting jig cannot be used for the detector FSWS50, which does not have a frame.

Masimum measurement range in hybrid mode
When the piping material is stainless steel, nominal wall thickness is Sch20s, and the fluid is water

<Maximum measurable flow velocity> Unit: m/s

Diameter	FSW12	FSW21	FSW40	FSW50
50A	6.04			
65A	4.99			
80A	4.40			
90A	3.92			
100A	3.54	6.95		
125A		5.86		
150A		5.04		
200A		3.96	7.59	
250A			6.26	
300A			5.32	
350A			4.82	
400A			4.25	
450A			3.80	
500A			3.45	3.45
550A				3.14
600A				2.89
650A				2.69
700A				2.50
750A				2.34
800A				2.19
850A				2.07
900A				1.95
1000A				1.76

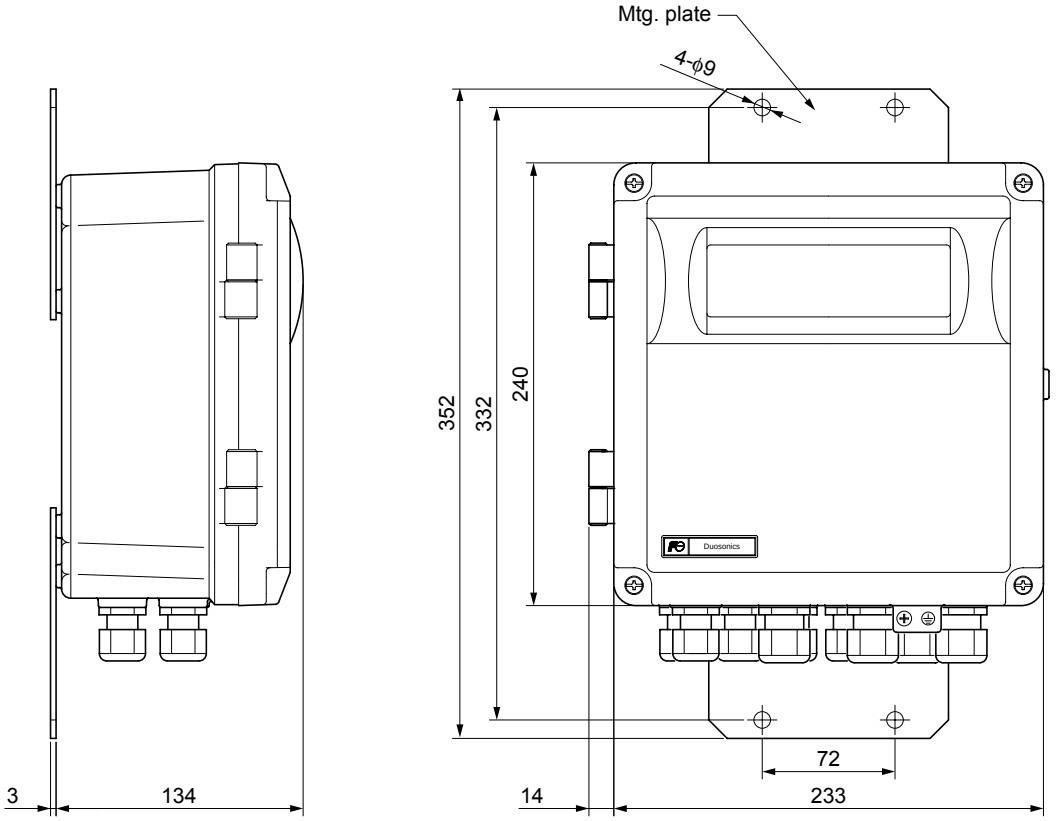
<Maximum measurable flow rate> Unit: m^3/h

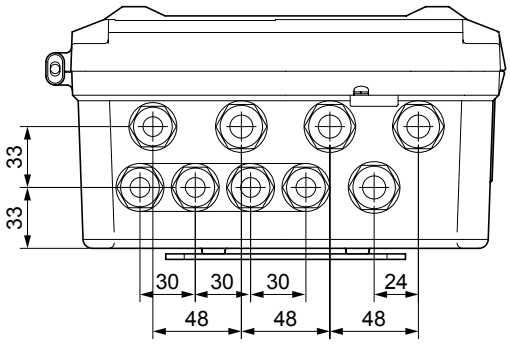
FSW12	FSW21	FSW40	FSW50
48.5			
67.8			
81.8			
97.1			
110.2	222.0		
	279.2		
	343.2		
	462.8	887	
		1146	
		1404	
		1572	
		1831	
		2091	
		2393	2393
			2587
			2850
			3067
			3325
			3590
			3839
			4112
			4357
			4852

8.3. Outline diagram

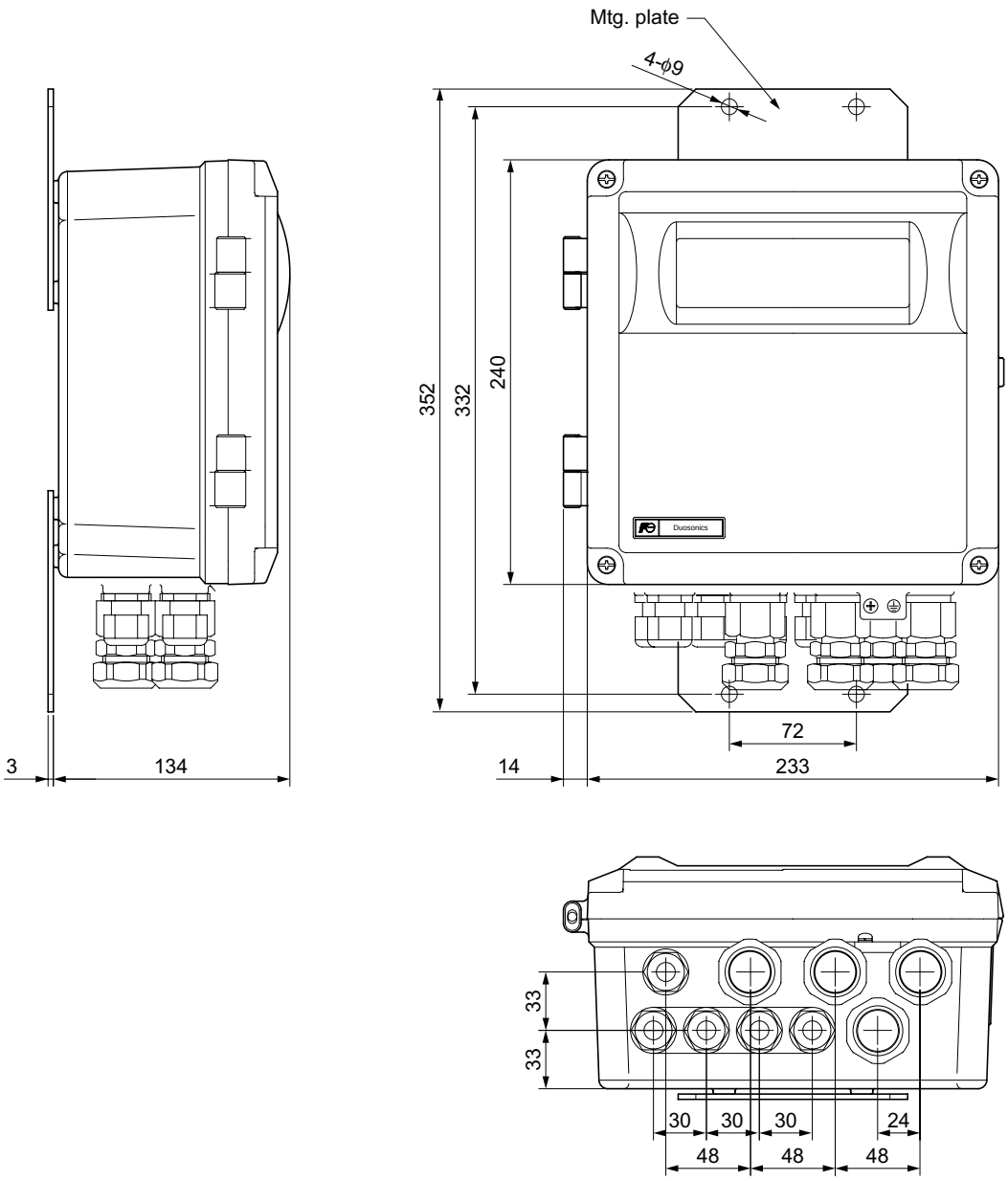
Flow transmitter (Type: FSH)

<With waterproof gland>

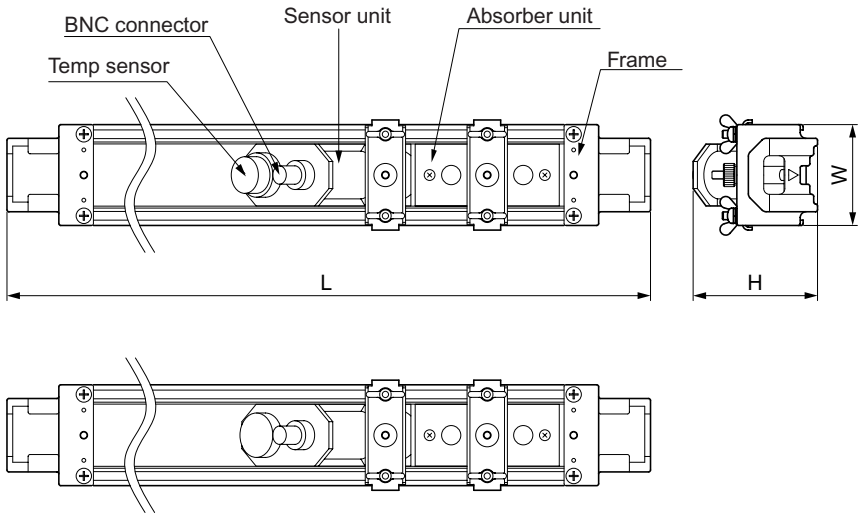




<With union gland>

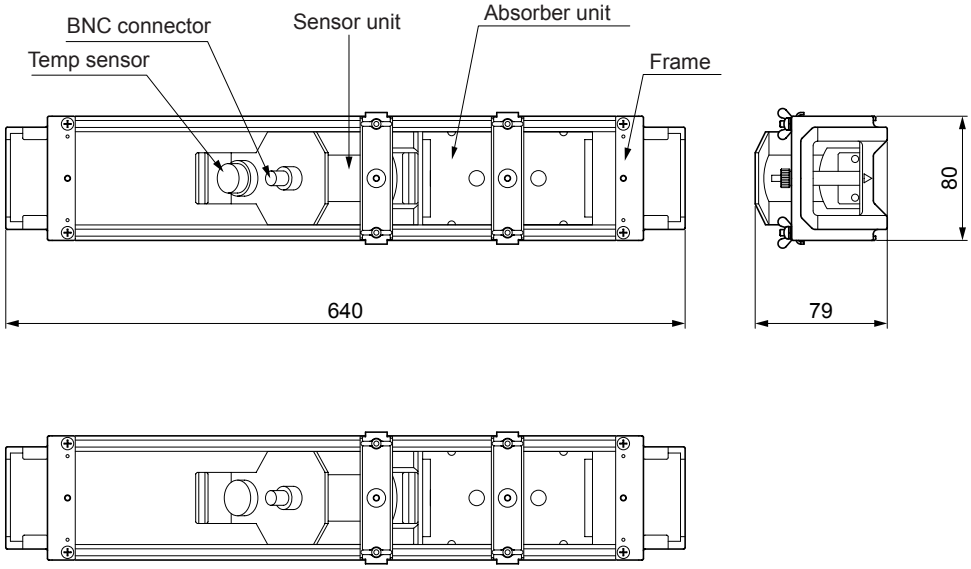


Detecter (Type: FSWS12, 21)

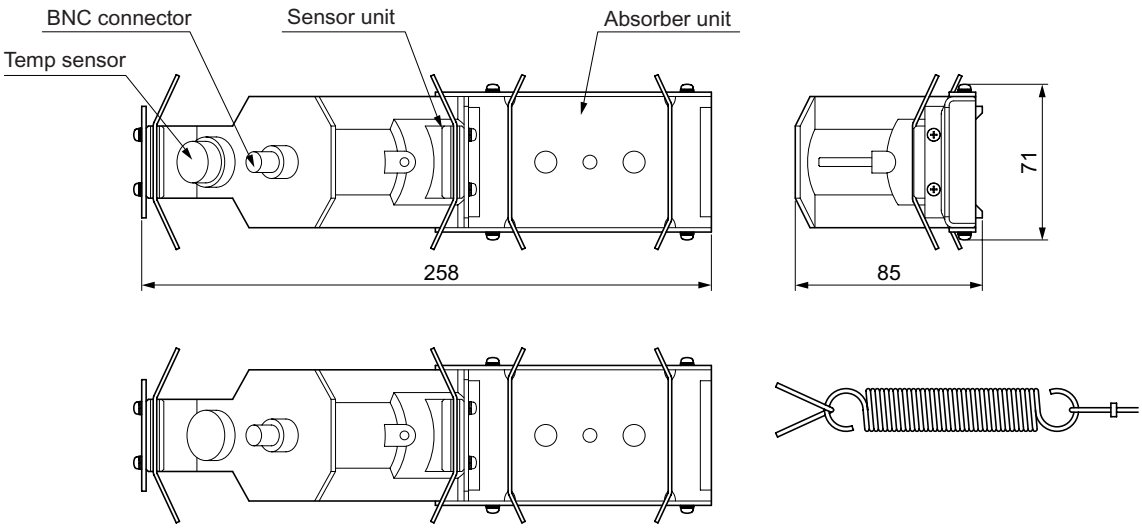


Type	Diameter (mm)	L	H	W
FSWS12	ϕ50 to ϕ100	360	70	57
FSWS21	ϕ100 to ϕ200	540	72	57

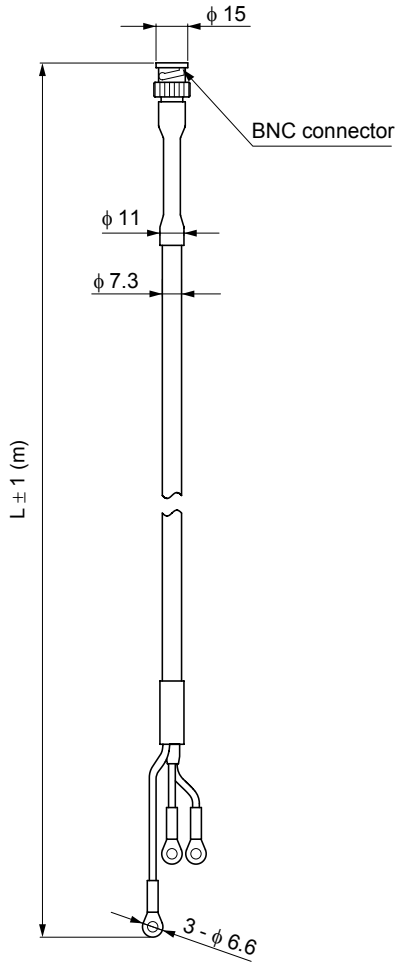
Detecter (Type: FSWS40)



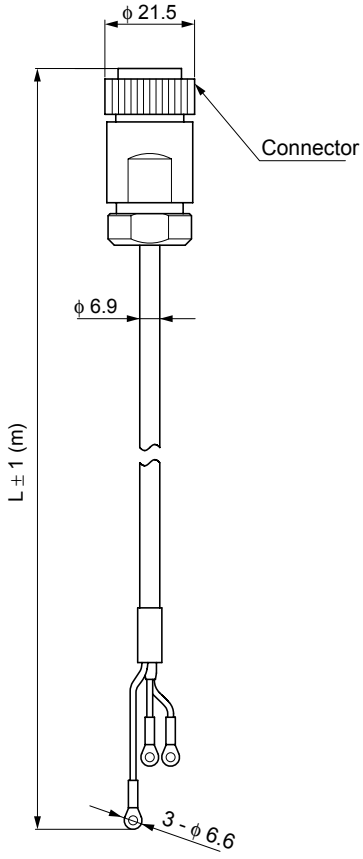
Detecter (Type: FSWS50)



Signal cable (Type: FLY6)



Signal cable (Type: FLY7)



8.4. Items to be specified at placement of an order

1. Type of detector
2. Type of flow transmitter
3. Type of signal cable
4. Tag No. (When tag plate is specified only)
5. Parameter setting table (When parameter setting is specified only)

No.	Setting item		Settable range	Initial value	Settable value
1	PiPing specification	Outer diameter	10.00 to 6200.00 mm (0.393 to 244.100 inch)	60.00 mm (2.362 inch)	[mm, inch]
2		Pipe material	12 menus Pipe S.V.: 1000 to 3700 m/s (3280 to 12140 ft/s)	PVC	Carbon steel, Stainless steel, PVC, Copper, Cast iron, Aluminum, FRP, Ductile iron, PEEK, PVDF, Acrylic Others (Sound velocity: [m/s, ft/s])
3		Wall thickness	0.10 to 100.00 mm (0.003 to 3.940 inch)	4.00 mm (0.157 inch)	[mm, inch]
4		Lining material	8 menus Lining S.V.: 1000 to 3700 m/s (3280 to 12140 ft/s)	No lining	No lining, Tar epoxy, Mortar, Rubber, Teflon, Pyrex glass, PVC, Others (Sound velocity: [m/s, ft/s])
5		Lining thickness	0.01 to 100.00 mm (0.000 to 3.940 inch)	–	[mm, inch]
6		Kind of Fluid	17 menus Fluid S.V.: 500 to 2500m/s (1641 to 8203 ft/s) Viscosity: 0.001 to 999.9999 × 10^{-6}m^2/s (0.0107 to 10763.9088 × 10^{-6} ft^2/s)	Water	Water, Seawater, DIST. water, Ammonia, Alcohol, Benzene, Bromide, Ethanol, Glycol, Kerosene, Milk, Methanol, Toluol, Lube oil, Fuel oil, Petrol, Others (Sound velocity: [m/s, ft/s]) (Viscosity [× 10^{-6}m^2/s, ft^2/s])
7		Range unit	19 menus	m/s (ft/s)	m/s, L/s, L/min, L/h, L/d, kL/d, ML/d, m^3/s, m^3/min, m^3/h, m^3/d, km^3/d, Mm^3/d, BBL/s, BBL/min, BBL/h, BBL/d, KBBL/d, MBBL/d (ft/s, ft^3/s, ft^3/min, ft^3/h, ft^3/d, kft^3/d, Mft^3/d, gal/s, gal/min, gal/h, gal/d, kgal/d, Mgal/d, BBL/s, BBL/min, BBL/h, BBL/d, kBBL/d, MBBL/d)
8	Range setting	Range type	4 menus	Single	Single, Auto 2, Bi-dir, Bi-dir Auto 2
9		Full scale or Full scale 1	In terms of flow velocity 0.00, ±0.30 to ±32.00m/s (0.00, ±0.98 to ±104.98 ft/s)	2.00 m/s (6.56 ft/s)	[(19) Unit]
10		Full scale 2	In terms of flow velocity 0.00, ±0.30 to ±32.00m/s (0.00, ±0.98 to ±104.98 ft/s)	4.00 m/s (13.12 ft/s)	[(19) Unit]
11		Range HYS.	0.00 to 20.00%	10.00%	%
12		Output limit Lo.	–20 to 0%	–20%	%
13		Output limit Hi.	100 to 120%	120%	%
14		Output burnout	5 menus	Hold	Not used, Hold, Upper, Lower, Zero
15		Burnout timer	0 to 900sec	10sec	sec
16		Rate limit	0.00 to 5.00m/s (0.00 to 16.40 ft/s) in terms of flow velocity	0.00m/s (0.00 ft/s)	[(19) Unit]
17		Rate limit timer	0 to 900sec	0 sec	sec
18	Damping		0.0 to 100.0sec	5.0 sec	sec

No.	Setting item		Settable range	Initial value	Settable value
19	Display setting	1: Display kind	7 menus	Flowrate (m3/s)	Velocity, Flowrate, Total forward, Total reverse, F: Total pulse, R: Total pulse, Flow rate (%)
20		2: Display kind	7 menus	Velocity (m/s)	Velocity, Flowrate, Total forward, Total reverse, F: Total pulse, R: Total pulse, Flow rate (%)
21	Low flow cut		0.00 to 5.00m/s (0.00 to 16.40 ft/s) in terms of flow velocity	0.01 m/s (0.03 ft/s)	[(19) Unit]
22	Total	Total mode	3 menus	Total stop	Total stop, Total run, Total reset
23		Total unit	8 menus	mL (ft^3)	mL, L, m^3, km^3, Mm^3, mBBL, BBL, kBBL, ft^3, kft^3, Mft^3, kgal, gal, mBBL, BBL, kBBL, ACRF
24		Total rate	0.000 to 999999.999	0.000	[(8) Unit]
25		F: Total preset	0.000 to 9999999999.999	0.000	[(8) Unit]
26		F: Total SW	0.000 to 9999999999.999	0.000	[(8) Unit]
27		R: Total preset	0.000 to 9999999999.999	0.000	[(8) Unit]
28		R: Total SW	0.000 to 9999999999.999	0.000	[(8) Unit]
29		Output burnout	2 menus	Hold	Not used, Hold
30		Burnout timer	0 to 900sec	10 sec	sec
31		Pulse width 1	3 menus	50 ms	50, 100, 200
32		Pulse width 2	9 menus	50.0 ms	0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0, 100.0, 200.0
33	Flow switch	Flow sw low	In terms of flow velocity 0.00 to ±32.00 m/s (0.00 to ±104.98 ft/s)	0.00 m/s (0.00 ft/s)	[(19) Unit]
34		Flow sw high	In terms of flow velocity 0.00 to ±32.00 m/s (0.00 to ±104.98 ft/s)	4.00 m/s (13.12 ft/s)	[(19) Unit]
35		Flow sw HYS.	0 to 20%	10%	%
36	Status output	Output DO.1	15 menus	Not used	Not use, Signal error, F: Total pulse, R: Total pulse, F: Total alarm, R: Total alarm, F: Total overflow, R: Total overflow, Flow SW high, Flow SW Low, Full scale2, AO range over, Pulse range over, R: Flow direction, Device error
37		Mode DO.1	2 menus	Normal	Normal, Reverse
38		Output DO.2	15 menus	Not used	Not use, Signal error, F: Total pulse, R: Total pulse, F: Total alarm, R: Total alarm, F: Total overflow, R: Total overflow, Flow SW high, Flow SW Low, Full scale2, AO range over, Pulse range over, R: Flow direction, Device error
39		Mode DO.2	2 menus	Normal	Normal, Reverse
40		Output DO.3	15 menus	Not used	Not used, Signal error, F: Total pulse, R: Total pulse, F: Total alarm, R: Total alarm, F: Total overflow, R: Total overflow, Flow SW high, Flow SW Low, Full scale2, AO range over, Pulse range over, R: Flow direction, Device error
41		Mode DO.3	2 menus	Normal	Normal, Reverse

No.	Setting item			Settable range	Initial value	Settable value
42	System	System unit		2 menus	Metric	Metric, English
43		Language		5 menus	English	Japanese, English, German, French, Spanish
44		Serial com.	COM. speed	3 menus	38400 bps	9600 bps, 19200 bps, 38400 bps
45			COM. parity	3 menus	None	None, Even, Odd
46			COM. stop bit	2 menus	1 bit	1bit, 2 bits
47			Serial method	2 menus	RS232C	RS232C, RS485
48			StationNo.	31 menus	1	1 to 31
49		Measurement mode	Measurement mode	2 menus	1 Path	1 Path, 2 Path
50			AO definition	3 menus	Line 1	Average, Line 1, Line 2
51		Sensor	Type	4 menus	FSW12	FSW12, FSW21, FSW40, FSW50

Note 1: When total pulse output is selected for DO1, DO2, DO3, specify the total rate and the total pulse width that satisfy conditions 1 and 2 shown below.

Contidion 1: $$\frac{\text{Flow rate span}^{*1}\ [m^3/s]}{\text{Total rate}\ [m^3]} \leq \frac{1000\ [Hz]\ [DO1 \text{ and } DO2]}{1\ [Hz]\ [DO3]}$$

Condition 2: $$\frac{\text{Flow rate span}^{*1}\ [m^3/s]}{\text{Total rate}\ [m^3]} \leq \frac{1000}{2 \times \text{Total pulse width}\ [ms]}$$

*) In the case of 2-range setting, calculate the total rate and the total pulse width, using the value of full scale 1 or full scale 2, whichever is larger.

8.5. Composition of key operation

PIPING SPECIFICATIONS

[FUNC] ⇒ [PIPE]

- OUTER DIAMETER
- PIPE MATERIAL
  - CARBON STEEL
  - STAINLESS STEEL
  - PVC
  - COPPER
  - CAST IRON
  - ALUMINUM
  - FRP
  - DUCTILE IRON
  - PEEK
  - PVDF
  - ACRYLIC
  - OTHERS
- PIPE S.V.
  Note: Displayed when “OTHERS” is selected from the pipe materials.
- WALL THICKNESS
- LINING MATERIAL
  - NO LINING
  - TAR EPOXY
  - MORTAR
  - RUBBER
  - TEFLON
  - PYREX GLASS
  - PCV
  - OTHERS
- LINING S.V.
  Note: Displayed when “OTHERS” is selected from the lining materials.
- LINING T.
  Note: Displayed when those other than “NO LINING” are selected
- KIND OF FLUID
  - WATER
  - SEAWATER
  - DISTILLED WATER
  - AMMONIA
  - ALCOHOL
  - BENZENE
  - BRIMIDE
  - ETHANOL
  - GLYCOL
  - KEROSENE
  - MILK
  - METHANOL
  - TOLUENE
  - LUB. OIL
  - FUEL OIL
  - PETROL
  - OTHERS
- FLUID S.V.
  Note: Displayed when “OTHERS” is selected as kind of fluid.
- VISCOSITY
- SENSOR SPACING

OUTPUT SETTING

[FUNC] ⇒ [RANGE]

- RANGE UNIT
  - m/s
  - L/s
  - L/min
  - L/h
  - L/d
  - kL/d
  - ML/d
  - m^3/s
  - m^3/min
  - m^3/h
  - m^3/d
  - km^3/d
  - Mm^3/d
  - BBL/s
  - BBL/min
  - BBL/h
  - BBL/d
  - kBBL/d
  - MBBL/d
- RANGE TYPE
  - SINGLE RANGE — FULL SCALE
  - AUTO 2 RANGE
    - FULL SCALE 1
    - FULL SCALE 2
    - HYSTERESIS
  - BI-DIR RANGE — Same as “AUTO 2 RANGE”
  - BI-DIR AUTO 2 RANGE — Same as “AUTO 2 RANGE”
- OUTPUT LIMIT LOW
- OUTPUT LIMIT HIGH
- BURNOUT
  - NOT USED
  - HOLD
  - UPPER
  - LOWER
  - ZERO

  Note: Displayed when those other than “NOT USED” are selected.
- BURNOUT TIMER
- RATE LIMIT
- RATE LIMIT TIMER

DAMPING

[FUNC] ⇒ [DAMP]

- DAMPING

ZERO ADJUSTMENT

[FUNC] ⇒ [ZERO]

- ZERO ADJUSTMENT
  - ZERO
  - CLEAR

DISPLAY SETTING

[FUNC] ⇒ [DISP]

- 1: DISPLAY KIND
  - TOTAL FORWARD
  - TOTAL REVERSE
  - F: TOTAL PULSE
  - R: TOTAL PULSE
  - FLOW RATE (%)
  - VELOCITY
  - FLOW RATE — 1: DISPLAY UNIT
    - L/s
    - L/min
    - L/h
    - L/d
    - kL/d
    - ML/d
    - m^3/s
    - m^3/min
    - m^3/h
    - m^3/d
    - km^3/d
    - Mm^3/d
    - BBL/s
    - BBL/min
    - BBL/h
    - BBL/d
    - kBBL/d
    - MBBL/d
- 2: DISPLAY KIND — Same as “1: DISPLAY KIND.”

CUT OFF

[FUNC] ⇒ [CUT OFF]

- CUT OFF

INTEGRATION

[FUNC] ⇒ [TOTAL]

- TOTAL MODE
  - STOP
  - START
  - RESET
- TOTAL UNIT
  - mL
  - L
  - m^3
  - km^3
  - Mm^3
  - mBBL
  - BBL
  - kBBL
- TOTAL RATE
- F: TOTAL PRESET
- F: TOTAL SW
- R: TOTAL PRESET
- R: TOTAL SW
- BURNOUT
  - NOT USED
  - HOLD
- BURNOUT TIMER
  - Note: Displayed when “HOLD” is selected for BURNOUT
- PULSE WIDTH 1
  - 50
  - 100
  - 200
- PULSE WIDTH 2
  - 0.5
  - 1.0
  - 2.0
  - 5.0
  - 10.0
  - 20.0
  - 50.0
  - 100.0
  - 200.0

FLOW SWITCH

[FUNC] ⇒ [FLOW SW]

- FLOW SW LOW
- FLOW SW HIGH
- HYSTERESIS

STATUS OUTPUT

[FUNC] ⇒ [STATUS]

- SELECT STATUS
  - DO.1
    - OUTPUT DO.1
      - NOT USED
      - SIGNAL ERROR
      - F: TOTAL PULSE
      - R: TOTAL PULSE
      - F: TOTAL SW
      - R: TOTAL SW
      - F: TOTAL OVERFLOW
      - R: TOTAL OVERFLOW
      - FLOW SW HIGH
      - FLOW SW LOW
      - FULL SCALE 2
      - RANGE OVER
      - PULSE RANGE OVER
      - R: FLOW DIRECTION
      - DEVICE ERROR
    - MODE DO.1
      - NORMAL
      - REVERSE
  - DO.2
    - OUTPUT DO.2 — Same as “DO.1”
    - MODE DO.2 — Same as “DO.1”
  - DO.3
    - OUTPUT DO.3 — Same as “DO.1”
    - MODE DO.3 — Same as “DO.1”

OUTPUT CALIBRATION

[FUNC] ⇒ [CAL]

- ZERO
- SPAN

SYSTEM

[FUNC] ⇒ [SYSTEM]

- UNIT & LANGUAGE
  - SKIP
  - SETTING
    - UNIT
      - METER
      - INCH
    - LANGUAGE
      - JAPANESE
      - ENGLISH
      - GERMAN
      - FRENCH
      - SPANISH
- COMMUNICATION
  - SKIP
  - SETTING
    - COM. SPEED
      - 9600 bps
      - 19200 bps
      - 38400 bps
    - PARITY
      - NONE
      - EVEN
      - ODD
    - STOP BIT
      - 1 BIT
      - 2 BITS
    - SERIAL METHOD
      - RS232C
      - RS485
    - STATION NO.
- MAINTENANCE
  - SKIP
  - AO.1
    - AO.1 ADJUST
      - 4 mA
      - 20 mA
    - AO.1 CHECK
  - DO.1
    - DO.1 CHECK
      - OFF
      - ON
  - DO.2
    - DO.2 CHECK
      - OFF
      - ON
  - DO.3
    - DO.3 CHECK
      - OFF
      - ON
  - WEDGE TEMP.
    - ADJUST TEMP.
      - CLEAR
      - ADJUST
        - SET 100Ω.
        - SET 140Ω.
    - CHECK TEMP.
  - TEST MODE
    - NOT USE
    - SETTING
      - INPUT DATA
      - TRACKING TIME
- MEASURE METHOD
  - HYBRID
  - TRANSIT TIME
- SENSOR SPACING
  - Z METHOD
  - V METHOD
- MEASUREMENT MODE
  - 1 PATH
  - 2 PATH
- AO DEFINITION
  - LINE 1
  - LINE 2 — Note: Displayed when “2 PATH” is selected for MEASUREMENT MODE.
  - AVERAGE — Note: Displayed when “2 PATH” is selected for MEASUREMENT MODE.
- SENSOR TYPE — Note: In the case of types “FLW11” to “FLW51,” displayed when “TIME DIFFERENCE” is selected for MEASURE METHOD.
  - FLW11
  - FLW41
  - FLW12
  - FLD12
  - FLD22
  - FLW32
  - FLW50
  - FLW51
  - FSW12
  - FSW21
  - FSW40
  - FSW50
- SENSOR CALIB.
  - SKIP
  - SETTING
    - LINE 1-F: METAL PIPE
    - LINE 1-R: METAL PIPE
    - LINE 1-F: PLASTIC PIPE
    - LINE 1-R: PLASTIC PIPE
    - LINE 1-P
    - LINE 2-F: METAL PIPE
    - LINE 2-R: METAL PIPE
    - LINE 2-F: PLASTIC PIPE
    - LINE 2-R: PLASTIC PIPE
    - LINE 2-P

    } Note: Displayed when “2 PATH” is selected.
- TRANS. VOLTAGE
  - 20 Vpp
  - 40 Vpp
  - 80 Vpp
  - 160 Vpp
- BACKLIGHT
  - AUTO
  - ON
  - OFF
- KEY LOCK
  - OFF
  - ON
    - PASSWORD
      - SKIP
      - SETTING
        - PASSWORD SETTING
- SYSTEM NAME

CHECK

[FUNC] ⇒ [CHECK]

- RAS INFORMATION
- STATUS INFORMATION
- TIME DELTA
  - SKIP
  - CHECK
    - WEDGE S.V.
    - WEDGE ANGLE
    - PIPE S.V.
    - ANGLE IN PIPE
    - LINING S.V.
    - ANGLE IN LINING
    - FLUID S.V.
    - WEDGE TEMP.
    - ANGLE IN FLUID
    - TOTAL TIME
    - WINDOW OPEN
    - LINE SELECT NO.
      - LINE 1
        - #: TOTAL TIME
        - #: FORWARD TIME
        - #: REVERSE TIME
        - #: TIME DIFFERENCE
        - #: DELAY TIME
        - #: FLUID S.V.
        - #: ANGLE IN FLUID
        - #: REYNOLDS NO.
        - #: K
        - #: VELOCITY
        - #: SIGNAL POWER (F)
        - #: SIGNAL POWER (R)
        - #: TRIG. LEVEL (F)
        - #: TRIG. LEVEL (R)
        - #: SIGNAL PEAK (F)
        - #: SIGNAL PEAK (R)
      - LINE 2 — Same as “LINE 1”

Note: #: Represents LINE No.

- PULSE DOPPLER
  - SKIP
  - CHECK
    - WEDGE S.V.
    - WEDGE ANGLE
    - PIPE S.V.
    - ANGLE IN PIPE
    - LINING S.V.
    - ANGLE IN LINING
    - FLUID S.V.
    - WEDGE TEMP.
    - ANGLE IN FLUID
    - TRANS. FREQUENCY
    - SAMPLING FREQ.
    - RECEIPT. WAIT TIME
    - REPETITION FREQ.
    - TRANS PULSE NO.
    - REFERENCE COUNT
    - NO. OF CHANNELS
    - MEAS. RANGE
    - PHASE ANGLE SHIFT
    - START GAIN
    - END GAIN
    - START DIST.
    - CHANNEL WIDTH
    - START CHANNEL
    - END CHANNEL
    - VELOCITY COEFF.
    - LINE SELECT
      - LINE 1-F
        - #: POWER
        - #: DEVIATION
        - #: SUCCESS RATE
        - #: VELOCITY
      - LINE 1-R — Same as “LINE 1-F”
      - LINE 2-F — Same as “LINE 1-F”
      - LINE 2-R — Same as “LINE 1-F”
    - MAX RANGE

Meaning of error symbol
E1: Device error
E2: Time difference method error
E3: Pulse Doppler method error
E4: Range over

DETAIL Note: Intended for our service personnel only.

[FUNC] ⇒ [DETAIL]

- VERSION INF.
  - SKIP
  - CHECK
    - MEASUREMENT BOARD
    - CONTROL BOARD
- SETTING DATA
  - NOT INITIALIZE
  - INITIALIZE
  - FACTORY SETTING
- RAS
  - SKIP
  - RAS DETAIL
  - RAS SETTING
- TRANSIT TIME
  - SKIP
  - SETTING
    - LINE SELECTION
      - LINE 1
        - #: TRANS. COUNT
          - 8
          - 16
          - 32
          - 64
          - 128
          - 256
        - #: TRIGGER CONTROL
          - AUTO
          - MANUAL
            - #: TRIGGER LEVEL
        - #: WINDOW CONTROL
          - AUTO
          - MANUAL
            - #: OPEN TIME (F)
            - #: OPEN TIME (R)
        - #: SATURATION
        - #: MEAS. METHOD
          - METHOD 1
          - METHOD 2
          - METHOD 3
        - #: SIGNAL BALANCE
        - #: TRANS. PATTERN
          - BURST 1
          - BURST 2
          - BURST 3
          - BURST 4
          - BURST 5
          - CHIRP 4
          - CHIRP 8
          - RESERVE
        - #: AGC GAIN
          - AUTO
          - MANUAL
            - #: AGC LEVEL (F)
            - #: AGC LEVEL (R)
        - #: SIGNAL PEAK
          - 2048
          - 3071
          - 4096
          - 5120
      - LINE 2
        - Same as “LINE 1”
- PULSE DOPPLER
  - SKIP
  - SETTING
    - WEDGE S.V.
      - AUTO
      - MANUAL
    - PIPE S.V.
      - AUTO
      - MANUAL
    - LINING S.V.
      - AUTO
      - MANUAL
    - FLUID S.V.
      - AUTO
      - MANUAL
    - TRANS. FREQUENCY
      - AUTO
      - MANUAL
    - TRANS. PULSE NO.
      - 0
      - 1
      - 2
      - 4
      - 8
      - 16
      - 32
      - 64
    - SAMPLING FREQ.
      - AUTO
      - MANUAL
    - RECEPT. WAIT TIME
      - AUTO
      - MANUAL
    - REPETITION FREQ.
      - AUTO
      - MANUAL
    - REFERENCE COUNT
      - 4
      - …
      - 512
    - NO. OF CHANNELS
      - AUTO
      - MANUAL
        - 16
        - 32
        - 48
        - 64
        - 80
        - 96
        - 112
        - 128

- MEAS. RANGE
  - F RADIUS
  - N RADIUS
  - DIAMETER
- PHASE ANGLE SHIFT
  - NORMAL 1
  - NORMAL 2
  - POSITIVE
  - NEGATIVE
- GAIN
  - AUTO
  - MANUAL
    - START GAIN
    - END GAIN
- LINE SELECTION
  - LINE 1-F
    - POWER
    - DEVIATION
    - SUCCESS RATE
  - LINE 1-R — Same as “LINE 1-F”
  - LINE 2-F — Same as “LINE 1-F”
  - LINE 2-R — Same as “LINE 1-F”

8.6. Piping data

Stainless steel pipe for pipe arrangement (JIS G3459-1988)

Nominal diameter		Outer diameter mm	Nominal thickness						
			Schedule 5S	Schedule 10S	Schedule 20S	Schedule 40	Schedule 80	Schedule 120	Schedule 160
A	B		Thickness mm	Thickness mm	Thickness mm	Thickness mm	Thickness mm	Thickness mm	Thickness mm
15	1/2	21.7	1.65	2.1	2.5	2.9	3.9	-	5.5
20	3/4	27.2	1.65	2.1	2.5	2.9	3.9	-	5.5
25	1	34.0	1.65	2.8	3.0	3.4	4.5	-	6.4
32	1 1/4	42.7	1.65	2.8	3.0	3.6	4.9	-	6.4
40	1 1/2	48.6	1.65	2.8	3.0	3.7	5.1	-	7.1
50	2	60.5	1.65	2.8	3.5	3.9	5.5	-	8.7
65	2 1/2	76.3	2.1	3.0	3.5	5.2	7.0	-	9.5
80	3	89.1	2.1	3.0	4.0	5.5	7.6	-	11.1
90	3 1/2	101.6	2.1	3.0	4.0	5.7	8.1	-	12.7
100	4	114.3	2.1	3.0	4.0	6.0	8.6	11.1	13.5
125	5	139.8	2.8	3.4	5.0	6.6	9.5	12.7	15.9
150	6	165.2	2.8	3.4	5.0	7.1	11.0	14.3	18.2
200	8	216.3	2.8	4.0	6.5	8.2	12.7	18.2	23.0
250	10	267.4	3.4	4.0	6.5	9.3	15.1	21.4	28.6
300	12	318.5	4.0	4.5	6.5	10.3	17.4	25.4	33.3
350	14	355.6	-	-	-	11.1	19.0	27.8	35.7
400	16	406.4	-	-	-	12.7	21.4	30.9	40.5
450	18	457.2	-	-	-	14.3	23.8	34.9	45.2
500	20	508.0	-	-	-	15.1	26.2	38.1	50.0
550	22	558.8	-	-	-	15.9	28.6	41.3	54.0
600	24	609.6	-	-	-	17.5	34.0	46.0	59.5
650	26	660.4	-	-	-	18.9	34.0	49.1	64.2

Polyethylene pipe for city water (JIS K6762-1982)

Nominal diameter (mm)	Outer diameter (mm)	1st type (Soft pipe)		2nd type (Hard pipe)	
		Thickness (mm)	Weight (kg/m)	Thickness (mm)	Weight (kg/m)
13	21.5	3.5	0.184	2.5	0.143
20	27.0	4.0	0.269	3.0	0.217
25	34.0	5.0	0.423	3.5	0.322
30	42.0	5.5	0.586	4.0	0.458
40	48.0	6.5	0.788	4.5	0.590
50	60.0	8.0	1.210	5.0	0.829

Galvanized steel pipe for city water SGPW (JIS G3442-1988)

Nominal diameter		Outer diameter (mm)	Thickness (mm)
(A)	(B)		
15	1/2	21.7	2.8
20	3/4	27.2	2.8
25	1	34.0	3.2
32	1 1/4	42.7	3.5
40	1 1/2	48.6	3.5
50	2	60.5	3.8
65	2 1/2	76.3	4.2
80	3	89.1	4.2
90	3 1/2	101.6	4.2
100	4	114.3	4.5
125	5	139.8	4.5
150	6	165.2	5.0
200	8	216.3	5.8
250	10	267.4	6.6
300	12	318.5	6.9

Asbestos cement pipe for city water (JIS A5301-1971)

Nominal diameter (mm)	1st type		2nd type		3rd type		4th type	
	Thickness of connected part (mm)	Outer diameter of connected part (mm)	Thickness of connected part (mm)	Outer diameter of connected part (mm)	Thickness of connected part (mm)	Outer diameter of connected part (mm)	Thickness of connected part (mm)	Outer diameter of connected part (mm)
50	10	70	-	-	-	-	-	-
75	10	95	-	-	-	-	-	-
100	12	124	10	120	9	118	-	-
125	14	153	11	147	9.5	144	-	-
150	16	182	12	174	10	170	-	-
200	21	242	15	230	13	226	11	222
250	23	296	19	288	15.5	281	12	274
300	26	352	22	344	18	336	14	328
350	30	410	25	400	20.5	391	16	382
400	35	470	29	458	23	446	18	436
450	39	528	32	514	26	502	20	490
500	43	586	35	570	28.5	557	22	544
600	52	704	42	684	34	668	26	652
700	-	-	49	798	39	778	30	760
800	-	-	56	912	44	888	34	868
900	-	-	-	-	49	998	38	976
1000	-	-	-	-	54	1108	42	1084
1100	-	-	-	-	59	1218	46	1192
1200	-	-	-	-	65	1330	50	1300
1300	-	-	-	-	73	1496	57	1464
1500	-	-	-	-	81	1662	63	1626

Polyethylene pipe for general use (JIS K6761-1979)

Nominal diameter	Outer diameter (mm)	1st type (Soft pipe)	2nd type (Hard pipe)
		Thickness of pipe (mm)	Thickness of pipe (mm)
13	21.5	2.7	2.4
20	27.0	3.0	2.4
25	34.0	3.0	2.6
30	42.0	3.5	2.8
40	48.0	3.5	3.0
50	60.0	4.0	3.5
65	76.0	5.0	4.0
75	89.0	5.5	5.0
100	114	6.0	5.5
125	140	6.5	6.5
150	165	7.0	7.0
200	216	8.0	8.0
250	267	9.0	9.0
300	318	10.0	10.0

Hi vinyl chloride pipe (city water pipe size)

Nominal diameter	Outer diameter	Thickness of pipe
13	18.0	2.5
20	26.0	3.0
25	32.0	3.5
30	38.0	3.5
40	48.0	4.0
50	60.0	4.5
75	89.0	5.8
100	114.0	7.0
125	140.0	7.5
150	165.0	8.5

Hi vinyl chloride pipe (conduit size)

Nominal diameter	Outer diameter	Thickness of pipe
28	34.0	3.0
35	42.0	3.5
41	48.0	3.5
52	60.0	4.0
65	76.0	4.5
78	89.0	5.5

Vertical cast iron pipe (JIS G5521)

Nominal diameter (D)	Thickness (T)		Actual outer diameter (D1)
	Normal pressure pipe	Low pressure pipe	
75	9.0	-	93.0
100	9.0	-	118.0
150	9.5	9.0	169.0
200	10.0	9.4	220.0
250	10.8	9.8	271.6
300	11.4	10.2	322.8
350	12.0	10.6	374.0
400	12.8	11.0	425.6
450	13.4	11.5	476.8
500	14.0	12.0	528.0
600	15.4	13.0	630.8
700	16.5	13.8	733.0
800	18.0	14.8	836.0
900	19.5	15.5	939.0
1000	22.0	-	1041.0
1100	23.5	-	1144.0
1200	25.0	-	1246.0
1350	27.5	-	1400.0
1500	30.0	-	1554.0

Carbon steel pipe for pipe arrangement (JIS G3452-1988)

Nominal diameter		Actual outer diameter	Thickness
(A)	(B)	(mm)	(mm)
15	1/2	21.7	2.8
20	3/4	27.2	2.8
25	1	34.0	3.2
32	1 1/4	42.7	3.5
40	1 1/2	48.6	3.5
50	2	60.5	3.8
65	2 1/2	76.3	4.2
80	3	89.1	4.2
90	3 1/2	101.6	4.2
100	4	114.3	4.5
125	5	139.8	4.5
150	6	165.2	5.0
175	7	190.7	5.3
200	8	216.3	5.8
225	9	241.8	6.2
250	10	267.4	6.6
300	12	318.5	6.9
350	14	355.6	7.9
400	16	406.4	7.9
450	18	457.2	7.9
500	20	508.0	7.9

Hard vinyl chloride pipe (JIS K6741-1984)

Type / Nominal diameter	VP		VU	
	Actual outer diameter	Thickness	Actual outer diameter	Thickness
13	18	2.2	-	-
16	22	2.7	-	-
20	26	2.7	-	-
25	32	3.1	-	-
30	38	3.1	-	-
40	48	3.6	48	1.8
50	60	4.1	60	1.8
65	76	4.1	76	2.2
75	89	5.5	89	2.7
100	114	6.6	114	3.1
125	140	7.0	140	4.1
150	165	8.9	165	5.1
200	216	10.3	216	6.5
250	267	12.7	267	7.8
300	318	15.1	318	9.2
350	-	-	370	10.5
400	-	-	420	11.8
450	-	-	470	13.2
500	-	-	520	14.6
600	-	-	630	17.8
700	-	-	732	21.0
800	-	-	835	23.9

Coated steel pipe for city water PTPW (JIS G3443-1968)

Nominal diameter (A)	Actual outer diameter (mm)	Thickness (mm)
80	89.1	4.2
100	114.3	4.5
125	139.8	4.5
150	165.2	5.0
200	216.3	5.8
250	267.4	6.6
300	318.5	6.9
350	355.6	6.0
400	406.4	6.0
450	457.2	6.0
500	508.0	6.0
600	609.6	6.0
700	711.2	6.0
800	812.8	7.1
900	914.4	7.9
1000	1016.0	8.7
1100	1117.6	10.3
1200	1219.2	11.1
1350	1371.6	11.9
1500	1524.0	12.7

Coated steel pipe for city water STW (JIS G3443-1987)

Nominal diameter A	Outer diameter mm	Symbol for type				Symbol for type			
		STW 30	STW 38	STW 41		STW 290	STW 370	STW 400	
				Nominal thickness				Nominal thickness	
				A	B			A	B
		Thickness mm	Thickness mm	Thickness mm	Thickness mm	Thickness mm	Thickness mm	Thickness mm	Thickness mm
80	89.1	4.2	4.5	-	-	4.2	4.5	-	-
100	114.3	4.5	4.9	-	-	4.5	4.9	-	-
125	139.8	4.5	5.1	-	-	4.5	5.1	-	-
150	165.2	5.0	5.5	-	-	5.0	5.5	-	-
200	216.3	5.8	6.4	-	-	5.8	6.4	-	-
250	267.4	6.6	6.4	-	-	6.6	6.4	-	-
300	318.5	6.9	6.4	-	-	6.9	6.4	-	-
350	355.6	-	-	6.0	-	-	-	6.0	-
400	406.4	-	-	6.0	-	-	-	6.0	-
450	457.2	-	-	6.0	-	-	-	6.0	-
500	508.0	-	-	6.0	-	-	-	6.0	-
600	609.6	-	-	6.0	-	-	-	6.0	-
700	711.2	-	-	7.0	6.0	-	-	7.0	6.0
800	812.8	-	-	8.0	7.0	-	-	8.0	7.0
900	914.4	-	-	8.0	7.0	-	-	8.0	7.0
1000	1016.0	-	-	9.0	8.0	-	-	9.0	8.0
1100	1117.6	-	-	10.0	8.0	-	-	10.0	8.0
1200	1219.2	-	-	11.0	9.0	-	-	11.0	9.0
1350	1371.6	-	-	12.0	10.0	-	-	12.0	10.0
1500	1524.0	-	-	14.0	11.0	-	-	14.0	11.0
1600	1625.6	-	-	15.0	12.0	-	-	15.0	12.0
1650	1676.4	-	-	15.0	12.0	-	-	15.0	12.0
1800	1828.8	-	-	16.0	13.0	-	-	16.0	13.0
1900	1930.4	-	-	17.0	14.0	-	-	17.0	14.0
2000	2032.0	-	-	18.0	15.0	-	-	18.0	15.0
2100	2133.6	-	-	19.0	16.0	-	-	19.0	16.0
2200	2235.2	-	-	20.0	16.0	-	-	20.0	16.0
2300	2336.8	-	-	21.0	17.0	-	-	21.0	17.0
2400	2438.4	-	-	22.0	18.0	-	-	22.0	18.0
2500	2540.0	-	-	23.0	18.0	-	-	23.0	18.0
2600	2641.6	-	-	24.0	19.0	-	-	24.0	19.0
2700	2743.2	-	-	25.0	20.0	-	-	25.0	20.0
2800	2844.8	-	-	26.0	21.0	-	-	26.0	21.0
2900	2946.4	-	-	27.0	21.0	-	-	27.0	21.0
3000	3048.0	-	-	29.0	22.0	-	-	29.0	22.0

Centrifugal nodular graphite cast iron pipe for city water (A type) (JWWA G-105-1971)

Nominal diameter D	Thickness of pipe T			Actual outer diameter D1
	1st type	2nd type	3rd type	
75	7.5	-	6.0	93.0
100	7.5	-	6.0	118.0
150	9.5	-	6.0	169.0
200	7.5	-	6.0	220.0
250	7.5	-	6.0	271.6
300	7.5	-	6.5	332.8
350	7.5	-	6.5	374.0
400	8.5	7.5	7.0	425.6
450	9.0	8.0	7.5	476.8
500	9.5	8.5	7.0	528.0

Centrifugal nodular graphite cast iron pipe for city water (K type) (JWWA G-105-1971)

Nominal diameter D	Thickness of pipe T			Actual outer diameter D1
	1st type	2nd type	3rd type	
400	8.5	7.5	7.0	425.6
450	9.0	8.0	7.5	476.8
500	9.5	8.5	8.0	528.0
600	11.0	10.0	9.0	630.8
700	12.0	11.0	10.0	733.0
800	13.5	12.0	11.0	836.0
900	15.0	13.0	12.0	939.0
1000	16.5	14.5	13.0	1041.0
1100	18.0	15.5	14.0	1144.0
1200	19.5	17.0	15.0	1246.0
1350	21.5	18.5	16.5	1400.0
1500	23.5	20.5	18.0	1554.0

Arc welded large-diameter stainless steel pipe for pipe arrangement (JIS G3468-1988)

Nominal diameter		Outer diameter	Nominal thickness			
			Schedule 5S	Schedule 10S	Schedule 20S	Schedule 40S
A	B	mm	Thickness mm	Thickness mm	Thickness mm	Thickness mm
150	6	165.2	2.8	3.4	5.0	7.1
200	8	216.3	3.4	4.0	6.5	9.3
250	10	267.4	4.0	4.5	6.5	10.3
350	14	355.6	4.0	5.0	8.0	11.1
400	16	406.4	4.5	5.0	8.0	12.7
450	18	457.2	4.5	5.0	8.0	14.3
500	20	508.0	5.0	5.5	9.5	15.1
550	22	558.8	5.0	5.5	9.5	15.1
600	24	609.6	5.5	6.5	9.5	17.5
650	26	660.4	5.5	8.0	12.7	17.5
700	28	711.2	5.5	8.0	12.7	17.5
750	30	762.0	6.5	8.0	12.7	17.5
800	32	812.8	-	8.0	12.7	17.5
850	34	863.6	-	8.0	12.7	17.5
900	36	914.1	-	8.0	12.7	19.1
1000	40	1016.0	-	9.5	14.3	26.2

Ductile iron specials

Nominal diameter (mm)	Thickness (mm)
75	8.5
100	8.5
150	9.0
200	11.0
250	12.0
300	12.5
350	13.0
400	14.0
450	14.5
500	15.0
600	16.0
700	17.0
800	18.0
900	19.0
1000	20.0
1100	21.0
1200	22.0
1350	24.0
1500	26.0
1600	27.5
1650	28.0
1800	30.0
2000	32.0
2100	33.0
2200	34.0
2400	36.0

Dimensions of centrifugal sand mold cast iron pipe (JIS G5522)

Nominal diameter	Thickness of pipe			Actual outer diameter
	High pressure pipe	Normal pressure pipe	Low pressure pipe	
75	9.0	7.5	-	93.0
100	9.0	7.5	-	118.0
125	9.0	7.8	-	143.0
150	9.5	8.0	7.5	169.0
200	10.0	8.8	8.0	220.0
250	10.8	9.5	8.4	271.6
300	11.4	10.0	9.0	322.8
350	12.0	10.8	9.4	374.0
400	12.8	11.5	10.0	425.6
450	13.4	12.0	10.4	476.8
500	14.0	12.8	11.0	528.0
600	-	14.2	11.8	630.8
700	-	15.5	12.8	733.0
800	-	16.8	13.8	836.0
900	-	18.2	14.8	939.0

Dimensions of centrifugal mold cast iron pipe (JIS G5523 1977)

Nominal diameter	Thickness of pipe		Actual outer diameter
	High pressure pipe	Normal pressure pipe	
75	9.0	7.5	93.0
100	9.0	7.5	118.0
125	9.0	7.8	143.0
150	9.5	8.0	169.0
200	10.0	8.8	220.0
250	10.8	9.5	271.6
300	11.4	10.0	322.8

Cast iron pipe for waste water (JIS G5525)

Nominal diameter	Thickness of pipe	Actual inner diameter	Actual outer diameter
	T	D_1	D_2
50	6.0	50	62
65	6.0	65	77
75	6.0	74	87
100	6.0	100	112
125	6.0	125	137
150	6.0	150	162
200	7.0	200	214

Arc welded carbon steel pipe (JIS G3457-1976)

Unit: kg/m

Nominal diameter		Thickness of pipe (mm) / Outer diameter (mm)	6.0	6.4	7.1	7.9	8.7	9.5	10.3	11.1	11.9	12.7	13.1	15.1	15.9
(A)	(B)														
350	14	355.6	51.7	55.1	61.0	67.7									
400	16	406.4	59.2	63.1	66.9	77.6									
450	18	457.2	66.8	71.1	78.8	87.5									
500	20	508.0	74.3	79.2	87.7	97.4	107	117							
550	22	558.8	81.8	87.2	96.6	107	118	129	139	150	160	171			
600	24	609.6	89.0	95.2	105	117	127	141	152	164	175	187			
650	26	660.4	96.8	103	114	127	140	152	165	178	190	203			
700	28	711.2	104	111	123	137	151	164	178	192	205	219			
750	30	762.0		119	132	147	162	176	191	206	220	235			
800	32	812.8		127	141	157	173	188	204	219	235	251	258	297	312
850	34	863.6		135		167	183	200	219	233	250	266	275	315	332
900	36	914.4		143		177	194	212	230	247	265	282	291	335	352
1000	40	1016.0				196	216	236	255	275	295	314	324	373	392
1100	44	1117.6						260	281	303	324	346	357	411	432
1200	48	1219.2						283	307	331	354	378	390	448	472
1350	54	1371.6									399	426	439	505	532
1500	60	1524.0									444	473	488	562	591
1600	64	1625.6											521	600	631
1800	72	1828.8											587	675	711
2000	80	2032.0												751	799

Hard vinyl chloride pipe for city water (JIS K6742-1975)

Nominal diameter	Outer diameter	Thickness of pipe
13	18	2.5
20	26	3.0
25	32	3.5
30	38	3.5
40	48	4.0
50	60	4.5
75	89	5.9
100	114	7.1
150	165	9.6

PVDF-HP

PVDF-HP	SDR33 S16 PN10	SDR21 S10 PN16	SDR17 S8 PN20
Outer diameter (mm)	Thickness (mm)	Thickness (mm)	Thickness (mm)
20		1.9	1.9
25		1.9	1.9
32		2.4	2.4
40		2.4	2.4
50		3.0	3.0
63	2.5	3.0	
75	2.5	3.6	
90	2.8	4.3	
110	3.4	5.3	
125	3.9	6.0	
140	4.3	6.7	
160	4.9	7.7	
180	5.5	8.6	
200	6.2	9.6	
225	6.9	10.8	
250	7.7	11.9	
280	8.6	13.4	
315	9.7	15.0	

(a) Velocity of sound subject to change f temperature of water (0 to 100°C)

T°C	V m/s	T°C	V m/s	T°C	V m/s	T°C	V m/s
0	1402.74						
1	1407.71	26	1499.64	51	1543.93	76	1555.40
2	1412.57	27	1502.20	52	1544.95	77	1555.31
3	1417.32	28	1504.68	53	1545.92	78	1555.18
4	1421.98	29	1507.10	54	1546.83	79	1555.02
5	1426.50	30	1509.44	55	1547.70	80	1554.81
6	1430.92	31	1511.71	56	1548.51	81	1554.57
7	1435.24	32	1513.91	57	1549.28	82	1554.30
8	1439.46	33	1516.05	58	1550.00	83	1553.98
9	1443.58	34	1518.12	59	1550.68	84	1553.63
10	1447.59	35	1520.12	60	1551.30	85	1553.25
11	1451.51	36	1522.06	61	1551.88	86	1552.82
12	1455.34	37	1523.93	62	1552.42	87	1552.37
13	1459.07	38	1525.74	63	1552.91	88	1551.88
14	1462.70	39	1527.49	64	1553.35	89	1551.35
15	1466.25	40	1529.18	65	1553.76	90	1550.79
16	1469.70	41	1530.80	66	1554.11	91	1550.20
17	1473.07	42	1532.37	67	1554.43	92	1549.58
18	1476.35	43	1533.88	68	1554.70	93	1548.92
19	1479.55	44	1535.33	69	1554.93	94	1548.23
20	1482.66	45	1536.72	70	1555.12	95	1547.50
21	1485.69	46	1538.06	71	1555.27	96	1546.75
22	1488.63	47	1539.34	72	1555.37	97	1545.96
23	1491.50	48	1540.57	73	1555.44	98	1545.14
24	1494.29	49	1541.74	74	1555.47	99	1544.29
25	1497.00	50	1542.87	75	1555.45	100	1543.41

Note) T: Temperature, V: Velocity of sound

(b) Sound velocity and density of various liquids

	T°C	ρ g/cm^3	V m/s
Acetone	20	0.7905	1190
Aniline	20	1.0216	1659
Alcohol	20	0.7893	1168
Ether	20	0.7135	1006
Ethylene glycol	20	1.1131	1666
n-Octane	20	0.7021	1192
o-Xylol	20	0.871	1360
Chloroform	20	1.4870	1001
Chlorobenzene	20	1.1042	1289
Glycerin	20	1.2613	1923
Acetic acid	20	1.0495	1159
Methyl acetate	20	0.928	1181
Ethyl acetate	20	0.900	1164
Cyclohexane	20	0.779	1284
Dioxane	20	1.033	1389
Heavy water	20	1.1053	1388
Carbon tetrachloride	20	1.5942	938
Mercury	20	13.5955	1451
Nitrobenzene	20	1.207	1473
Carbon bisulfide	20	1.2634	1158
Bromoform	20	2.8904	931
n-propyl alcohol	20	0.8045	1225
n-pentane	20	0.6260	1032
n-hexane	20	0.654	1083
Diesel oil	25	0.81	1324
Transformer oil	32.5	0.859	1425
Spindle oil	32	0.905	1342
Petroleum	34	0.825	1295
Gasoline	34	0.803	1250
Water	13.5	1.	1460
Seawater (Salt content 3.5%)	16	1.	1510

Note)
T: temperature, ρ: density V: sound velocity

(c) Sound velocity by piping material

Material	V m/s
Iron	3230
Steel	3206
Ductile cast iron	3000
Cast iron	2460
Stainless steel	3206
Copper	2260
Lead	2170
Aluminum	3080
Brass	2050
Polyvinyl chloride	2640
Acrylic	2644
FRP	2505
Mortar	2500
Tar epoxy	2505
Polyethylene	1900
Teflon	1240

Note) V: sound velocity

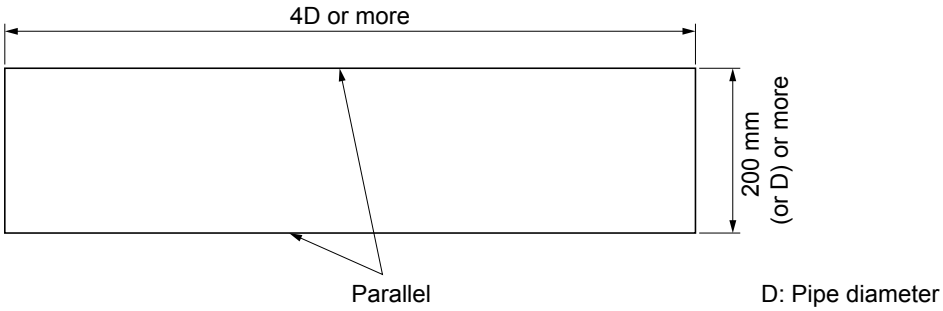
(d) Dynamic viscosity coefficient of various liquids

Fluid	T°C	ρ g/cm^3	V m/s	ν ($\times 10^{-6}$m^2/s)
Acetone	20	0.7905	1190	0.407
Aniline	20	1.0216	1659	1.762
Ether	20	0.7135	1006	0.336
Ethylene glycol	20	1.1131	1666	21.112
Chloroform	20	1.4870	1001	0.383
Glycerin	20	1.2613	1923	11.885
Acetic acid	20	1.0495	1159	1.162
Methyl acetate	20	0.928	1181	0.411
Ethyl acetate	20	0.900	1164	0.499
Heavy water	20	1.1053	1388	1.129
Carbon tetrachloride	20	1.5942	938	0.608
Mercury	20	13.5955	1451	0.114
Nitrobenzene	20	1.207	1473	1.665
Carbon bisulfide	20	1.2634	1158	0.290
n-pentane	20	0.6260	1032	0.366
n-hexane	20	0.654	1083	0.489
Spindle oil	32	0.905	1324	15.7
Gasoline	34	0.803	1250	0.4 to 0.5
Water	13.5	1.	1460	1.004 (20°C)

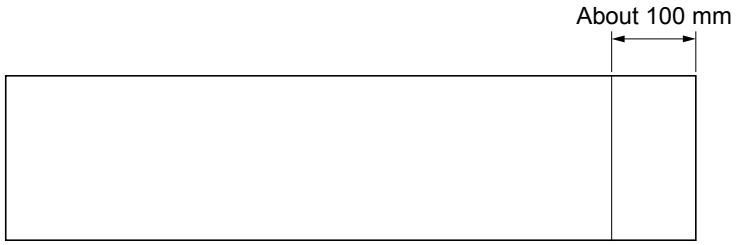
Note) T: Temperature, ρ: density, V: sound velocity, υ: viscosity

8.7. Making gauge paper

(1) Provide a sheet of paper (or vinyl) having the length of 4D and width of 200 mm (D if possible) or longer, with long sides parallel to each other.



(2) Draw a line that intersects with the long sides at right angles at a place about 100 mm from one end.



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