Badger Meter Europa GmbH

MoniSonic 4600

Ultrasonic transit time flow meter

INSTRUCTION MANUAL

May 2005

Version MoniSonic 4600-e-INF-TN3FLV

PREFACE

We are grateful for your purchase of this ultrasonic flow meter.

- First read this instruction manual carefully until an adequate understanding is acquired, and then proceed to installation, operation and maintenance of the converter (sensor) of the ultrasonic flow meter. Wrong handling may cause an accident or injury.
- The specifications of this flow meter will be changed without prior notice for further product improvement.
- Modification of this flow meter is strictly prohibited unless a written approval is obtained from the manufacturer. We will not bear any responsibility for a trouble caused by such a modification.
- This instruction manual shall be stored by the person who actually uses the flowmeter.
- After reading the manual, be sure to store it at a place easier to access.
- This instruction manual should be delivered to the end user without fail.

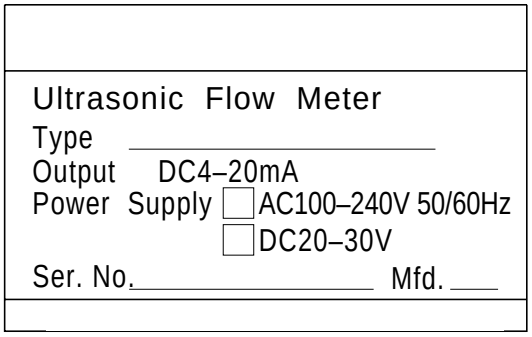
About ultrasonic flowmeter

The ultrasonic flowmeter in combination with the ultrasonic sensor mounted on the external wall of existing piping, is used to convert the amount of flow of a fluid flowing in the piping into a unified current signal and integrated pulse signal.

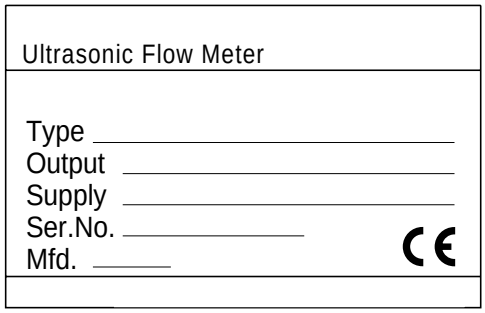
Check on type and specifications

The name of type is inscribed on the specification nameplate. Check the specification nameplate to make sure that type and specifications are correct as ordered (the nameplate is attached to the side of the converter, the upper side of the sensor cover (small type, large type) and the side of the frame (for high temperature).

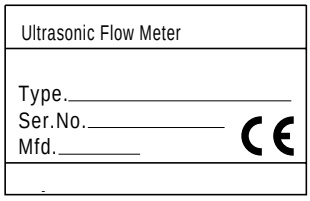
(1) Specification nameplate



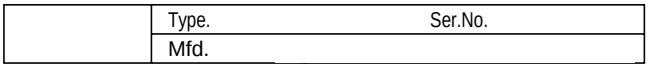
Converter



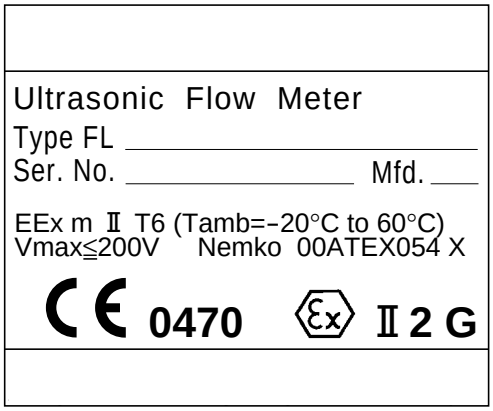
Large type sensor



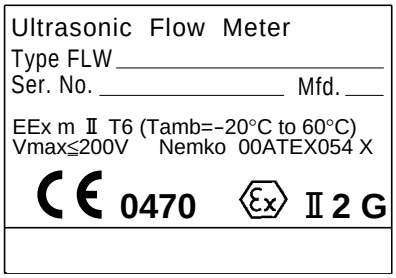
Small and Middle type sensor



High temperature sensor

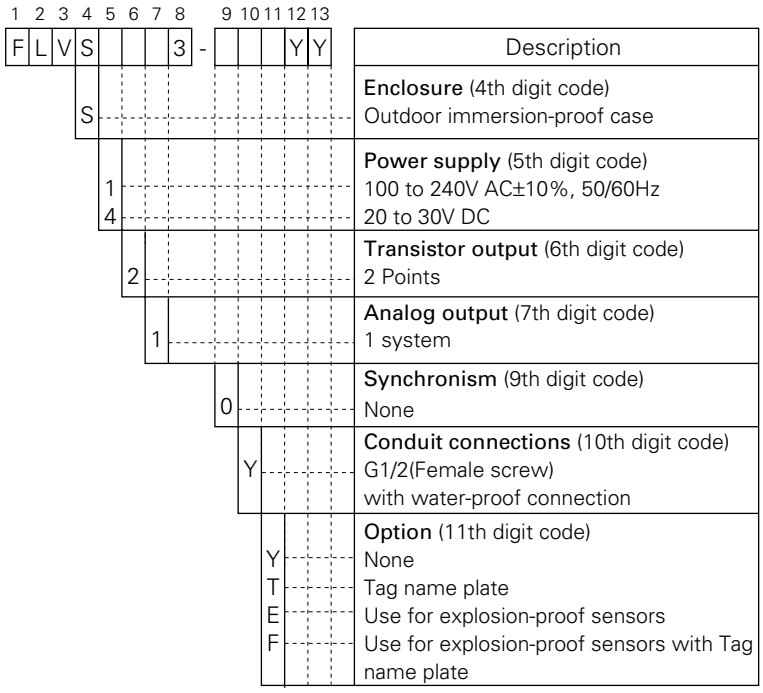


Converter (Use for explosion-proof sensors)
Large type sensor (Explosion-proof type)



Small & Middle type sensors
(Explosion-proof type)

(2) Code symbols of converter

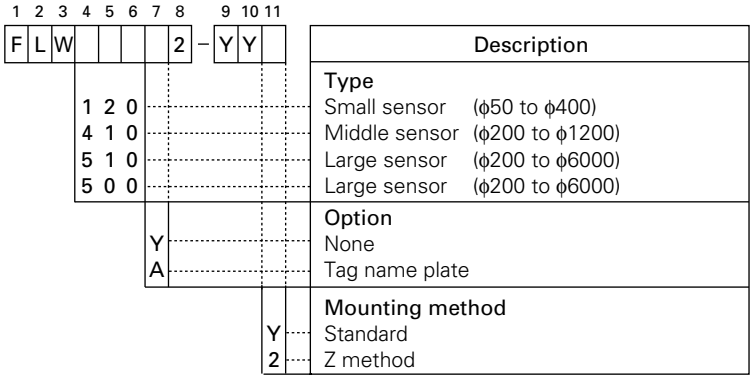


1	2	3	4	5	6	7	8		9	10	11	12	13	Description
F	L	V	S				3	-				Y	Y	
			S											**Enclosure** (4th digit code) Outdoor immersion-proof case
				1 4										**Power supply** (5th digit code) 100 to 240V AC±10%, 50/60Hz 20 to 30V DC
					2									**Transistor output** (6th digit code) 2 Points
						1								**Analog output** (7th digit code) 1 system
									0					**Synchronism** (9th digit code) None
										Y				**Conduit connections** (10th digit code) G1/2(Female screw) with water-proof connection
											Y			**Option** (11th digit code) None
											T			Tag name plate
											E			Use for explosion-proof sensors
											F			Use for explosion-proof sensors with Tag name plate

(Note) As for explosion-proof type, the converter should be located in safe area.
See Installation instruction of Item 8.2.

(3) Code symbols of sensor

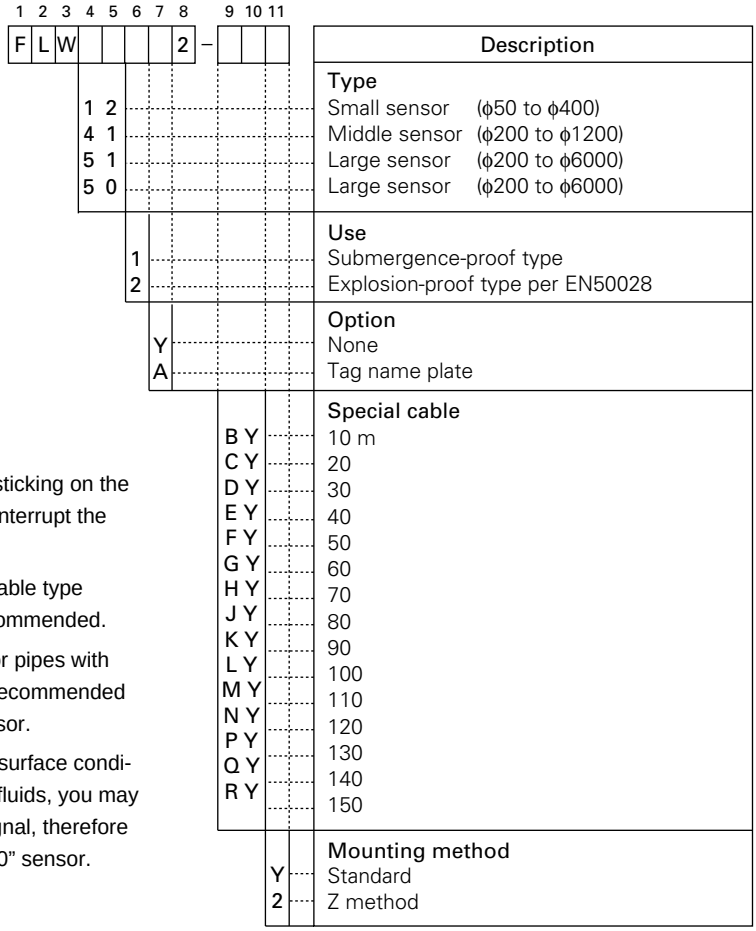
- Standard type



Description	
Type	
1 2 0	Small sensor (ϕ50 to ϕ400)
4 1 0	Middle sensor (ϕ200 to ϕ1200)
5 1 0	Large sensor (ϕ200 to ϕ6000)
5 0 0	Large sensor (ϕ200 to ϕ6000)
Option	
Y	None
A	Tag name plate
Mounting method	
Y	Standard
2	Z method

(Note) Signal cables are not provided with detector.
Signal cable FLY should be ordered separately.

- Moulded type



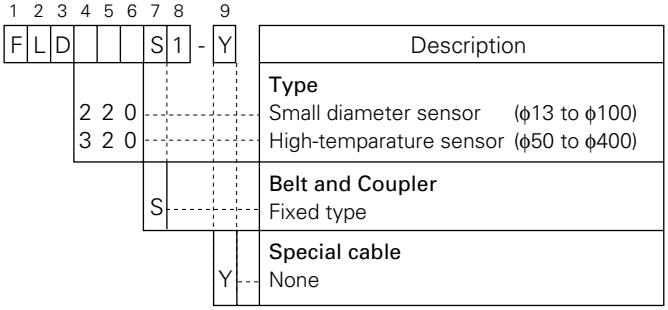
Description	
Type	
1 2	Small sensor (ϕ50 to ϕ400)
4 1	Middle sensor (ϕ200 to ϕ1200)
5 1	Large sensor (ϕ200 to ϕ6000)
5 0	Large sensor (ϕ200 to ϕ6000)
Use	
1	Submergence-proof type
2	Explosion-proof type per EN50028
Option	
Y	None
A	Tag name plate
Special cable	
B Y	10 m
C Y	20
D Y	30
E Y	40
F Y	50
G Y	60
H Y	70
J Y	80
K Y	90
L Y	100
M Y	110
N Y	120
P Y	130
Q Y	140
R Y	150
Mounting method	
Y	Standard
2	Z method

Note)

1. High turbid fluid or scales sticking on the internal wall of pipes may interrupt the ultrasonic propagations.

   Previous check with a portable type ultrasonic flowmeter is recommended.
2. In case of cast iron pipes or pipes with lining, the large sensor is recommended rather than the middle sensor.
3. If the pipe has poor inside surface conditions or highly attenuating fluids, you may not be able to a reliable signal, therefore you should use the “FLW50” sensor.

- Small diameter and high-temperature sensor



Description	
Type	
2 2 0	Small diameter sensor (ϕ13 to ϕ100)
3 2 0	High-temparature sensor (ϕ50 to ϕ400)
Belt and Coupler	
S	Fixed type
Special cable	
Y	None

(4) Code symbols of signal cable

1	2	3	4	5	6	7	8	Description
F	L	Y					1	
								Type of sensor (4th digit code)
			1					Small, middle and large sensor (FLW120/410/510)
			2					Small dia. and high temp. sensor (FLD 22/32)
								Cable length (5, 6 and 7th digit)
				0	0	5		5m
				0	1	0		10 m
				0	1	5		15 m
				0	2	0		20 m
				0	2	5		25 m
				0	3	0		30 m
				0	3	5		35 m
				0	4	0		40 m
				0	4	5		45 m
				0	5	0		50 m
				0	5	5		55 m
				0	6	0		60 m
				0	6	5		65 m
				0	7	0		70 m
				0	7	5		75 m
				0	8	0		80 m
				0	8	5		85 m
				0	9	0		90 m
				0	9	5		95 m
				1	0	0		100 m
				1	1	0		110 m
				1	2	0		120 m
				1	3	0		130 m
				1	4	0		140 m
				1	5	0		150 m

Note: No need to order signal cable of FLY when your ordering submergence-proof or explosion-proof type sensor.
A pair of cables is provided as one unit.

CAUTION ON SAFETY

First of all, read this "Caution on safety" carefully, and then use the flowmeter in the correct way.

- The cautionary descriptions listed here contain important information about safety, so they should always be observed. Those safety precautions are ranked in 2 levels; DANGER and CAUTION.

DANGER	Wrong handling may cause a dangerous situation, in which there is a risk of death or heavy injury.
CAUTION	Wrong handling may invite a dangerous situation, in which there is a possibility of medium-level trouble or slight injury or only physical damage is predictable.

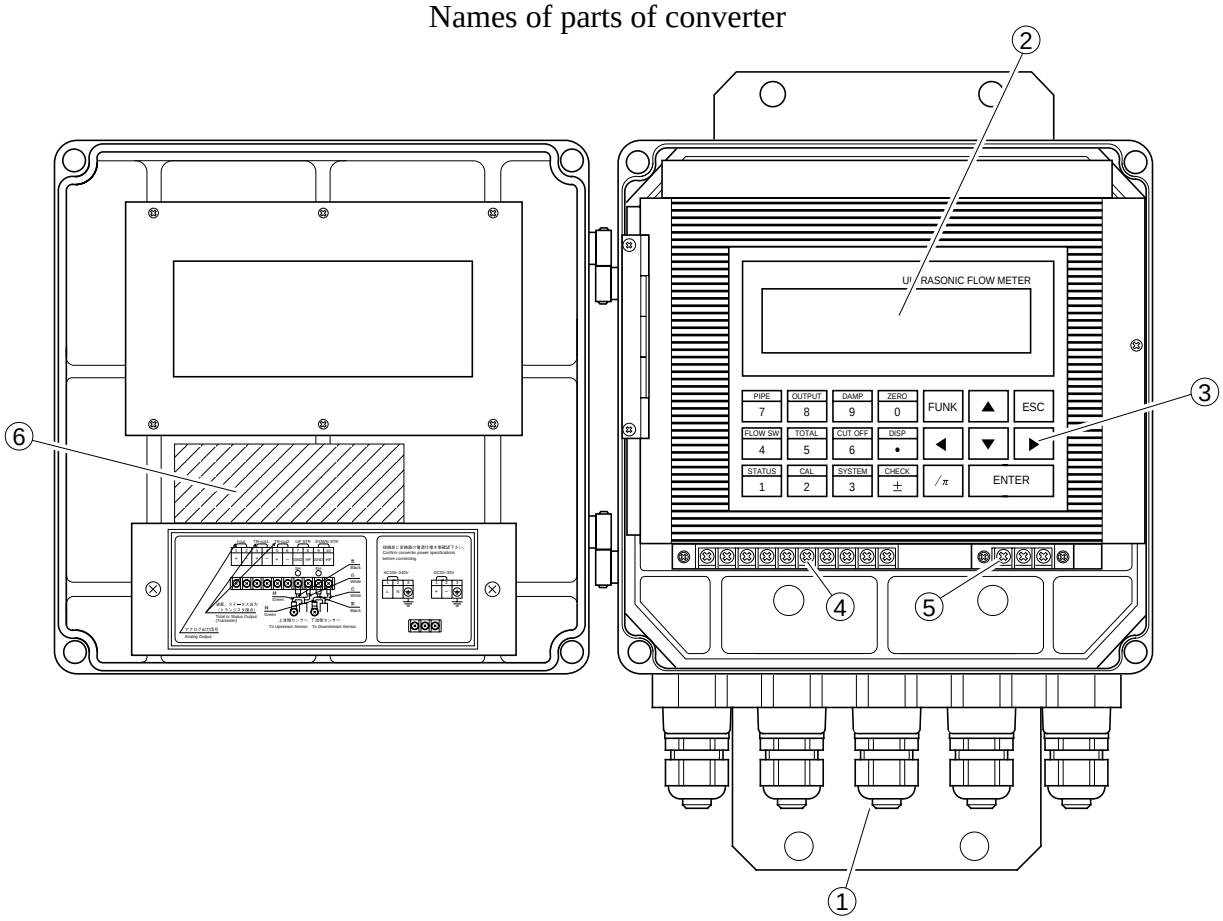
	Caution on installation and wiring
CAUTION	• The flowmeter should be installed in a place that meets the operating conditions shown in this instruction manual. Installation at an unsuited place may cause electric shock, fire or incorrect operation. • Install the flowmeter according to the instruction manual. Improper installation may lead to the cause of fall, trouble or incorrect operation. • When installing, make sure that the flowmeter interior is free from cable chips and other foreign objects to prevent fire, trouble, or incorrect operation. • Connect a power source of correct rating to prevent fire accidents. • Before making wiring work, be sure to turn OFF the power supply to prevent electric shocks. • Use wiring materials of correct rating to prevent fire accidents.

CONTENTS

1. OPERATING PARTS AND THEIR FUNCTIONS

The names and functions of parts of the converter are as follows.

Names of parts of converter



Item	Description
① Wiring port	Wiring port for power cable and signal cable
② Data indicator	Liquid crystal indicator for measurement data and set values
③ Key board	Used for setting the conditions of adjustments and measurements.
④ Main board terminal block	Used for connecting signal cables from sensor. Used for connection of signal cables for analog output and status output.
⑤ Power terminal block	Used for connecting power cable.
⑥ Parameter table	Used for entering setting data.

2. MOUNTING OF CONVERTER

2.1 Selection of mounting place

Install the converter at a place satisfying the following conditions.

① Ambient temperature does not exceed a range of −10°C to +60°C. When installing outdoors, attach a shade or put the converter in an outdoor panel to protect it from direct sunlight.

② Not exposed to moisture.
Even an immersion-proof type is not protected against entry of water. Make arrangements so that water can be drained quickly.

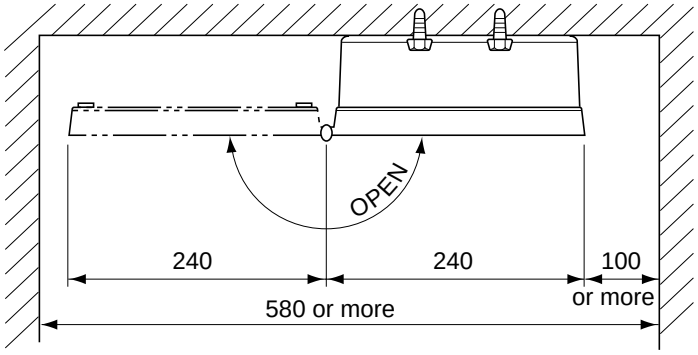


Fig. 2-1 Installation space (top view)

③ Not exposed to dust or corrosive gases.

④ Free from vibrations and shocks.

⑤ Space shown in Fig.2-1 is available for easy inspection and adjustment.

2.2 Mounting method

Wall mounting or 2B bypass stand mounting is available for the converter.

For wall mounting, use 4-M8 bolts.

Be sure to mount the converter at correct position as shown in Fig. 2-2.

Make a hole in the wall or the like according to the cutout dimensions shown in the diagram below, and mount the converter with M8 bolts.

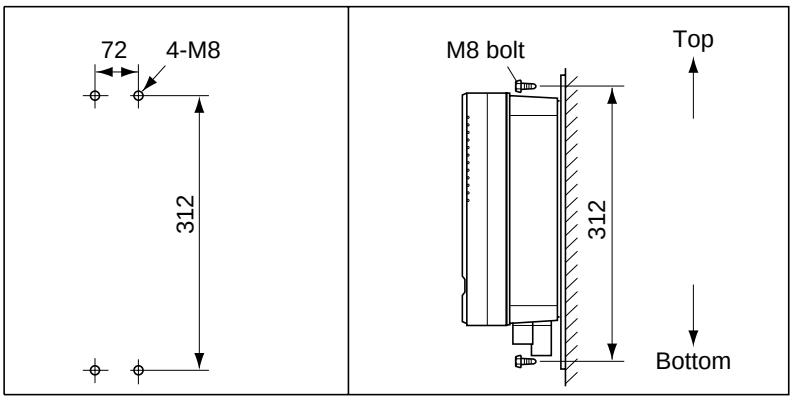
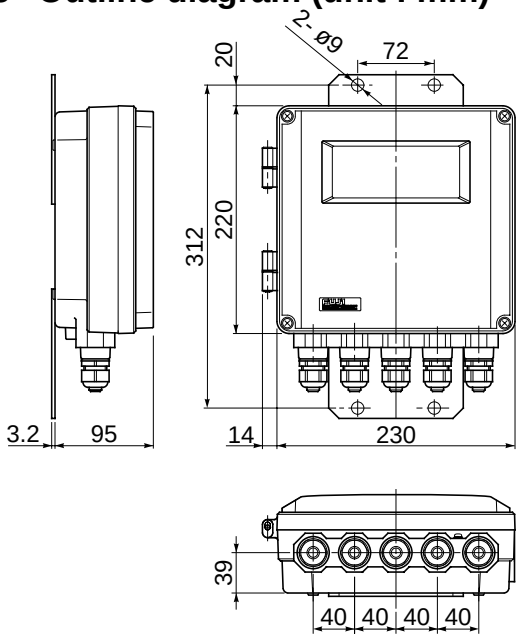


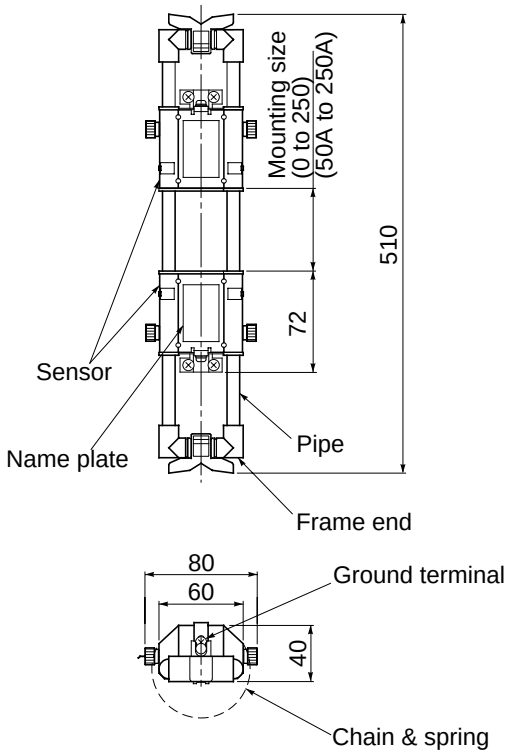
Fig. 2-2 Mounting method

In case of 2B pipe standing type, use U bolts (M8) on the market.

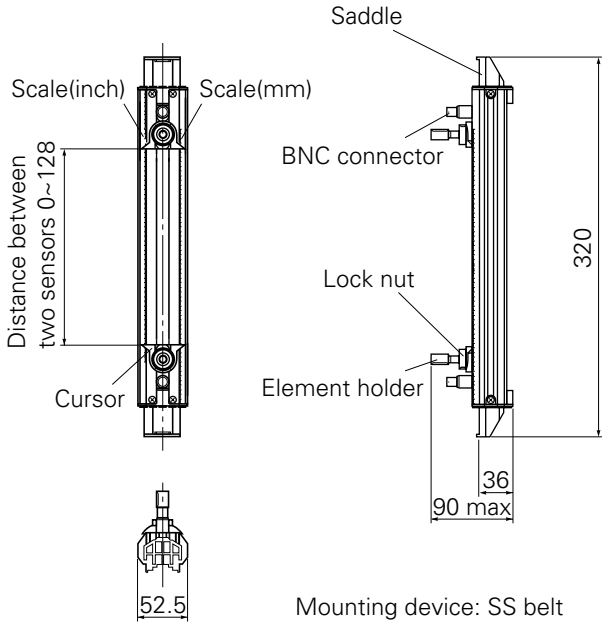
2.3 Outline diagram (unit : mm)



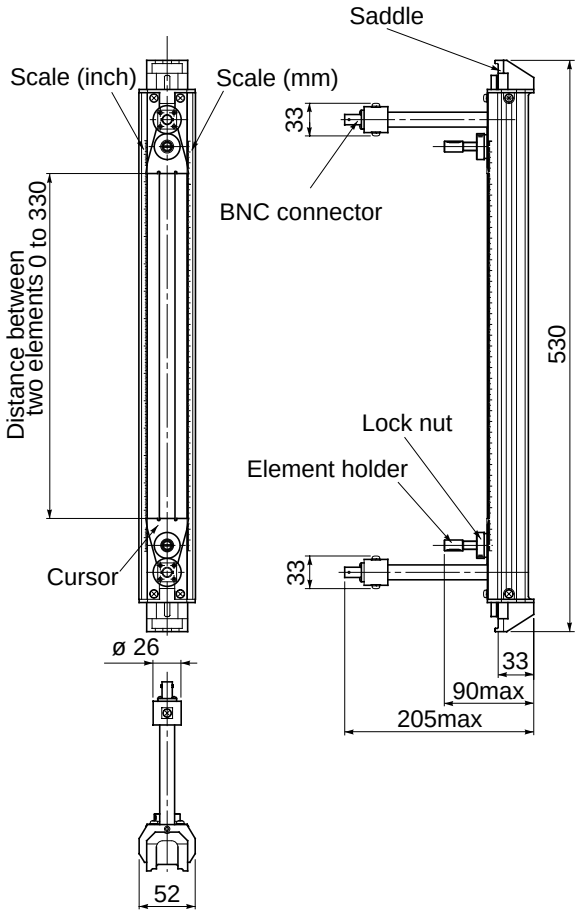
Converter FLV



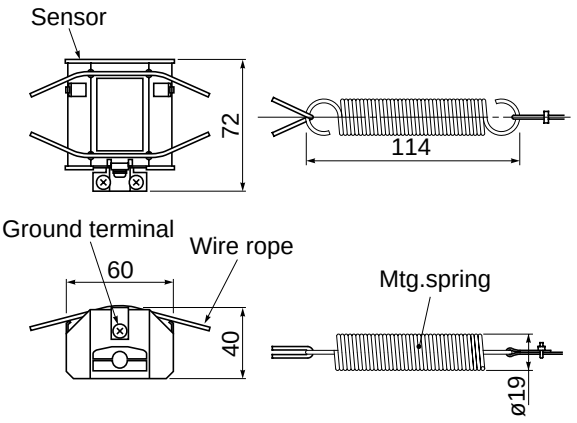
Sensor FLW120 (small sensor)



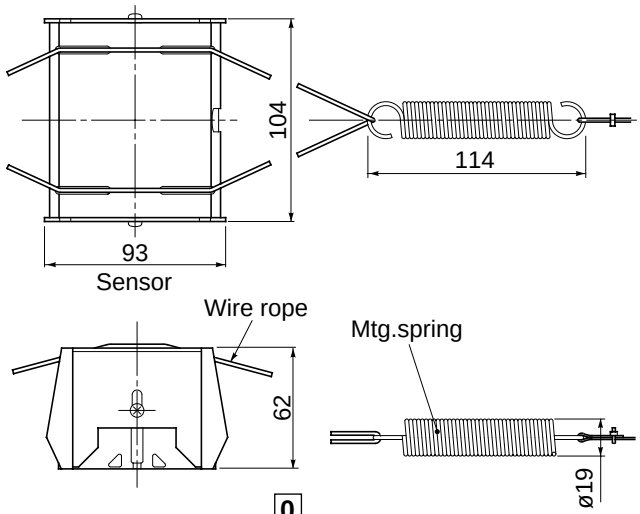
Sensor FLD220 (small diameter sensor)



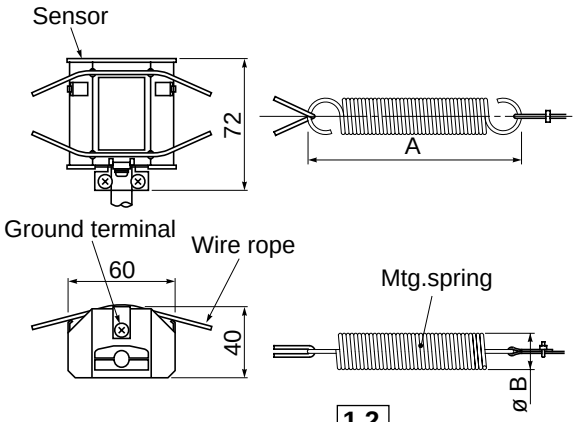
Sensor FLD320 (high-temperature sensor)



Sensor FLW410 (middle sensor)



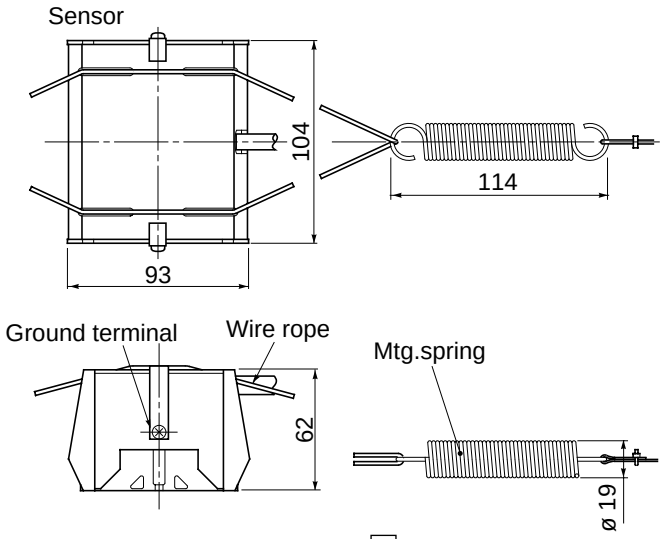
Sensor FLW5 $\frac{0}{1}$ 0 (large sensor)



Sensor FLW $\frac{1\,2}{4\,1}$ 2

(small/middle explosion-proof sensor)

Type	A	B
FLW122	68	10
FLW412	114	19



Sensor FLW5 $\frac{1}{0}$ 2

(large explosion-proof sensor)

3. WIRING OF THE CONVERTER

3.1 Before wiring

① **For signal cable between the sensor and converter, use double-shielded coaxial cables.**
The coaxial cable should be refrained from connecting midway.

② The signal cable between the sensor and converter should be run in metalic conduits.
To prevent the effects of induction noise, upstream and downstream signal cables should be wired as far away from power cable as possible.

③ An output signal cable should use shielded cable as much as possible.

④ To prevent the effects of noise, do not install signal cables together with power cable in the same duct.

⑤ A power cable is provided with earth wire, it should be connected to the ground.

⑥ As this instrument is not equipped with a power switch, be sure to mount a power switch on the instrument.

⑦ Wiring ports should be closed when they are not ready to use.

3.2 Wiring

Use the following cables :

- Power cable : 3 or 2 core cabtyre cable,
  Nominal sectional area : 0.75mm^2 or more,
  Finished outside diameter : ø11mm
- Output signal cable : 2 core cable or multi-core cabtyre cable as needed.
  Finished outside diameter : ø11mm
- Cable between sensor and converter :
  Signal cable specified by Code Symbols
  (High frequency coaxial cable with characteristic impedance of 50Ω)
  Finished outside diameter : ø7.3mm

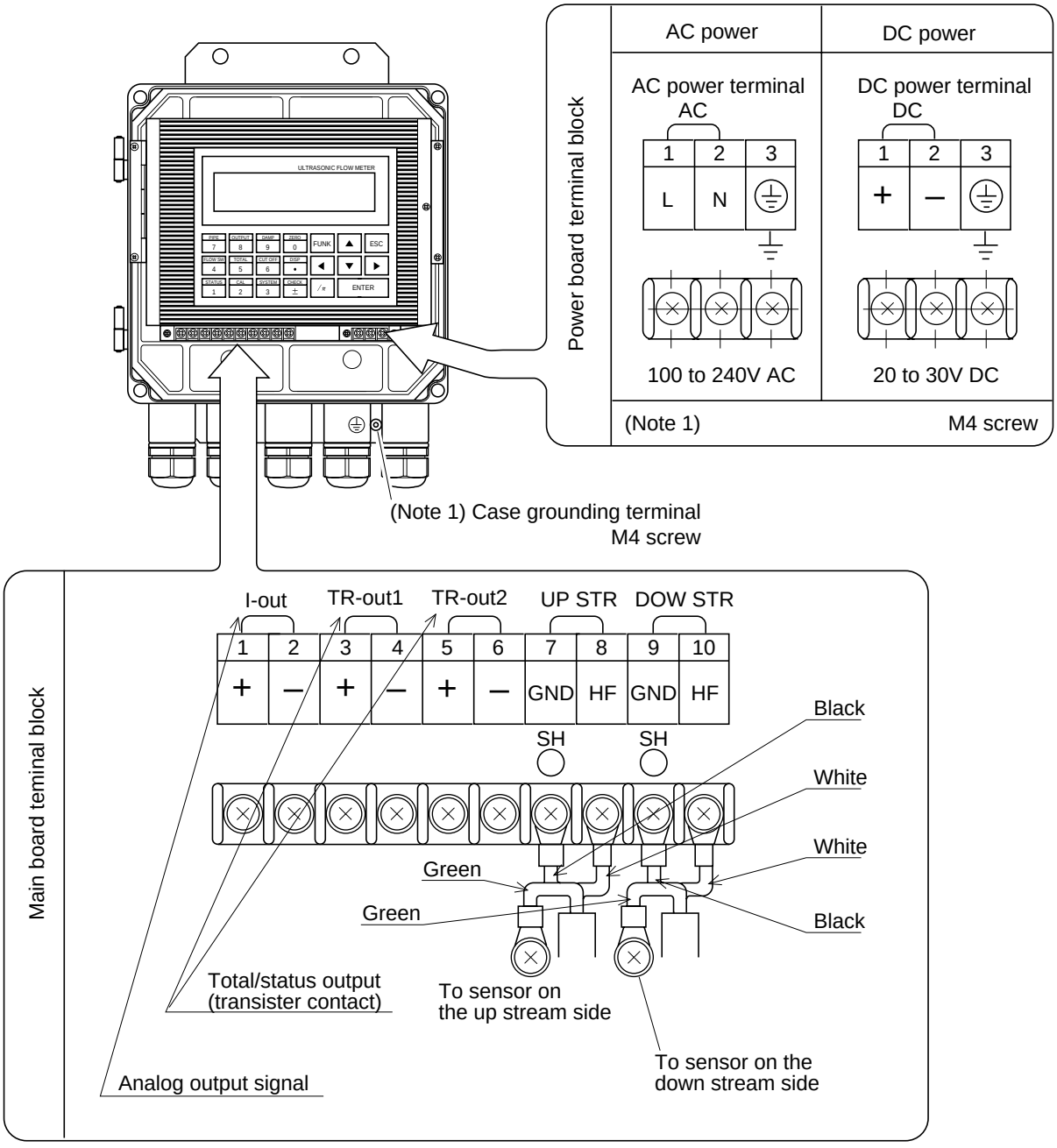
3.3 Treatment of the wiring port

The converter is an immersion-proof type specified by JIS C0920 “Rules for water-proof tests of electromechanical instruments and wiring materials“. However, if the converter is to be installed in a pit, air tightness treatment should be provided for the wiring port to prevent possible entry of moisture, dew condensation or immersion of water.

Waterproof measures should be taken by using waterproof gland or plica tube gland furnished with this instrument. A gland, which is not ready to be used, should be sealed by supplied cover.

3.4 Wiring to terminals

Cables should be connected as shown in the following diagrams.



Note 1) Power board terminal block (for power) and case grounding terminals are available for grounding terminals.
Be sure to earth either of them. (Class D, wiring)

4. OPERATION AND WORKS

4.1 Before operation

Check the following before starting operation.

1. Power

Power check …… See Item 4.2 (1)

2. Wiring

① Check of main board terminal block ……
② Check of power board terminal block …… } See Item 3.4
③ Check of grounding terminal ……

3. Piping

① Check that a piping is filled with fluid.
② Check that there is no problem when water stops or flows.

4.2 Power ON and status

(1) Power specification

① AC power

Use power supply of 100 to 240VAC ±10% (50/60 Hz).

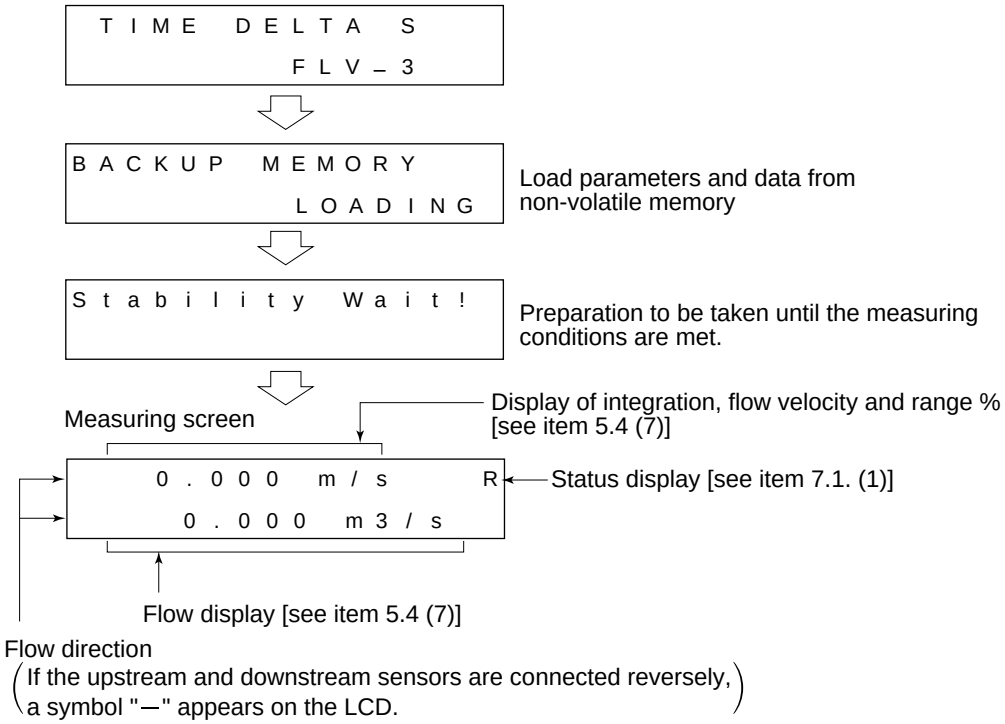
② DC power

A power of 20V to 30V DC is available.

(2) Power ON

When the instrument is turned on, the following data are displayed on the LCD after making a self-check of the devices.

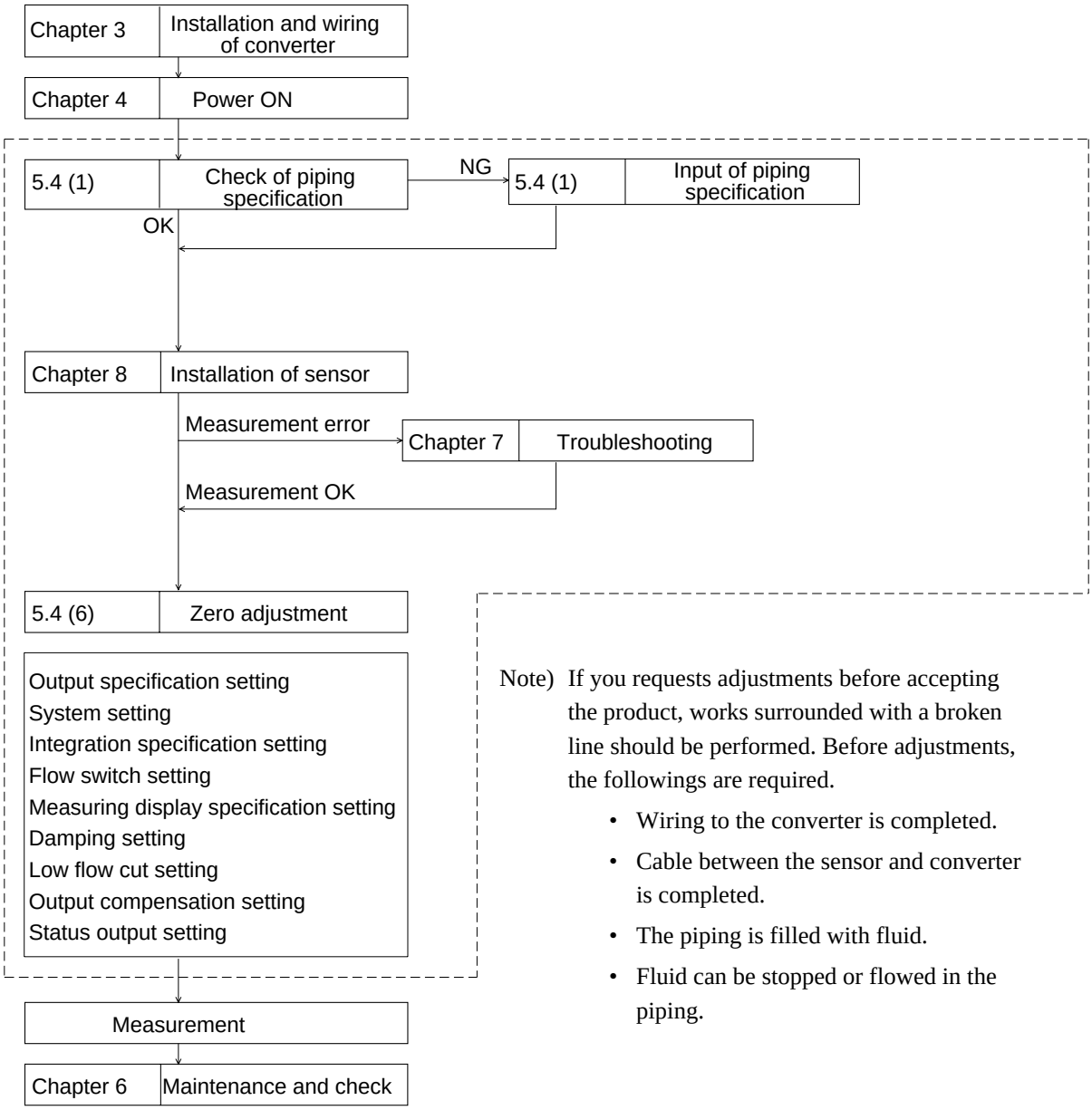
The numerical values and symbols being displayed are as described below:



5. SETTING OF PARAMETERS

5.1 Outline of operating procedures

Proceed to the following procedure before starting measurements.



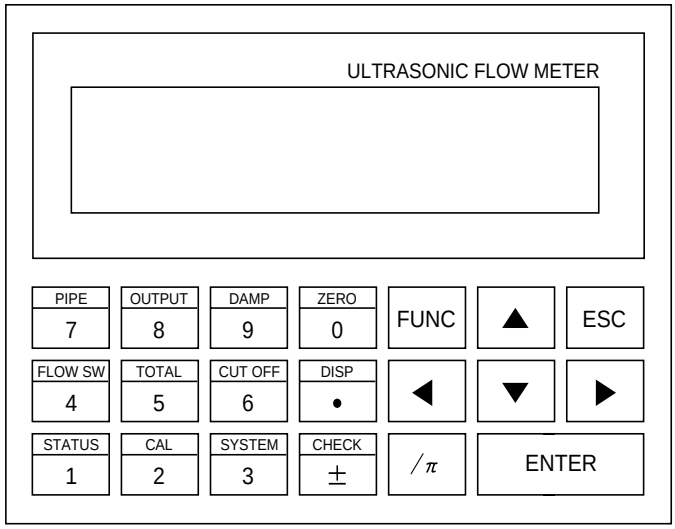
Note) If you requests adjustments before accepting the product, works surrounded with a broken line should be performed. Before adjustments, the followings are required.

- Wiring to the converter is completed.
- Cable between the sensor and converter is completed.
- The piping is filled with fluid.
- Fluid can be stopped or flowed in the piping.

5.2 Description of key operation

Note) When adjustment is performed or setting is changed in this chapter, be sure to enter parameters in the list attached to the converter.

Pressing the FUNC key enables you to perform the functions shown on the upper side of the ten-keys.



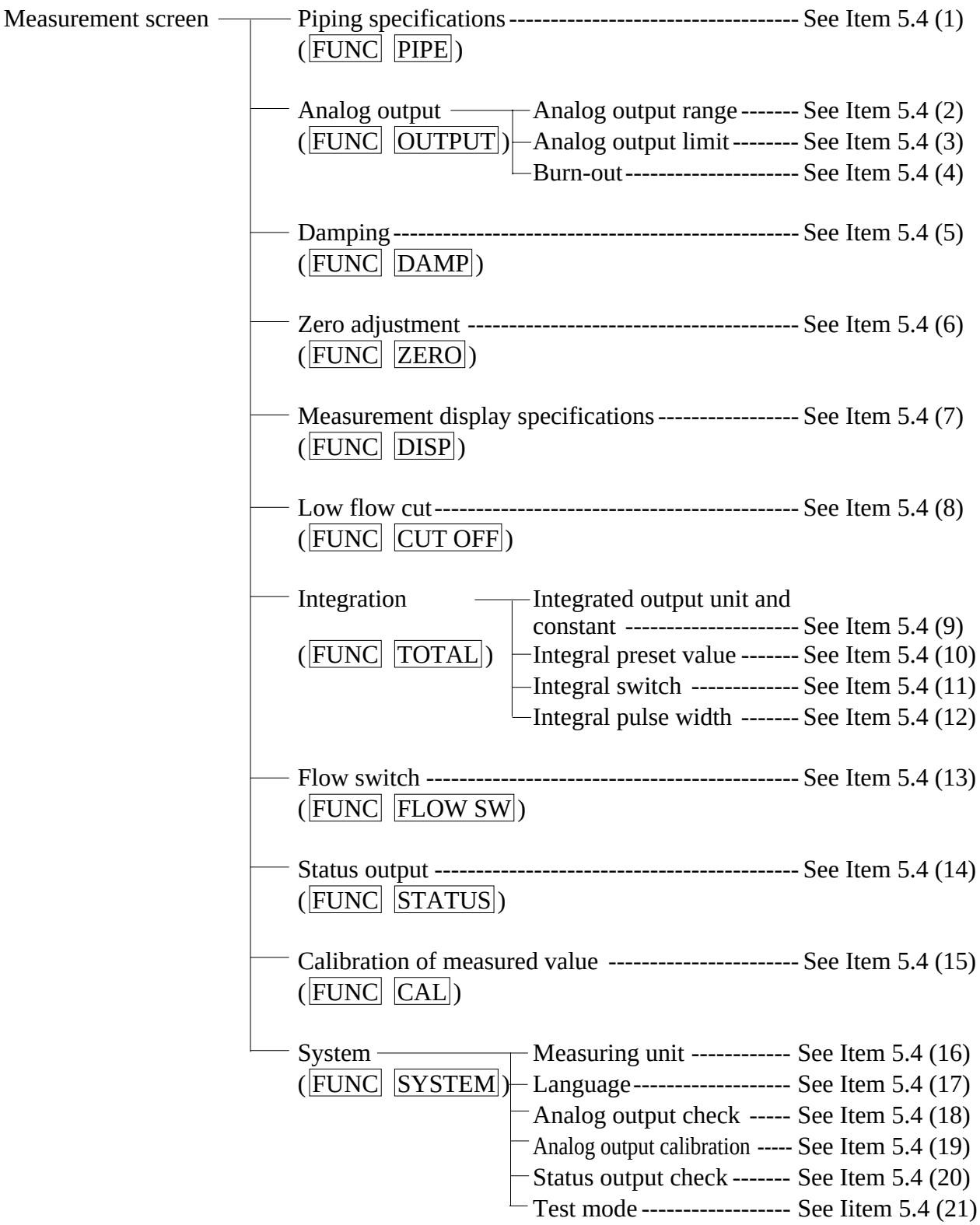
Description of key (1/2)

Name	Key display	Description
Ten-keys	0 to 9 , • , ±	To enter data and numeric values of piping specifications.
ENTER	ENTER	By pressing this key, numeric data and selected interactive items are set. In the interactive mode, questions are displayed.
◀ , ▶	◀ , ▶	To move the cursor to correct numeric values. Pressing the ◀ key allows the cursor to be moved the left. Pressing the ▶ key allows the cursor to be moved the right. Select the menu item display in an interactive message.
▲ , ▼	▲ , ▼	Pressing the ▲ key allows the menu page to advance. Pressing the ▼ key allows the menu page return.
ESCAPE (Stop)	ESC	To stop interactive operation.
FUNC. (Function)	FUNC	To perform the function inscribed on each ten-key.

Description of key (2/2)

Name	Key display	Description
/π	/π	By pressing this key, the circumstance of pipe, which has been entered, is converted into the outside diameter. (valid only when setting the outside diameter of pipe)
PIPE	FUNC PIPE	To enter the size and material of the sensor piping.
OUTPUT (Analog output)	FUNC OUTPUT	To set the condition of an analog output (units, range, limit, burn-out)
DAMPING	FUNC DAMP	To set the damping.
ZERO	FUNC ZERO	To use when zero adjustment is performed.
DISPLAY	FUNC DISP	Keys used to change items or unit system on the measurement display screen.
CUT OFF (Low flow cut)	FUNC CUT OFF	To set the low flow cut.
TOTAL (Integration)	FUNC TOTAL	To set condition required for integration of flow rate. (units, constant, preset value, integral switch, pulse width)
FLOW SW (Flow switch)	FUNC FLOW SW	To set the measured high/low value switch
STATUS	FUNC STATUS	To set condition of status output (integration pulse, measuring status)
CAL. (Calibration)	FUNC CAL	To compensate indication values of zero point and 100% point. (Current output is effected)
SYSTEM	FUNC SYSTEM	To switch the measuring unit system and language, or confirm or calibrate analog output.
CHECK	FUNC CHECK	To display an error message and countermeasures when an error appears. (An error message is displayed on the upper-right of the LCD.)

5.3 List of setting items



5.4 Setting of parameters

• Units are displayed in metric system.

5.4 (1) Setting of piping specifications

Description

Set the data of pipe required for measurement. The mounting dimension of the sensor is automatically calculated. Data of each item should be entered according to the display.

Item	Entry	Range or menu
Outer diameter of pipe	Numeric value	13mm to 6100mm
Material of pipe	Selectable	CARBON STEEL, STAINLESS STEEL, PVC, COPPER, CAST IRON, ALUMINUM, FRP, ASBESTOS, DUCTILE IRON, PEEK, PVDF, ACRYLIC, OTHERS*1
Pipe wall thickness	Numeric value	0.1mm to 100mm
Lining (with/without) and material	Selectable	NO LINING, TAR EPOXY, MORTAR, RUBBER, TEFLON, PYREX GLASS, PVC, OTHERS *1
Type of fluid	Selectable	WATER, SEAWATER, OTHERS *1
Kinematic viscosity coefficient of fluid	Numeric value	0.001E−6m^2/s to 999.999E−6m^2/s *2
Mounting method of sensor	Selectable	V METHOD, Z METHOD
Type of sensor	Selectable	FLW12, FLD22, FLD32, FLW41, FLD12, FLW50, FLW51
Transmission voltage of sensor	Selectable	1 TIME, 2 TIMES, 4 TIMES, 8 TIMES

*1) Selection of “OTHERS”
Materials of piping and lining should be selected within the range of 1000 to 3700m/s of sound velocity and 500 to 2500m/s of flow velocity (see Appendix).

*2) Kinematic viscosity coefficient is expressed in water (20°C 1.003E−6m^2/s)
When more accurate data need be obtained or fluid other than water is selected, enter an appropriate data as needed from Appendix.

Operation (example)	Outside diameter: 114.3mm, pipe material: carbon steel, thickness: 4.5mm, lining material: mortar, thickness: 1.25mm, fluid: heavy water, sound velocity: 1388m/s, kinematic viscosity coefficient: $1.129 \times 10^{-6} m^2/s$, sensor mounting method: V method, type: FLW12, transmission voltage: 8 times

Key operation	Description	Display
FUNC PIPE	The sensor mounting dimension is displayed.	SENSOR SPACING 0.00 mm (V)
▲ or ▼	Select “OUTER DIAMETER”.	OUTER DIAMETER 114.3 mm
1 1 4 . 3, ENTER	Enter “114.3” with ten keys.	
◀ or ▶, ENTER	Select “CARBON STEEL”.	PIPE MATERIAL CARBON STEEL
4 . 5, ENTER	Enter “4.5” with ten keys.	WALL THICKNESS 4.5 mm
◀ or ▶, ENTER	Select :MORTAR”.	LINING MATERIAL MORTAR
1 . 2 5 , ENTER	Enter “1.25” with ten keys.	LINING THICKNESS 1.25 mm
◀ or ▶, ENTER	Select “OTHERS”.	KIND OF FLUID OTHERS
1 3 8 8, ENTER	Enter “1388” with ten keys.	FLUID S.V. 1388 m/s
1 . 1 2 9, ENTER	Enter “1.129” with ten keys.	VISCOSITY 1.129E-6 m2/s
◀ or ▶, ENTER	Select “V METHOD”.	SENSOR MOUNTING V METHOD
◀ or ▶, ENTER	Select “FLW12”.	SENSOR TYPE FLW12
Note 3 ◀ or ▶, ENTER	SELECT “8 TIMES”.	TRANS. VOLTAGE 8 TIMES
	The sonsor mounting dimension is displayed.	SENSOR SPACING 79.49 mm (V)
ESC ESC	Press the key twice.	(Measurement display)

Note 3) When selecting the transmission voltage, generally choose “4 TIMES”.

5.4 (2) Setting of analog output range

Description

An analog output range is set to provide an output of 4 to 20mA in the specified range of measured values (flow rate or flow velocity).

[Measurement items]

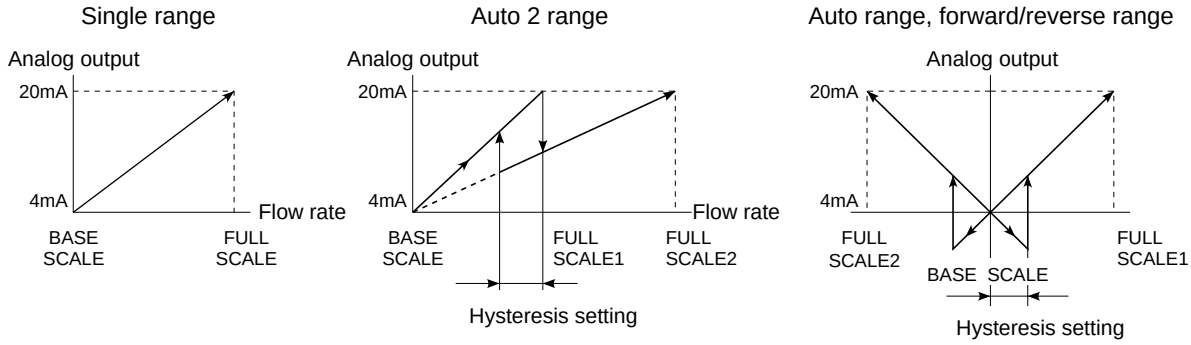
① Selection of range unit ..... m/s

Note 1) L/s, L/min, L/h, ML/d
m^3/s, m^3/min, m^3/h, Mm^3/d
BBL/s, BBL/min, BBL/h, MBBL/d

Choose any of the unit : METRIC system

② Selection of range type

- SINGLE RANGE : Single range
- AUTO 2 RANGES : Auto 2 ranges
- BI-DIR. RANGE : Auto forward/reverse range



③ Setting of range

- BASE SCALE : Set flow rate value or flow velocity value for 4mA output.
  Flow velocity value should be set within the range of 0 to ±32m/s.
- FULL SCALE : Set flow rate value or flow velocity value for 20mA output.
  Flow velocity value should be set within the range of ±0.3 to ±32m/s.

④ Setting of hysteresis

When selecting "AUTO 2 RANGES" or "BI-DIR.RANGE" from the type of range, hysteresis is selectable.

Set the hysteresis within the range of 0 to 20% of full scale.

- In case of auto 2-range : Hysteresis of span size of full-scale 1 or full-scale 2, whichever is smaller
- In case of forward/reverse range : Hysteresis of span in action range

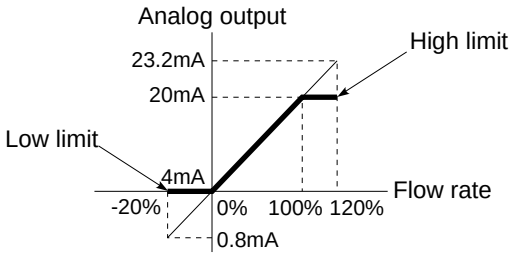
Note 1) Flow units of low flow cut, flow switch and output compensation flow units are changed with the selection of the range unit.

Operation (example)	When setting the base scale to 0m³/h, full scale 1 to 100m³/h, full scale 2 to −100m³/h and hysteresis to 5% in the forward/reverse range.	
Key operation	Description	Display
FUNC OUTPUT		
◀ or ▶, ENTER	Select “m3/h”.	RANGE UNIT m3/h
◀ or ▶, ENTER	Select “BI-DIR. RANGE”.	RANGE TYPE BI-DIR. RANGE
0 , ENTER	Enter “0” with ten keys.	BASE SCALE 0 m3/h
1 0 0, ENTER	Enter “100” with ten keys.	FULL SCALE 1 100 m3/h
± 1 0 0, ENTER	Enter “−100” with ten keys.	FULL SCALE 2 −100 m3/h
5 , ENTER	Enter “5” with ten keys.	RANGE HYSTERESIS 5 %
ESC ESC	Press the key twice.	(Measurement display)

5.4 (3) Setting of analog output limit

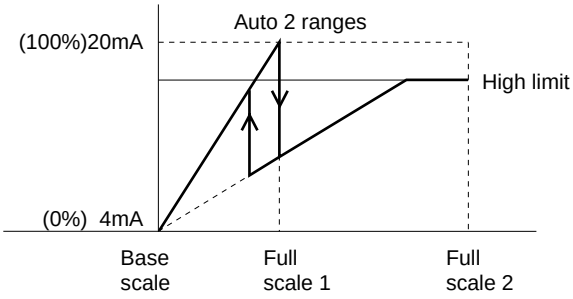
Description

Set the high/low limits within the range of analog output of 0.8 to 23.2mA (−20 to 120%).



Operation (example)	Low limit : -10% (2.4mA), high limit : 110% (21.6mA)	
Key operation	Description	Display
FUNC OUTPUT		
▲ or ▼	Select “OUTPUT LIMIT”.	OUTPUT LIMIT LOW −20 %
± 1 0 , ENTER	Enter “−10”with ten keys.	OUTPUT LIMIT LOW −10 %
1 1 0 , ENTER	Enter “110” with ten keys.	OUTPUT LIMIT HIGH 110 %
ESC ESC	Press the key twice.	(Measurement display)

- In case of AUTO 2-RANGE :
  Low limit is limited to the small range, and high limit is limited to the large range.
- In case of BI-DIR. RANGE :
  The low/high limits are limited to the range of action.



5.4 (4) Setting of burn-out

Description

When the pipe is empty of fluid or when air bubbles are contained in fluid, the flow rate can not be measured correctly. In such a case, the analog output needs to be set to “HOLD”, “HIGH” limit or “LOW” limit. A burnout timer is used to set the time needed for burnout.

(Setting items)

- HOLD : Measured value is held
- UPPER : 120% output (23.2mA) is obtained.
- LOWER : –20% output (0.8mA) is obtained.
- ZERO : 0 % output (4.0mA) is obtained.
- NOT USED : Not used.
- Liquid crystal display : Measured value is held.
- Integrated pulse output : Output stops Note)
- Internal integration : Integration stops Note)

Note) Integrated pulse output and internal integration is integrated until the burnout timer is energized.

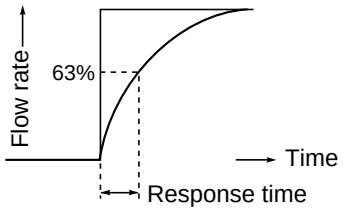
Operation (example)	When setting the burnout to the “HOLD” limit and burnout timer to 15 seconds.	
Key operation	Description	Display
FUNC OUTPUT		
▲ or ▼	Select “OUTPUT BURNOUT”.	OUTPUT BURNOUT NOT USED
◀ or ▶, ENTER	Select “HOLD”.	OUTPUT BURNOUT HOLD
1 5 , ENTER	Enter “15” with ten keys.	BURNOUT TIMER 15 sec
		(Measurement display)

5.4 (5) Setting of damping

Description

Damping is used to suppress fluctuation of measured values.

The set value is a time constant (about 63% response time). (Setting range : 0 to 100 sec)



Unless otherwise specified in the order sheet, the setting time of damping is adjusted to 5 sec.

Operation (example)	Change of set value to 20 sec.	
Key operation	Description	Display
[FUNC] [DAMP] [2] [0], [ENTER]	Enter “20” with ten keys.	DAMPING 20 sec (Measurement display)

5.4 (6) Zero adjustment

Description

Zero point of measured value is adjusted.

(Setting items)

- SET ZERO : Stop the flow of fluid and adjust zero point.
  The zero pont is the state of measurement at set point.
- CLEAR : This setting is used when fluid will not stop flowing.
  Adjusted zero point is cleared.

Operation (example)	Zero point adjustment when fluid is in stop mode.	
Key operation	Description	Display
FUNC ZERO ◀ or ▶ , ENTER	Select “SET ZERO”.	ZERO MODE SET ZERO Zero Set Adjust! ********** Wait a moment. (Measurement display)

5.4 (7) Setting of measurement display specifications

Description

Select measured value from the following.

① Setting of measurement display 1st line

Select any one from the following 7 types for the 1st line display.

F : TOTAL	: Forward integral value
R : TOTAL	: Reverse integral value
TOTAL DIFF	: Forward/reverse difference between integral values
F : TOTAL PULSE	: Forward integral pulse counter
R : TOTAL PULSE	: Reverse integral pulse counter
FLOW VELOCITY	: Instantaneous flow velocity [m/s]
RANGE %	: Ratio of analog output to range

② Setting of decimal measurement display on 2nd line

On the second display is instantaneous flow rate displayed.

Select one from the following 12 units of flow rate.

L/s, L/min, L/h, ML/d, m^3/s, m^3/min, m^3/h, Mm^3/d
BBL/s, BBL/min, BBL/h, MBBL/d } (metric system)

③ Setting of decimal point position of instantaneous flow rate display

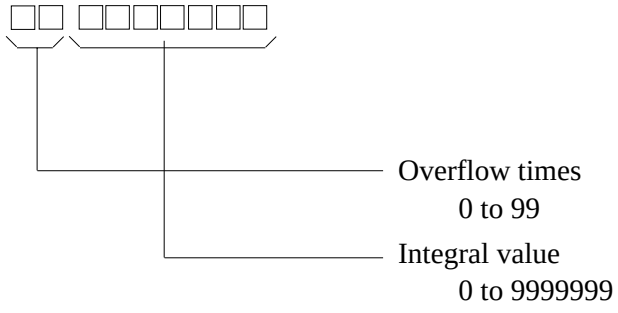
Setting of digit display after the decimal point is available.

Select any one from the following.

Position of decimal point (digit)		Range of data display				
00000000.	:	−99999999.	to	0.	to	99999999.
0000000.0	:	−9999999.9	to	0.0	to	9999999.9
000000.00	:	−999999.99	to	0.00	to	999999.99
00000.000	:	−99999.999	to	0.000	to	99999.999
0000.0000	:	−9999.9999	to	0.0000	to	9999.9999
000.00000	:	−999.99999	to	0.00000	to	999.99999
00.000000	:	−99.999999	to	0.000000	to	99.999999
0.0000000	:	−9.9999999	to	0.0000000	to	9.9999999

Display of integral value

1. Display of forward/reverse integral values



2. Display of forward/reverse difference between integral values

Difference of integrated value = forward integral value − reverse integral value.

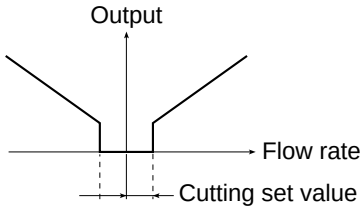
Note : If any of integral values in the forward and reverse directions exceeds the over flow mark, ####### is displayed.

Operation (example)	Display instantaneous flow velocity and instantaneous flow unit in m3/h, and instantanous flow rate in 3 digits after decimal point.	
Key operation	Description	Display
FUNC DISP		
◀ or ▶ , ENTER	Select “VELOCITY”.	1: DISPLAY KIND VELOCITY
◀ or ▶ , ENTER	Select :m^3/h”.	2: FLOW UNIT m3/h
◀ or ▶ , ENTER	Select “00000.000”.	2: DECIMAL POINT 00000.000 m3/h
		(Measurement display)

5.4 (8) Low flow cut

Description

A low flow output can be cut.
This flowmeter will display the flow rate, when the fluid in the piping is moving with the valve closed due to a convection current. The cutting point should be set as needed.
(Setting range : 0 to 5m/s in terms of flow velocity value)



Operation (example)	Setting of cutting point to 0.05m/s.	
Key operation	Description	Display
FUNC CUT OFF 0 . 0 5 , ENTER	Enter “0.05” with ten keys.	CUT OFF 0.05 m/s (Measurement display)

5.4 (9) Setting of integrated output unit and constant

Description

Integrated output unit is set to integrate measurement value (flow rate)

Just after setting of measured value is completed, the pulse counter begins integration by clearing the previous integrated value.

① Integrated unit……Select one of the following 8 kinds of integral units.

mL, L, m^3, km^3, Mm^3, mBBL, BBL, kBBL (metric system)

Note : When changing the integrated unit, integral constant value and integral preset value are cleared.

②Integral constant

When the flow rate reaches the value set by the integral constant, integral pulse value is displayed on the measurement screen, and the integral pulse counter provides an output of 1 pulse.

Setting range : 0 to 9999999

Operation (example)	Integrated output of 100m^3	
Key operation	Description	Display
FUNC TOTAL ▲ or ▼, ENTER	Display “TOTAL MODE”.	TOTAL MODE TOTAL STOP
◀ or ▶, ENTER	Select “m3”.	TOTAL UNIT m3
1 0 0 , ENTER	Enter “100” with ten keys.	TOTAL RATE 100 m3
ESC	Display “TOTAL MODE”.	TOTAL MODE TOTAL STOP
◀ or ▶, ENTER	Select “TOTAL RUN”.	TOTAL MODE TOTAL RUN
ESC ESC	Press the key twice.	(Measurement display)

Integral mode

TOTAL STOP : Integration is stopped.

TOTAL START : Integration is started (integral parameter can not be changed at a time of start).

TOTAL RESET : Integral value is set to the integral preset value, and integration is stopped.

When the flowmeter is restored from power interruption, it will be operated in the integral mode that was set before power interruption.

[Note : If measurement is abnormal, refer to burnout setting for integration.]

5.4 (10) Setting of integral preset value

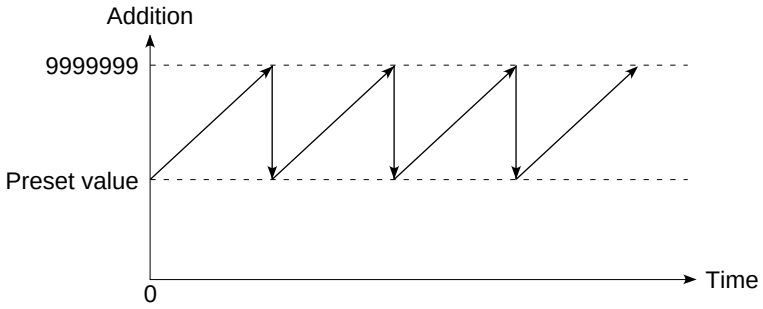
Description

Set integrated preset value

F : TOTAL PRESET : Forward integral preset value

R : TOTAL PRESET : Reverse integral preset value

Setting range : 0 to 9999999



Note : In case of setting, please keep “TOTAL MODE” suspended.

Operation (example)	Forward direction : 1000m^3, reverse direction : 2000m^3	
Key operation	Description	Display
FUNC TOTAL		
▲ or ▼	Select “F : TOTAL PRESET”.	F:TOTAL PRESET 0 m3
1 0 0 0 , ENTER	Enter “1000” with ten keys.	F:TOTAL PRESET 1000 m3
ENTER	Select “R : TOTAL PRESET”.	R:TOTAL PRESET 0 m3
2 0 0 0 , ENTER	Enter “2000” with ten keys.	R:TOTAL PRESET 2000 m3
ESC ESC	Press the key twice.	(Measurement display)

5.4 (11) Setting of integration switch

Description

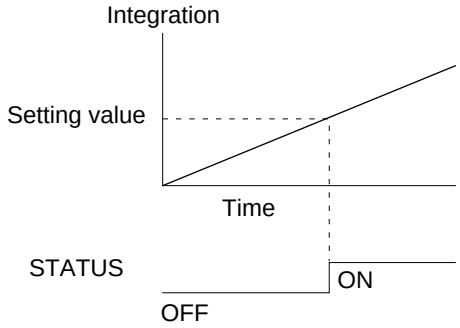
When an integral value exceeds the set value, the status output is provided.

F : TOTAL SW : Forward integration switch

R : TOTAL SW : Reverse integration switch

Setting range : 0 to 9999999

Note) When setting the status output, integration switch is valid only when “F : TOTAL SW” or “R : TOTAL SW” is set.



Note : In case of setting, please keep “TOTAL MODE” suspended.

Operation (example)	Set value of forward integration switch :50000m^3	
Key operation	Description	Display
FUNC TOTAL ▲ or ▼	Select “TOTAL SW”.	F: TOTAL SW 0 m3
5 0 0 0 0 , ENTER	Enter “50000” with ten keys.	F: TOTAL SW 50000 m3
ESC ESC	Press the key twice.	(Measurement display)

5.4 (12) Selection of integral pulse width

Description

When setting status output, set the pulse width to use “F:TOTAL” or “R:TOTAL”.
The following 2 types can be selected according to the counter connected.

- 50msec
- 100msec

Note : In case of setting, please keep “TOTAL MODE” suspended.

Operation (example)	Pulse width : 100msec.	
Key operation	Description	Display
FUNC TOTAL		
▲ or ▼	Select “Pulse width”.	PULSE WIDTH 50 msec
◀ or ▶, ENTER	Select “100msec”.	PULSE WIDTH 100 msec
ESC ESC	Press the key twice.	(Measurement display)

5.4 (13) Setting of flow switch

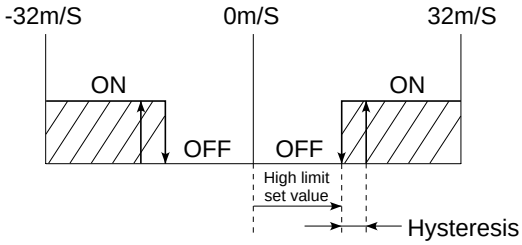
Description

①Set high limit and low limit of switching point when using high limit flow or low limit flow to set the status output.

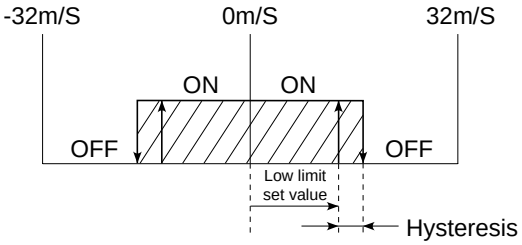
Setting range : 0 to ±32m/s of flow velocity

[Relation between status output and set value]

• High limit setting and high limit flow



• Low limit setting and low limit flow



②Setting of hysteresis

Switching hysteresis can be held in the following range.

Set hysteresis within 0 to 20% of the analog output range full scale (with auto 2 range, and forward and reverse auto range, effective for full scale 1 and 2, whichever small).

Operation (example)	Low limit flow velocity : 3.5m/s, high limit flow velocity value: 12m/s, hysteresis: 5%	
Key operation	Description	Display
[FUNC] [FLOW SW]		
[3] [.] [5], [ENTER]	Enter “3.5” with ten keys.	FLOW SW LOW 3.5 m/s
[1] [2], [ENTER]	Enter “12” with ten keys.	FLOW SW HIGH 12 m/s
[5], [ENTER]	Enter “5” with ten keys.	FLOW SW HYS. 5 %
		(Measurement display)

5.4 (14) Setting of status output

Description

• When the status of setting or integral pulse is outputted, the contents of output is set.

①	NOT USED	: No output
②	SIGNAL ERROR	: ON at abnormal measurement
③	F : TOTAL PULSE	: Forward flow integral pulse
④	R : TOTAL PULSE	: Reverse flow integral pulse
⑤	FLOW SW HIGH	: ON when the flow rate is over the high limit set by flow switch.
⑥	FLOW SW LOW	: ON when the flow rate is below the low low limit set by flow switch.
⑦	F : TOTAL ALARM	: ON when the flow rate is over the forward flow integration switch.
⑧	R : TOTAL ALARM	: ON when the flow rate is below the reverse flow integration switch.
⑨	F : TOTAL OVERFLOW	: ON when the forward flow integral value overflows.
⑩	R : TOTAL OVERFLOW	: ON when reverse flow integral value overflows.
⑪	FULL SCALE 2	: ON at FULL SCALE 2 RANGE in analog output range status.
⑫	R : FLOW DIRECTION	: ON when the flow direction is reverse.
⑬	RANGE OVER	: ON when the set value of the output span exceeds the range of –10 to 110%, or integral pulse output exceeds 5 pulse/sec.
⑭	BACKUP ERROR	: ON when the backup non-volatile memory is abnormal.

• Setting of status output pulse mode
NORMAL : effective when status output is ON.
REVERSE : effective when status output is OFF.

Operation (example)	When setting the forward integral pulse and contact output in the normal mode. Channel 1 is outputted to the TR out1.	
Key operation	Description	Display
FUNC STATUS		
◀ or ▶, ENTER	Select “CHANNEL 1”.	STATUS CHANEL CHANNEL 1
◀ or ▶, ENTER	Select “F : TOTAL PULSE”.	STATUS SEL. : CH1 F : TOTAL PULSE
◀ or ▶, ENTER	Select “NORMAL”.	STATUS MODE : CH1 NORMAL
ESC	(Continued on next page)	

Operation (example)	When setting the forward integral pulse and contact output in the reverse mode. Channel 2 is outputted to the TR out2.	
Key operation	Description	Display
◀ or ▶, ENTER	Select “CHANNEL 2”.	STATUS CHANEL CHANNEL 2
◀ or ▶, ENTER	Select “F : TOTAL ALARM”.	STATUS SEL : CH2 F : TOTAL ALARM
◀ or ▶, ENTER	Select “REVERSE”.	STATUS MODE : CH2 REVERSE
ESC ESC	Press the key twice.	(Measurement display)

5.4 (15) Calibration of measured value

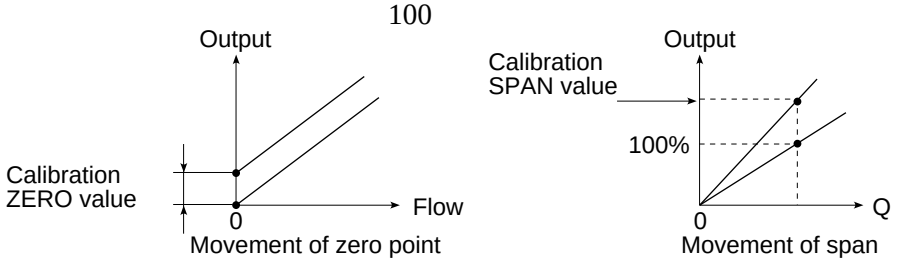
Description

Measured value (zero and span points) can be calibrated, if required.
Zero point and span point can be calibrated.

Calibration range : Zero point : ±5m/s of flow velocity
Span : ±200%

Measured value and analog output value are calculated by the following formula.

$$\text{Output} = \frac{\text{Measured value} \times [\text{span set value \%}]}{100} + \text{Zero point}$$



Operation (example)	Calibration of zero point to −0.5m/s and span point 105%	
Key operation	Description	Display
FUNC CAL		
±, 0, ., 5, ENTER	Enter “−0.5” with ten keys.	CALIBRATION ZERO −0.5 m/s
1, 0, 5, ENTER	Enter “105” with ten keys.	CALIBRATION SPAN 105 %
		(Measurement display)

5.4 (16) Switch of measuring unit

Description

Measuring units can be set in the two systems, metric system and inch system.

(Setting contents)

- METRIC (metric system)
  - Pipe dimension ---------- mm
  - Flow velocity unit --------- m/s
  - Flow rate unit ---------- L/s, L/min, L/h, ML/d
    m^3/s, m^3/min, m^3/h, Mm^3/d
    BBL/s, BBL/m, BBL/h, MBBL/d
  - Integration unit ---------- mL, L, m^3, km^3, Mm^3, mBBL, BBL, kBBL
- ENGLISH (inch system)
  - Pipe dimension ---------- inch
  - Flow velocity unit --------- ft/s
  - Flow rate unit ---------- gal/s, gal/m, gal/h, Mgal/d
    ft^3/s, ft^3/m, ft^3/h, Mft^3/d
    BBL/s, BBL/m, BBL/h, MBBL/d
  - Integration unit ---------- gal, kgal, ft^3, kft^3, Mft^3, mBBL, BBL, kBBL

Operation (example)	Change of measurement unit to inch system	
Key operation	Description	Display
FUNC SYSTEM ◀ or ▶, ENTER	Select “ENGLISH”.	SYSTEM OF UNITS ENGLISH
ESC ESC	Press the key twice.	(Measurement display)

5.4 (17) Switch of language (English/Japanese/German/French)

Description

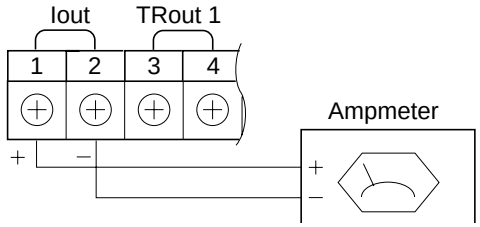
4 kinds of language, English, Japanese (Katakana), German and French can be selected on this display, at the time of setting.

Operation (example)	Selection of English display	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select “LANGUAGE”.	LANGUAGE JAPANESE
◀ or ▶, ENTER	Select “ENGLISH”.	LANGUAGE ENGLISH
ESC ESC	Press the key twice.	(Measurement display)

5.4 (18) Analog output check

Description

Check the analog output circuit.
Check to make sure that the output values at –20% to 120% are 0.8mA to 23.2mA.
Connect an ampmeter to the Iout terminal as shown below.



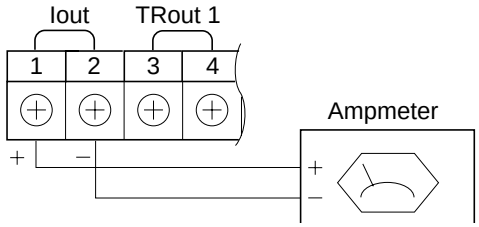
Operation (example)	Check of analog output of 20mA	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select “OUTPUT CHECK”.	OUTPUT CHECK 0 %
1 0 0, ENTER	Enter “100” with ten keys. Output changes after pressing ENTER. [100% (20mA) check]	OUTPUT CHECK 100 %
ESC ESC	Press the key twice.	(Measurement display)

5.4 (19) Analog output calibration

Description

The analog output circuit is calibrated so that the measured flow rate is set to provide an output of 4mA in the base scale and 20mA in the full scale.

Calibration should be performed by connecting an ampmeter to Iout terminal as shown below.



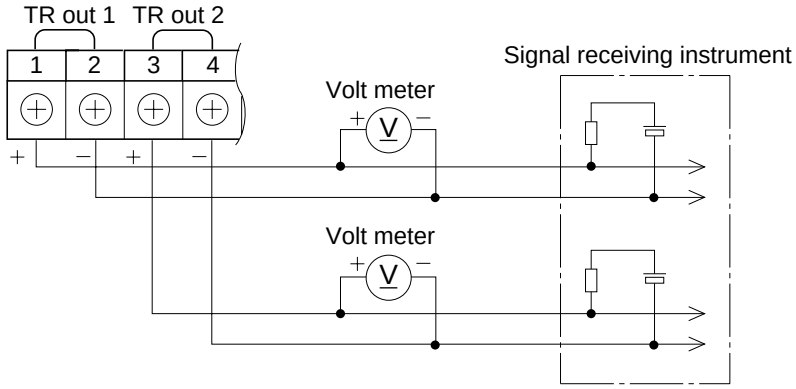
Operation (example)	Calibration of output of 4mA, 20mA	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select “OUTPUT ADJUST”.	OUTPUT ADJUST SKIP
◀ or ▶, ENTER	Select “SET”.	OUTPUT ADJUST SET
▲ (up) or ▼ (down) ◀ (down) or ▶ (up) , ENTER	Fine calibration Coarse calibration } Ammeter should indicate 4mA.	OUTPUT ADJUST 4mA Flashing
▲ (up) or ▼ (down) ◀ (down) or ▶ (up) , ENTER	Fine calibration Coarse calibration } Ammeter should indicate 20mA.	OUTPUT ADJUST 20mA
ESC ESC	Press the key twice.	(Measurement display)

Note : After calibration is completed, set the calibration mode to Skip.

5.4 (20) Status output check

Description

Perform check of status output for ON-OFF operation. Status output is an open collector. A check is performed by connecting a voltmeter to terminals, TRout 1 and TRout 2 as shown below.



Operation (example)	Check of status channel 1.	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select “STATUS CHK.”.	STATUS CHK. Channel 1
◀ or ▶, ENTER	Select “CHANNEL 1”.	STATUS CHECK Channel 1
◀ or ▶	Select “ON or OFF”.	STATUS CHECK ON
ESC ESC ESC	Press the key 3 times .	(Measurement display)

Note: Status output changes depending upon “NORMAL” or “REVERSE” specified under the status mode conditions.

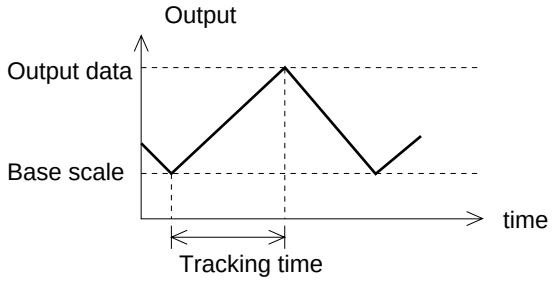
Note: If the status output check is finished with STATUS CHECK ON, “STATUS CHECK ON” is started when attempting to perform “STATUS CHECK”.

5.4 (21) Test mode

Description

The test mode is used to check for integrated conditions and action of the flow switch, etc. by entering measuring flow rate simulately.

With base scale set to 0% and full scale to 100%, an arrival time from previous value to target value can be set as shown below:
Data setting range : 0 to ±120%
Tracking time setting range : 0 to 900sec



Note : During measurement, set the test mode to “NOT USED”.

Operation (example)	To set the tracking time to 15 seconds so that the target value reach from 0 to 100%.	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select “TEST MODE”.	TEST MODE NOT USED
◀ or ▶, ENTER	Select “SETTING”.	TEST MODE SETTING
1, 0, 0, ENTER	Enter “100” with ten keys.	INPUT DATA 100%
1, 5, ENTER	Enter “15” with ten keys.	TRACKING TIME 15 sec
		(Measurement display)

6. MAINTENANCE AND INSPECTION

6.1 Maintenance

(1) LCD display unit

Expected service lift of LCD is 7 years. It is recommended that LCD should be replaced with new one in about 5 years since it is put into operation, or it may offer deteriorated contrast.

[Replacement procedure]

① Power OFF

② Remove the connector from the key panel and replace the LCD display unit (see parts list).

③ Assembly

④ Power ON

⑤ Check for normal operation

6.2 Inspection

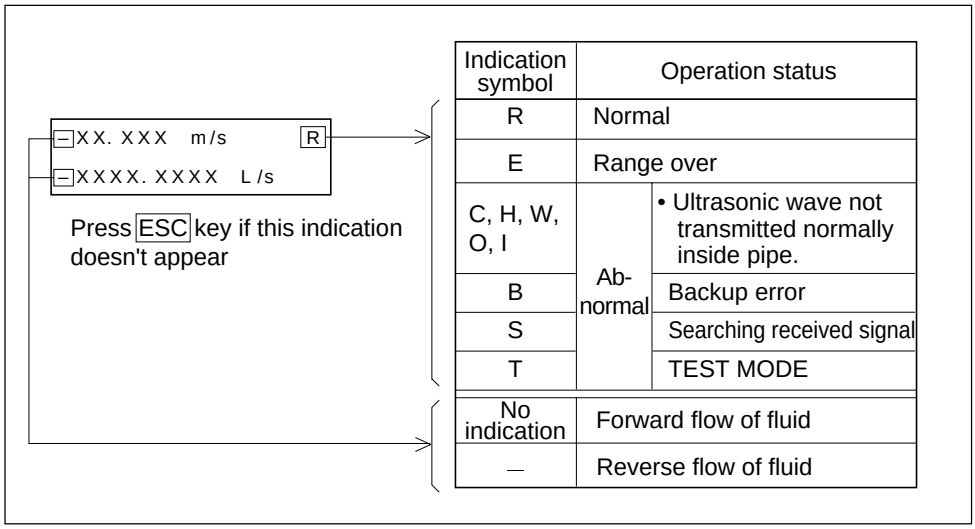
(1) Daily check

Confirm the converter is operating normally by using the LCD display unit in accordance with Item “7.1 How to confirm normal operation”.

7. TROUBLESHOOTING

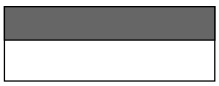
7.1 How to confirm normal operation

7.1 (1) When checking by LCD indicator



Indication symbol	Operation status	
R	Normal	
E	Range over	
C, H, W, O, I	Ab-normal	• Ultrasonic wave not transmitted normally inside pipe.
B		Backup error
S		Searching received signal
T		TEST MODE
No indication	Forward flow of fluid	
—	Reverse flow of fluid	

7.1 (2) LCD indication when power turned ON



In case of no indication

System abnormal (CPU stopped)

└ Contact supplier.

7.1 (3) Detail check for abnormal status

Description

Status display at the upper right of the measurement screen is detailed as follows:

(Status display)	(Contents of display)	(Detailed contents)
R :	NORMAL	
C :	CAL. ERROR	• Check for piping input data. • Turn ON/OFF the power.
H :	RECEIVED SIGNAL ERROR	• Check for air bubbles in pipe • Check for particles in pipe
W :	WINDOW ERROR	• Check for piping input data.
O :	RECEIVED SIGNAL OVERFLOW	• Check for the sensor mounting method.
I :	NO RECEIVED SIGNAL	• Check for piping input data. • Check for sensor installation. • Check for cable connections. • Check for type of sensor.
E :	RANGE OVER	• Check for output setting. • Check for integral constant. • Check zero point.
B :	BACKUP ERROR	• Non-volatile memory fault.
S :	SERCHING RECEIVED SIGNAL	• Please wait now.
T :	TEST MODE	• Test mode running.

Operation (example)	It appears at the upper right of the measurement screen.	
Key operation	Description	Display
FUNC CEHCK	(Contens of display)	I : NO RECEIVED SIGNAL
ENTER	(Detailed contents)	CHECK PIPE DATA
▼	(Detailed contents)	CHECK SENSOR MOUNT
▼	(Detailed contents)	CHECK CABLE CONNECT
▼	(Detailed contents)	CHECK SENSOR TYPE
ESC ESC	Press the key twice.	(Measurement display)

7.1 (4) Measurement data check

Description

Data (10 kinds) under measurement are displayed.

Normal measurement : All the data, (1) through (10), are displayed in real time.

Abnormal measurement : Data with exception of (7), (9) and (10) are “zero” or “hold”.

(1)	**Fluid acoustic velocity (Cf)**	: Fluid acoustic velocity due to temperature change. Refer to Appendix 6.
(2)	**Propagation time (T0)**	: Average value of propagation time of ultrasonic receive signal in forward and reverse directions T0 = (T1+T2)/2
(3)	**Forward direction time (T1)**	: Propagation time of ultrasonic receive signal in forward direction (Fig. 7-1), total time of Tw, Tp, Tl and Tf in Pu → Pd direction
(4)	**Reverse direction time (T2)**	: Propagation time of ultrasonic receive signal in reverse direction (Fig. 7-1), total time of Tw, Tp, Tl and Tf in Pd → Pu direction
(5)	**Propagation time difference (ΔT)**	: Difference in propagation time of ultrasonic receive signal between forward and reverse directions ΔT = T2-T1
(6)	**Delay time (τ)**	: Delay propagation time; time required for ultrasonic signal to propagate into sensor and piping until send signal is received (Fig. 7-1) τ = Tw+Tp+Tl
(7)	**Fluid angle (θf)**	: Fluid incident angle; angle of ultrasonic signal bending in fluid (Fig. 7-1)
(8)	**Reynolds number (Re)**	: Estimation of flow velocity distribution and compensation of flow rate Re = Flow velocity v × tube inside diameter D/ Dynamic viscosity factor ν
(9)	**Wave strength**	: Sensitivity of ultrasonic receive signal; sensitivity of 0.45 or more can be measured, less than 0.45 needs to increase the power of send signal voltage.
(10)	**Regulated value of propagation time**	: Propagation time based on logic value at 20°C.

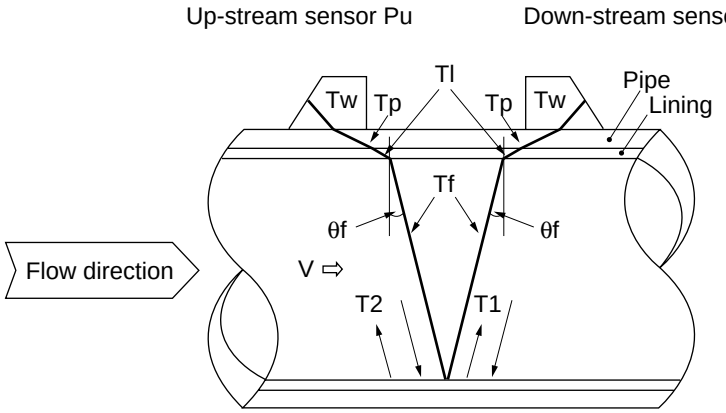
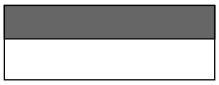


Fig. 7-1 V-method measurement diagram

Operation (example)	Data display (example)	
Key operation	Description	Display
FUNC /π 1	Display of fluid acoustic velocity (Cf)	SOUND SPEED 1465.373 m/s
◀ or ▶	Display of propagation time (T0)	TOTAL TIME 482.00524 μsec
	Display of propagation time (T1) in forward direction	FORWARD TIME 482.00800 μsec
	Display of propagation time (T2) in reverse direction	REVERSE TIME 481.99744 μsec
	Display of propagation time difference (ΔT)	DELTA TIME 3.50341 nsec
	Display of delay propagation time (τ)	DELAY TIME 27.04046 μsec
	Display of fluid incident angle (θf)	THETA 22.934 °
	Display of reynolds number (Re)	REYNOLDS NO. 5204
	Display of wave strength	SIGNAL STRENGTH 0.72
	Display of regulated value of propatation time	TOTAL TIME (CAL) 490 μsec
ESC or ENTER		(Measurement display)

7.2 Faults and remedies

7.2 (1) LCD display abnormal

Status	Cause
 No indication appears.	• Power is not turned ON. • Power voltage is low. • Fuse is burnout. • LCD is abnormal. ➡ Take remedy in "7.2 (5) Remedy for hardware fault" • DC power supply polarity is connected reversely.
 Dark indication on upper side.	• Power voltage is low. • LCD is abnormal. ➡ Take remedy in "7.2 (5) Remedy for hardware fault" • DC power supply polarity is connected reversely.
 Random indication	• Hardware fault. ➡ Take remedy in "7.2 (5) Remedy for hardware fault"
 Unclear display	• Ambient temperature low. (less than –10°C) ➡ Increase the temperature. • LCD indicator is worn out. ➡ Replace the LCD.
 Whole is dark	• Ambient temperature is high. (60°C or more) ➡ Decrease the temperature.

7.2 (2) Key abnormal

Status	Cause
No response at press of input key	• Hardware fault. ➡ Take remedy in "7.2 (5) Remedy for hardware fault"
Specific keys can not be operated. Key operation is different from that defined.	

7.2 (3) Measured value abnormal

Status	Cause	Remedy
Minus (–) symbol indicated on measured value	• Connection between transmitter and sensor is reversed. (Upstream and down stream detectors should be connected reversely)	➡ Connect correctly.
	• Flow of fluid is reversed.	
Measured value fluctuates though flow rate is constant.	• Straight pipe length is inadequate.	➡ Move instrument to a place where 10D can be maintained on upstream and 5D on downstream.
	• Pump, valve etc. which disturbs flow is located nearby.	➡ Attach instrument at least 30D away
	• There is pulstation in the flow	➡ Set the damping to increase the response time.
Measured value is not changed with change in flow rate.	Ultrasonic wave is not transmitted inside pipe but measured value remains unchanged (HOLD). 1. Installation is improper • Error in piping specifications • Sensor attached to welded part • Error in sensor mounting dimensions • Error in silicon appliance at the time of mounting the sensor • Error in connection of the sensor cable.	➡ After confirming the cause, remove the sensor and apply sufficient amount of silicone to the sensor. Then, mount the sensor again at a position slightly away from previous position.
	2.Problem with piping, fluid ◎ Pipe not filled with fluid	➡ Fluid out a pipe filled with fluid on the same pipeline, and relocate the sensor to the pipe. • Attach the sensor to the lowest place on the pipeline.
	◎ Bubbles included in the fluid If measured value becomes normal when flow has stopped, it indicates that bubbles are contained in the fluid.	➡ Eliminate the bubbles. • Raise the level of the pump well. • Check the shaft seal of the pump. • Retighten the flange of negative pressure pipe. • Arrange so that fluid doesn't fall into the pump well
	When the sensor is mounted right after the valve, cavitation may occur in the pipe, resulting in entry of air bubbles.	Move the sensor to a place where no bubbles are contained. • Pump inlet side • Upstream side of valve
	(Contined)	

Status	Cause	Remedy
(Continued)	◎ Turbidity is high. Turbidity is higher than inflow water contamination or return sludge. ➡ ◎ Scale deposits on the inside of old pipe ➡ ◎ Thick lining Mortar lininig is several ten millimeters thick ➡ ◎ Separation of lining This is gap between lining and pipe. ➡	• Change sensor mounting from V method to Z method. • Move sensor to a place of smaller diameter on the same pipeline. • Relocate sensor to another place or pipe line.
	◎ Sensor is mounted on bent or tapered pipe. ➡	Mount sensor on a straight pipe.
	3. Effect of external noise • There is a radio broadcast station nearby. • Measurement conducted near a passage of vehicles or electric cars. ➡	• Keep the cable between converter and sensor as short as possible. • Ground the converter and piping.
	• Mounting of sensor is improper. • Mounting dimensions • Sensor is separated from pipe ➡	• Mount sensor parallel with pipe at the correct position. • Press sensor so it is securely mounted on the pipe.
	4. Hardware fault ➡	Refer to Item “7.2(5) Remedy for hardware fault”.
Measured value not zero when fluid stops flowing.	• Fluid forms a convection inside the pipe. ➡	This is normal.
	• Zero point adjustment ➡	• Readjust the zero point after fluid has stopped flowing.
	• Pipe is not full of water or it is empty of water when water stops flowing. ➡	This is normal. • The value may vary at Item “5.4(4) Setting of output at abnormal measurement”.

Status	Cause	Remedy
Error in measured value	• Input piping specifications differ from the actual ones.	Error of about 3% occurs when inner diameter differs by 1%. • Input the correct specifications
	• Scale deposits on old pipe	• Input scale as a lining.
	• Length of straight pipe is inadequate. (should be at least 10D upstream and 5D downstream.)	Change the sensor to another mounting position (upstream of disturbing objects) No disturbing objects in flow within 30D upstream without pump, valve, combined pipe, etc.
		• Try mounting the sensor at various angles versus the pipe section, and mount it where average value is obtained.
	• Pipe is not filled with fluid or sludge is deposited in the pipe.	Occurs particularly where sectional area is small. • Move sensor to a vertical pipe.

7.2 (4) Analog output abnormal

Status	Cause	Remedy
Current output is not matched though indication value is not 0.	Range setting is not performed.	➡ • Set.
Output is 0mA.	Cable is disconnected.	
Output is below 4mA when indication is 0.	Zero adjustment of analog output has deviated.	➡ Adjust the analog output.
Output is greater than 20mA.	E is displayed on LCD indicator. Note)	➡ Range over: • Reset analog output range data.
	Span adjustment is incorrect.	➡ • Adjust the analog output.
Indication is changed but analog output remains the same.	Output load is greater than 1kΩ.	➡ • Reduce the load to 1kΩ or less.
Indication does not agree with analog output.	Zero or span of analog output has deviated.	➡ Adjust the analog output.
Analog output doesn't change even after it has been adjusted.	Hardware falut	➡ Contact manufacturer.

Note: When the base scale is not set to 0 within the range of an analog output, the flow display may not be matched with the analog output.

7.2 (5) Remedy for hardware fault

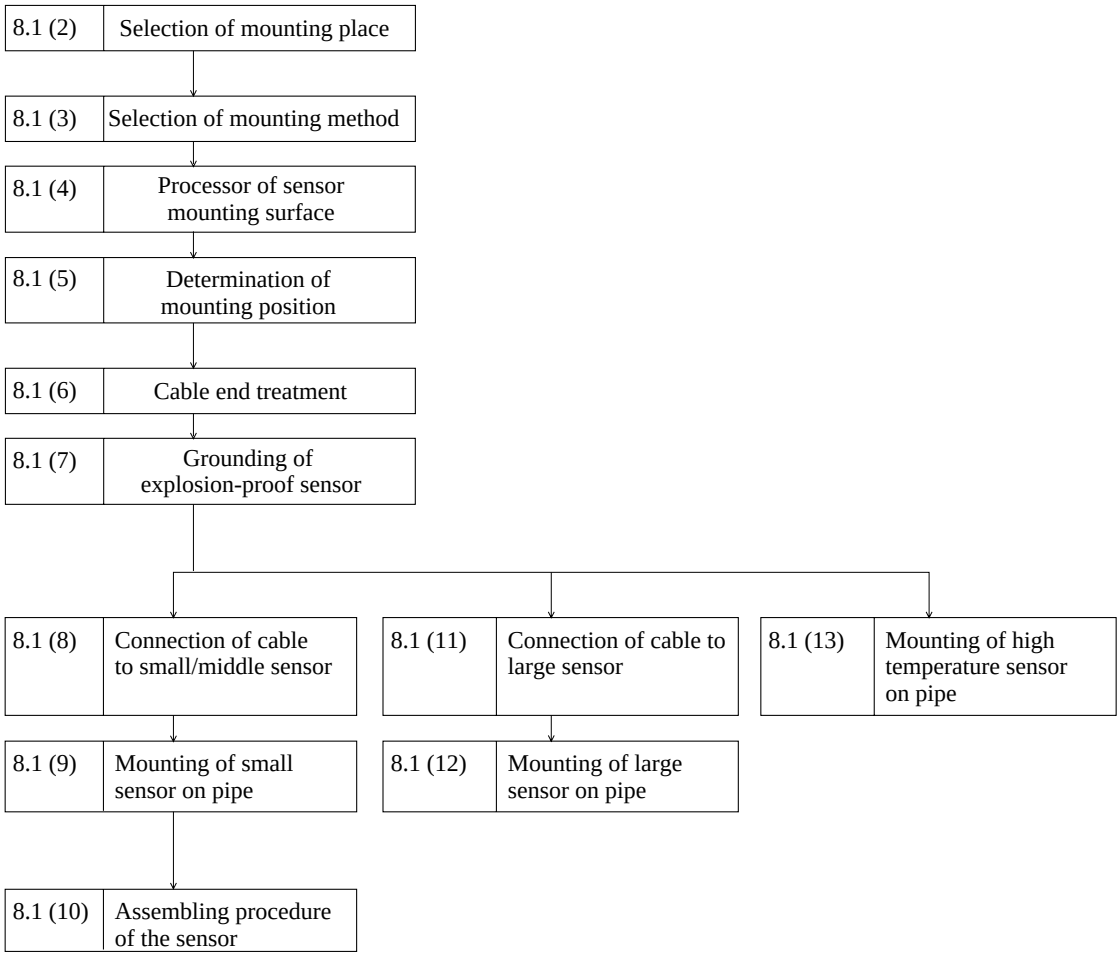
When hardware is in trouble after following "6. Maintenance and inspection" and "7. Trouble-shooting", details of trouble and self-check should be notified.

8. SENSOR INSTALLATION GUIDE

8.1 Mounting of sensor

8.1 (1) Mounting procedure of sensor

Mount the sensor on the pipe, and perform the following works in order before making measurement.



⚠ CAUTION

In case of explosion-proof type sensors, the following special conditions should be taken into account when installing them:

Special Conditions for Safe Use:

① The flow sensors shall only be used together with the Converter FLV which incorporates an internal fuse according to document TD531469. The fuse is rated 2A, 250V and 1500A breaking capacity. The prospective short circuit current at the power supply connection point for the Converter shall not exceed 1500A.

② The flow sensors have been tested with low impact energy (4 joule) and shall only be used in areas with low risk of mechanical damage.

③ The sensors have permanently connected cables. The cable end shall be connected with certified equipment according to the types of protection listed in EN 50014 or in the safe area.

8.1 (2) Selection of mounting place

Mounting place for the sensor, i. e. conditions of piping where flow rate is measured, has considerable influence on measurement accuracy.

A place satisfying the following conditions should be selected.

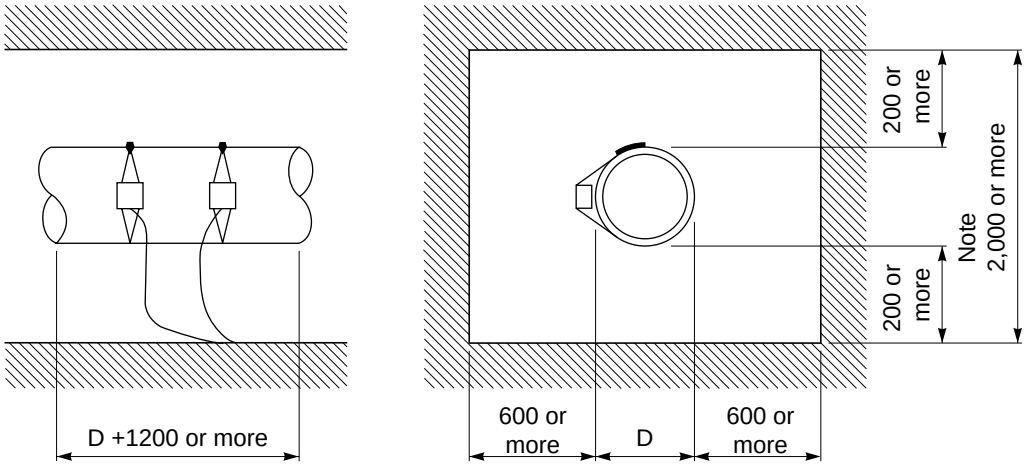
① A place where there is a straight pipe portion of 10D or more on upstream side and of 5D or more on the downstream side.

② A place where there are no factors which disturb the flow (pumps, valves, etc.) within 30D on upstream side.

③ Pipe must be filled up with fluid. No bubbles should be contained.

④ Make sure that a maintenance space is provided around the piping where the sensor is mounted. (See Fig. 8-1.)

Note) A space should be provided so that maintenance work can be made with workers standing on both sides of the piping.

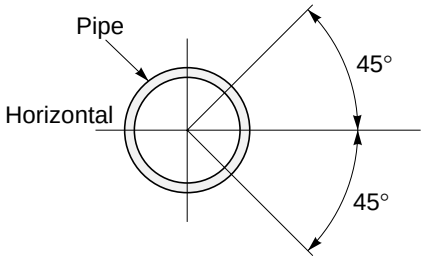


D : Pipe diameter

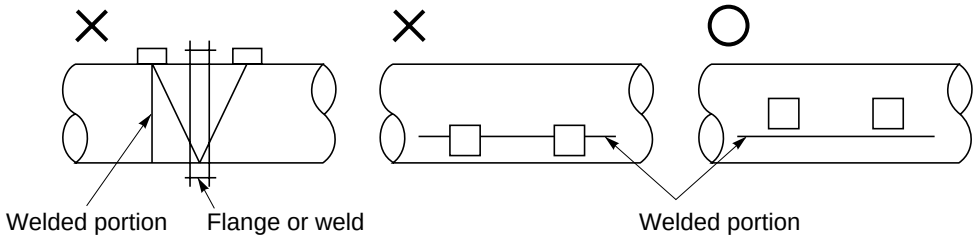
Fig.8-1 Space required for mounting sensor

⚠ CAUTION

① Where a horizontal pipe is used, install the sensor within ±45˚ from the horizontal plane.
Where a vertical pipe is used, the sensor can be installed anywhere.



② Avoid installing the sensor on a deformed portion of pipe or welded portion of pipe, or on flange.



8.1 (3) Selection of mounting method

There are two ways for mounting the sensor, the V method and the Z method (see fig. 8-2).

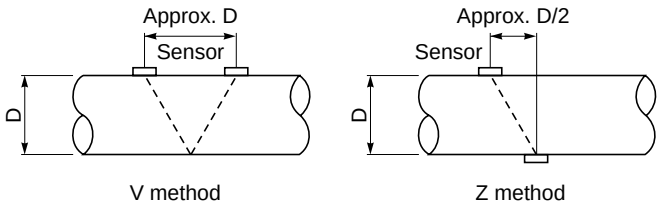


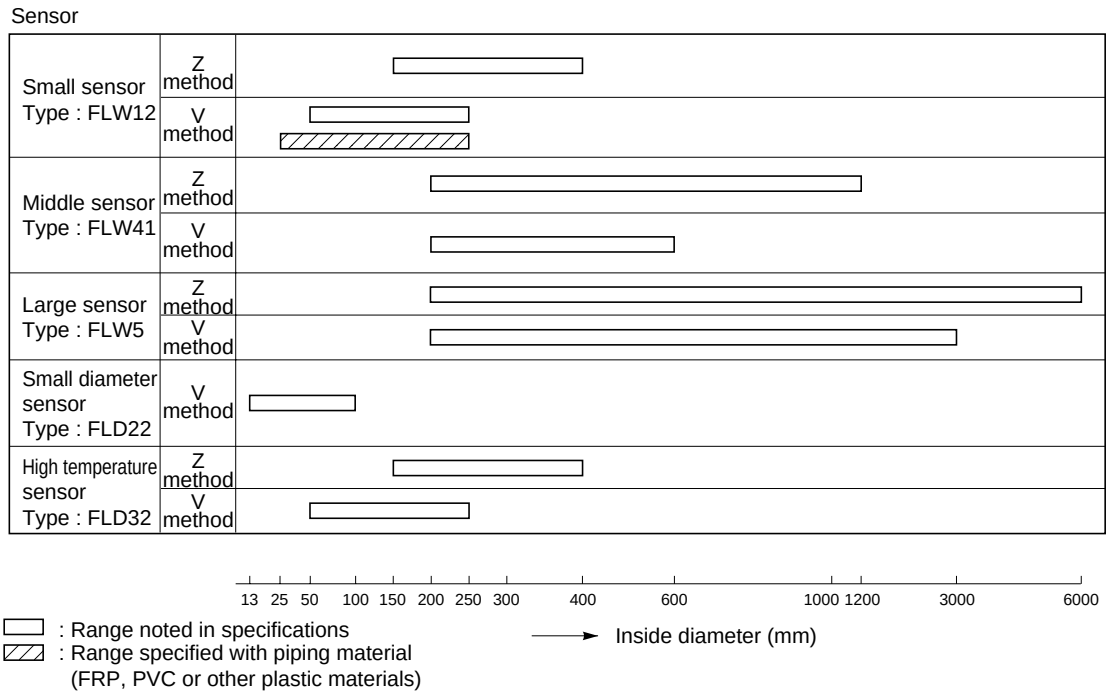
Fig. 8-2 Mounting method

The Z method should be used in the following cases.

- Where a mounting space is not available (as shown in the figure above, the mounting dimension with the Z method is about half of that with the V method).
- When measuring fluid of high turbidity such as sewage.
- When the pipe has a mortar lining.
- When the pipe is old and has a thick accumulation of scale on its inner wall.

Selection standard

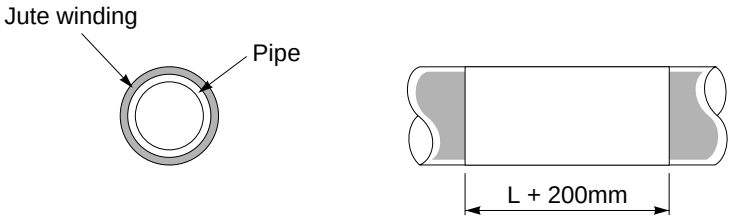
For a large size sensor with inside diameter of more than 300 mm, the Z method is recommended for mounting.



8.1 (4) Processing of sensor mounting surface

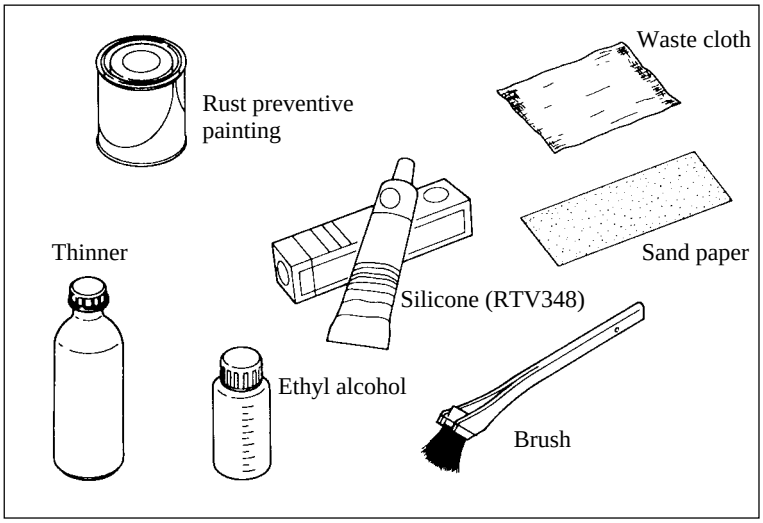
Using thinner and/or sandpaper, remove pitch, rust and unevenness over a width of (L) + 200mm on the pipe circumference where the sensor is mounted.

Note) If there is a jute winding on the pipe circumference, remove it and carry out the above processing.



Large size sensor (FLW5) is attached to the following accessories.

Use for surface treatment of pipes.



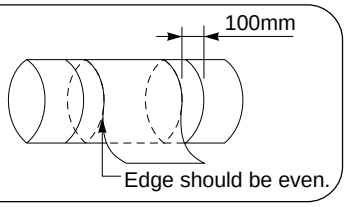
Name	Quantity	Application
• Rust preventive painting	1	Applied to detector or related parts for rust prevention
• Ethyl alcohol	1 bottle	Used for surface treatment of pipes and degreasing of transmitting surface
• Sand paper	1 pc	Used for removing rust from pipe surface or used for making surface smooth
• Brush	1	
• Waste cloth	1 sheet	
• Thinner	1 can	Used for remove pitch from piping surface
• Silicone	1 tube	Used for mounting sensor or for molding sensor terminal block.

8.1 (5) Determination of mounting position (with Z method for large and small types)

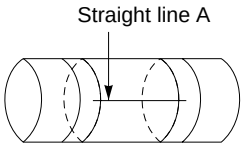
Carry out the following to determine the mounting position.

Gauge paper is necessary for this work. (Refer to Appendix 1. “How to make gauge paper”.)

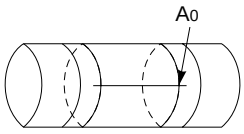
① Align the edge of gauge paper with a point about 100mm from one end of the processed section, and wrap the paper around the pipe so that the line drawn on the paper is parallel with the pipe shaft. (The paper should be taped to prevent slipping.)
At this time, make sure that the paper edge is even.



② Extended the line drawn on the paper and mark a straight line A on the pipe.

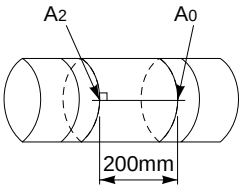


③ Mark a line along on edge of the paper. Assume the intersection of the line and the straight line A is A_0.



V method

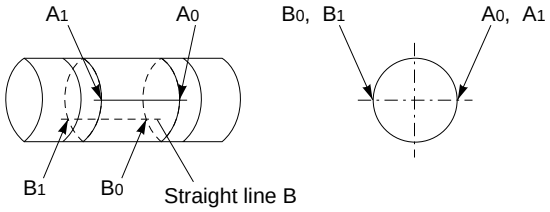
Example) L = 200mm



④ Remove the gauge paper and measure the mounting dimension from A_0.
Then , draw a line which crosses the straight line A (determine the position A_2).

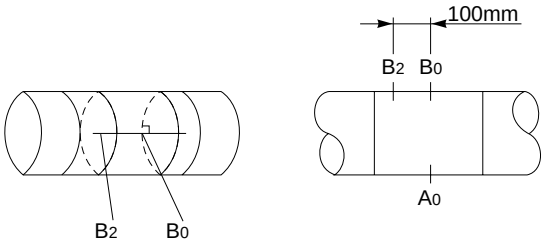
A_0 and A_2 are the mounting position.

Z method



④ Measure the circumference of the pipe from the point A_0, and mark a line (straight line B) between the point B_0 and B_1 obtained at 1/2 of the circumference.

Example) L = 100mm

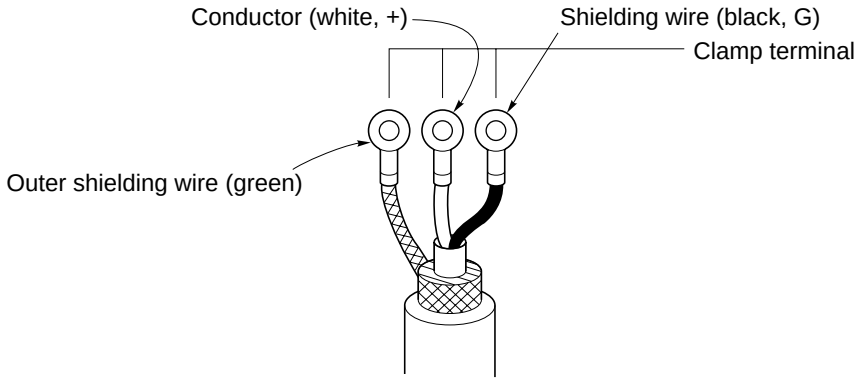


⑤ Put a mark at point B_0 and remove the gauge paper.
Measure the mounting dimension from B_0 and mark a line crossing the straight line B (determine the position B_2).
In this way, the mounting position is determined.

A_0 and B_2 are the mounting position.

8.1 (6) Cable end treatment

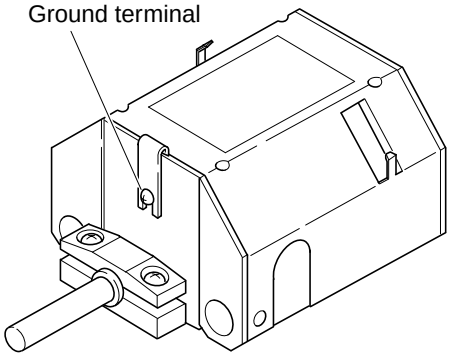
The end of coaxial cable is treated at the factory prior to delivery. If the cable needs to be cut before use, the conductor and the shielding wires should be treated using clamp terminals.



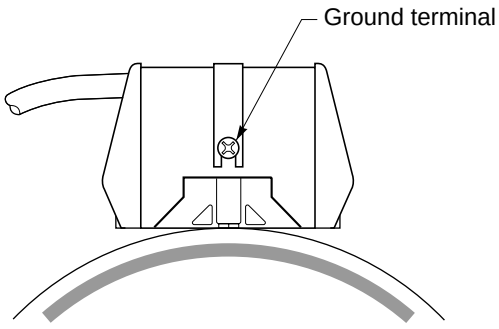
Note) When cutting the coaxial cable, make sure that the upstream side and the downstream side are the same in length.

8.1 (7) Grounding of explosion-proof sensor

When installing the explosion-proof sensor, be sure to ground the metal cover by means of a ground terminal (Class D).



FLW $\frac{12}{41}$ 2

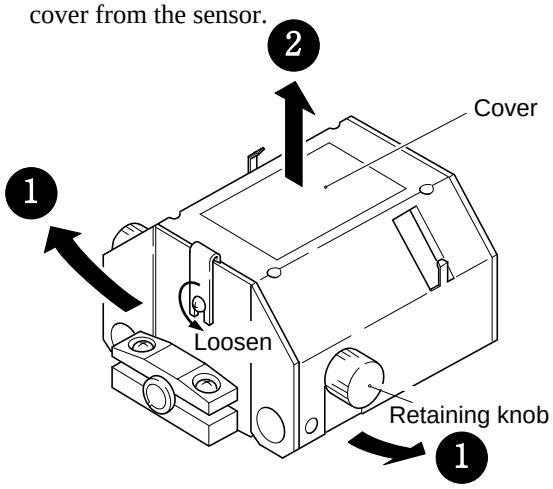


FLW5 $\frac{1}{0}$ 2

8.1 (8) Connection of cable to small/middle sensor

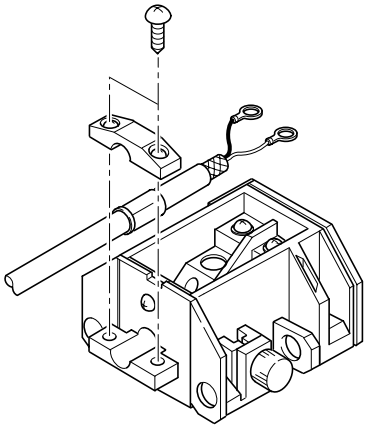
Since molded terminal unit is used for the explosion-proof sensor, the wiring work is not required.

① Loosen the earth screw and the retaining knob on the sensor using a screwdriver, then remove the cover from the sensor.



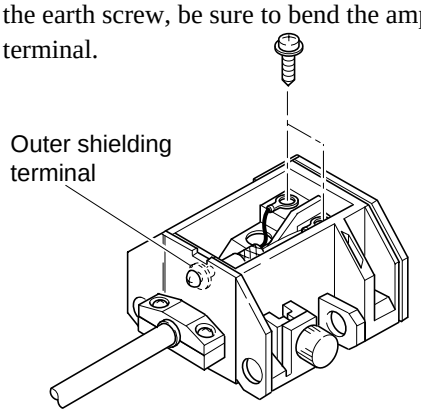
② Select a mounting position on the pipe.

Note) Mount the sensors so that the upstream and downstream sensors can be distinguished with each other.
Remove the cable clamp and insert the coaxial cable through the cable lead-in port.

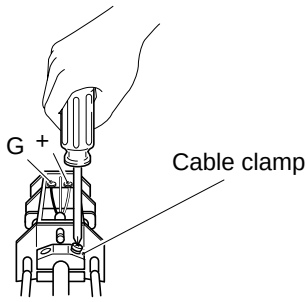


③ Connect the cable to the terminal (G, +) and the earth screw.

Note) After connecting the outer shielding wire to the earth screw, be sure to bend the amplifier terminal.

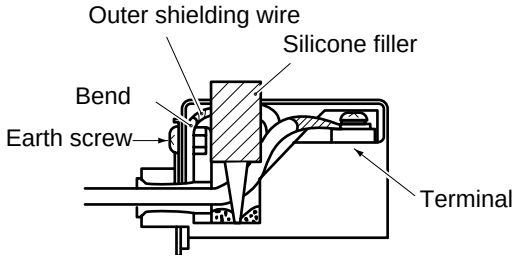


④ Secure the coaxial cable with the cable clamp.

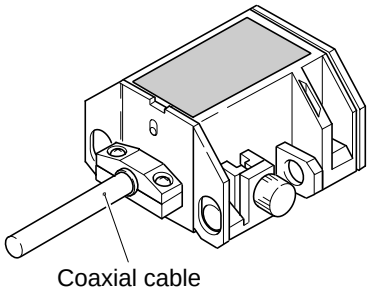


⑤ Remove foreign matters from the terminals, and mold the while terminal block with silicone filler.

- Cut off the tip of the silicone filler tube.
  Apply silicone to the terminal block while pressing the head of the tube against the bottom of terminals.
  At this time, care should be taken to prevent entry of air bubbles.



⑥ Put the cover on the sensor.

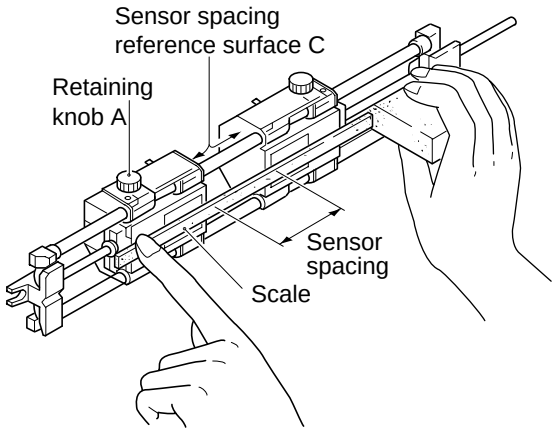


8.1 (9) Mounting of small sensor on pipe

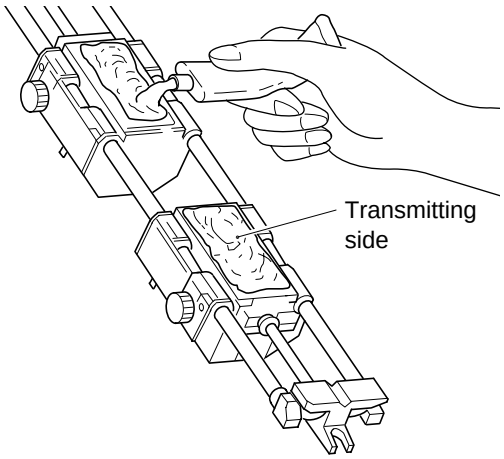
The small type sensor is mounted on pipe with a diameter of ø50 to 250 (V method) or ø150 to 400 (Z method) for measurements.

1) Mounting of sensor (V method)
Mounting the sensor using the following procedure.
For mounting, prepare a scale or a slide calipers.

① Loosen the retaining knob A (4 places), slide the sensor so as to match the mounting dimension, place a scale on the mounting dimension reference surface C and adjust the dimension, then tighten the retaining knob A.

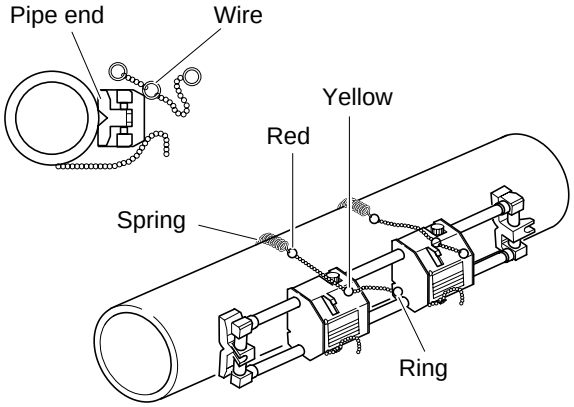


② Spread silicone filler over the whole transmitting side of the sensor. Care should be taken to prevent entry of air bubbles.



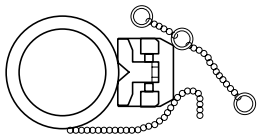
Clean the surface of the pipe and mount the sensor.

③ Raise the end of the pipe fitted with the sensor, and attach the yellow ring on the chain to the hook.

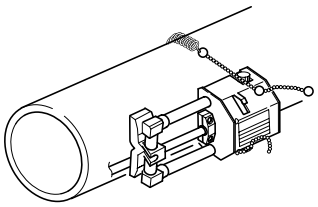


Attach the other chain to the other hook of sensor, and secure it loosely.

④ Pull the red ring and attach it to the hook.
Use the same procedure for the other sensor.



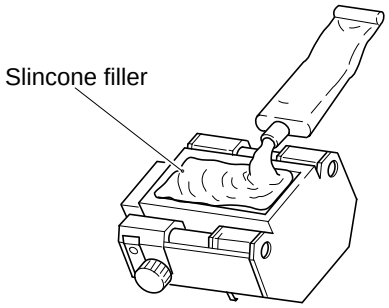
Turn over the frame end so that the sensor makes a close contact with the pipe.



Press the sensor firmly against the pipe.
Ensure that the sensor makes a close contact with the pipe.

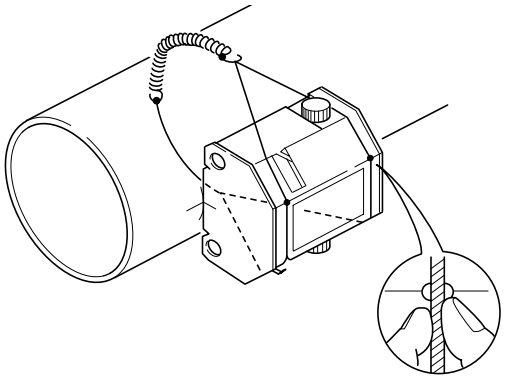
2) Mounting of sensor (Z method/explosion-proof sensors)
Mounting the sensor using the following procedure

① Spread silicone filler over the whole transmitting side of the sensor. Care should be taken to prevent entry of air bubbles.

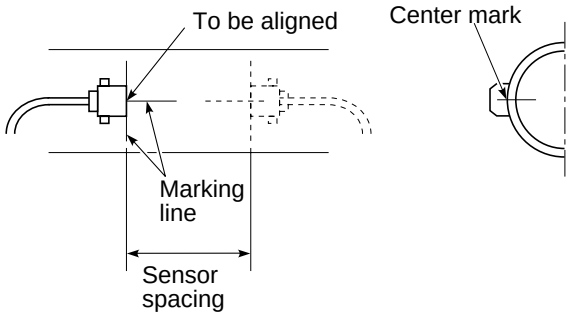


Clean the surface of the pipe, then mount the sensor.

② Press the sensor against the pipe. Align the center of the sensor with the intersection of the marking line, and the mounting dimension reference surface with the marking line.

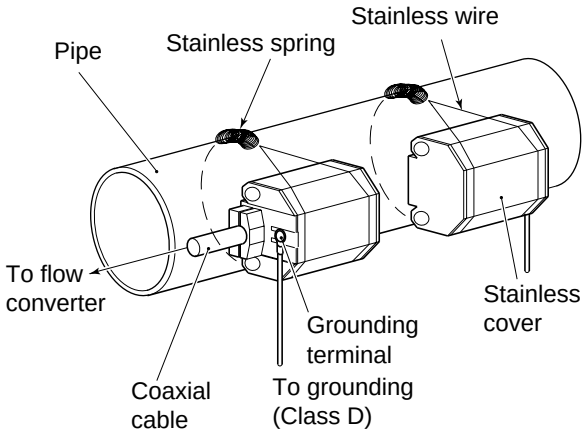


③ Make sure that the center mark on the sensor is aligned with the marking line. Then, connect the coaxial cable to the transmitter.



Note) Do not pull the coaxial cable. If it is pulled, the sensor is shifted which results in incorrect measurements due to poor contact with the pipe.

④ (Explosion-proof sensor only)
Ground the explosion-proof sensor only by using the grounding screw.



8.1 (10) Assembling procedure of the sensor

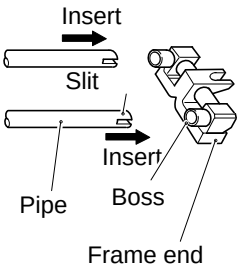
When the small type sensor (FLW121) is shipped with cables of more than 10m in length, it is delivered, disassembled since cable weight is applied to the stand or piping of the sensor during shipment.

Follow the procedure given below.

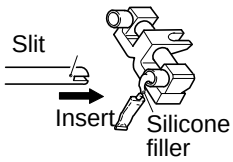
Assemble of parts

① Be sure to read the "Cautions" before assembling the parts.

Insert the frame end onto one side of 2 pipes.

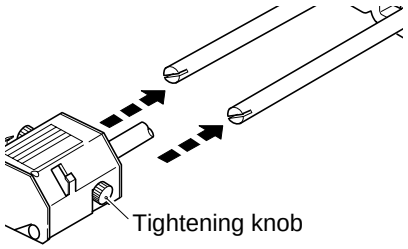


Apply a coat of silicone to the frame end. Take care of the direction of the frame end and the slit of pipe.



After inserting the pipes, tap the frame end with a plastic hammer or the like.

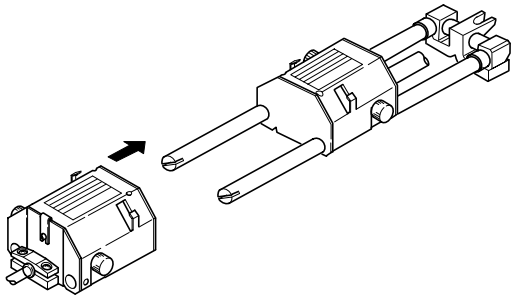
② Loosen the tightening knob on the sensor and insert the pipes.



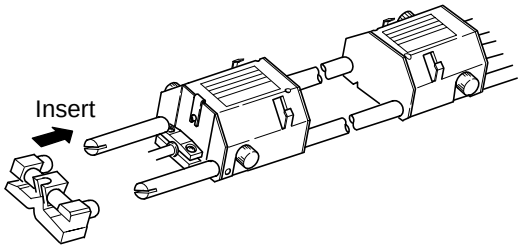
The sensor should be inserted in the correct direction.

③ Insert another sensor onto the pipes.

Insert it in the correct direction.



④ Insert the frame end onto the other side of pipes. Assembling method is the same as ①

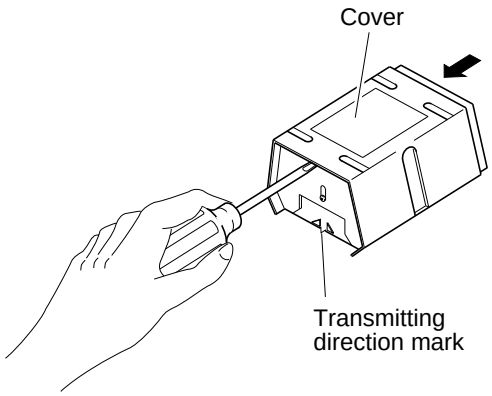


Note) After assembling the sensor, leave it at room temperature for a day to harden the filler (to obtain the required assembling strength).

8.1 (11) Connection of cable to large sensor

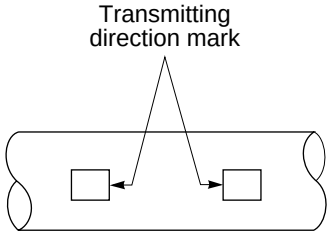
Since molded terminal unit is used for the explosion-proof sensor, the wiring work is not required.

① Slightly move the sensor cover and remove it using an screwdriver or the like.

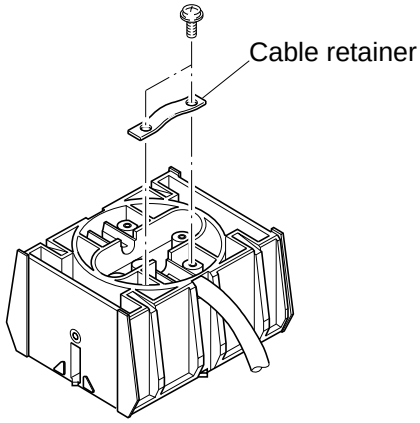


② Confirm the mounting position on the pipe.

- Align the transmitting direction marks so that they are facing with each other.

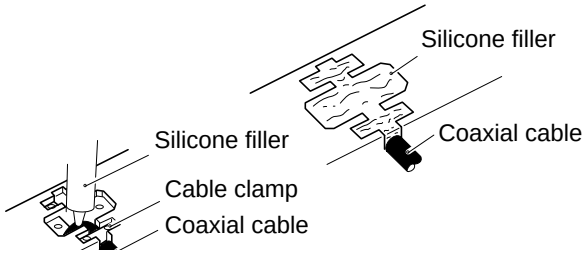


③ Connect the coaxial cable to the terminals (G, +) and secure the cable with the cable clamp.



④ Remove foreign objects from the terminal section, and mold the whole terminal section with silicone filler.

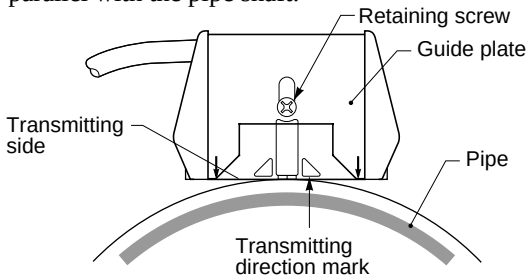
- Cut the tip of the silicone filler tube. Apply silicone while pressing the head of the tube against the bottom of the terminal section Be careful not to let babbles form.



8.1 (12) Mounting of large sensor on pipe

① Adjustment of guide plate height

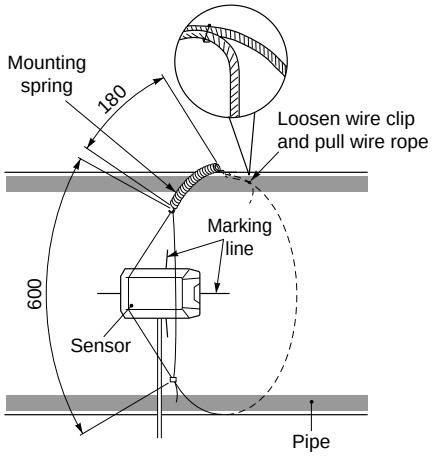
Attach the sensor to the pipe. Make sure that it is parallel with the pipe shaft.



Loosen the guide plate retaining screw, and slide the plate until its edge and the transmitting side are in contact with the pipe surface.
Tighten the retaining screw.

② Setting of wire rope length

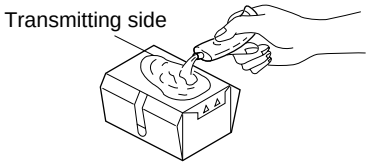
Place the sensor on the marking line and attach the wire rope and mounting spring.



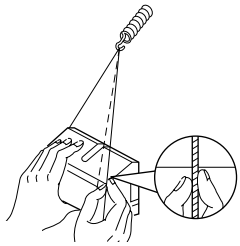
Loosen the wire clip, stretch the wire rope until the overall length of the mounting spring becomes 180mm, and secure the wire clip (free length of the mounting spring is 110mm).
Remove the sensor with the wire rope fixed in place.

③ Mounting of sensor

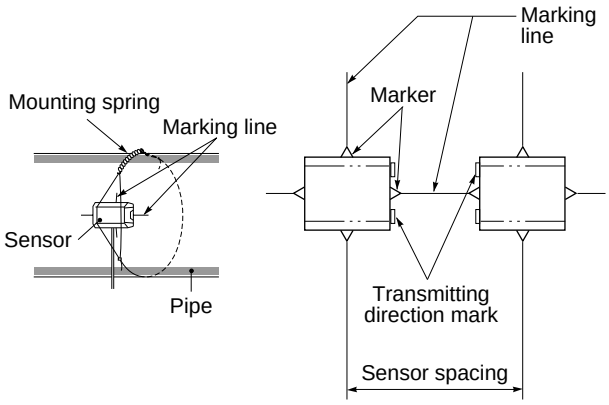
1) Clean the sensor transmitting surface and pipe mounting surface.
2) Spread silicone filler over the whole transmitting surface of the sensor.
3) The thickness of silicone filler should be about 3mm.



4) Spread the wire rope near the marking line to right and left. Attach the sensor firmly to the pipe and hook the wire rope.



5) Make sure that the matching mark on the sensor is aligned with the marking line. Also, make sure the transmitting direction marks on the sensor are facing with each other.

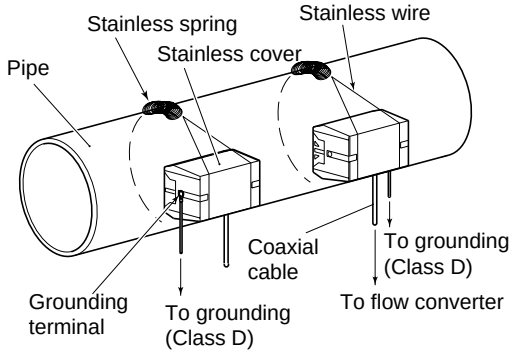


6) Confirm that the sensor matching mark is aligned with the marking line, then connect the coaxial cable to sensor.

Note) Do not pull the coaxial cable. If it is pulled, the sensor may move from its mounting position which affects correct measurements.

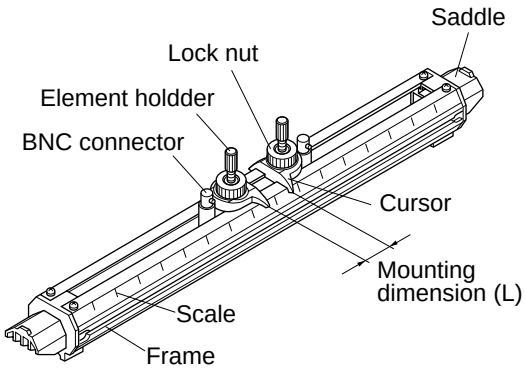
④ (Explosion-proof sensor only)

Ground the explosion -proof sensor only by using the grounding screw.



8.1 (13) Mounting of small diameter sensor on pipe

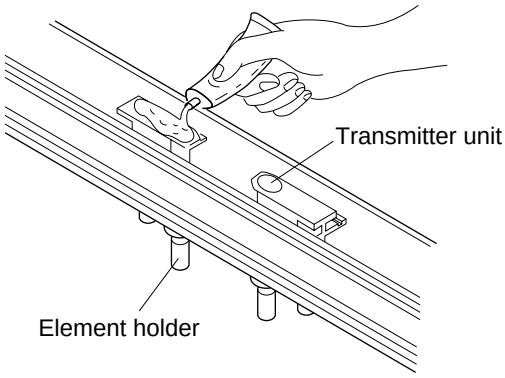
① Loosen the lock nut and slide the sensor so as to meet the mounting dimension and then tighten the nut.



② Apply a coat of silicone filler to the transmitting surface of the sensor. Spread the compound over the entire area.

Keep the sensor retracted by turning the element holder counterclockwise.

After cleaning the surface of the pipe, the sensor should be mounted.

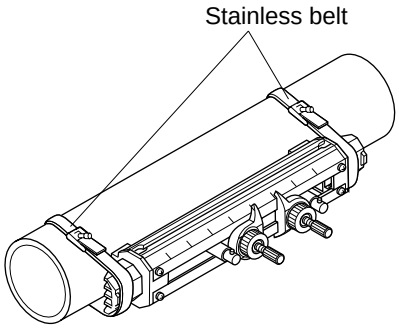


⚠ CAUTION

Apply a small quantity (like toothpaste) of silicon filler to the transmitter unit.

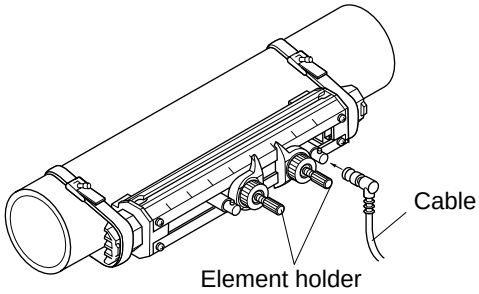
③ Fix the both ends (saddles) of the sensor to the pipe by stainless belts.

Mounting will be facilitated by winding the stainless belts on the pipe in advance.



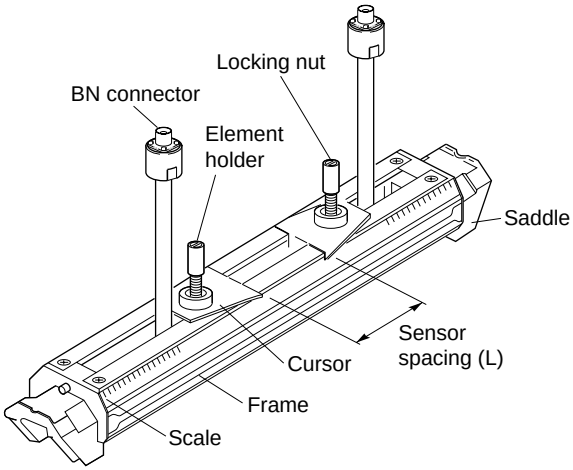
④ Make sure the sensor is mounted in parallel with the pipe axis and the mounting dimension is right. Then, turn the element holder clockwise until the sensor comes in close contact with the pipe.

Stop turning the element holder when it stiffens because the transmitting surface comes in contact with the pipe surface. Be careful not to turn the holder excessively.

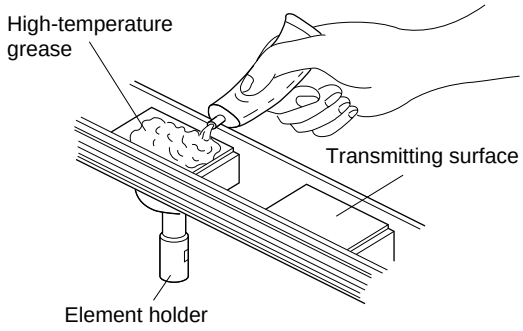


8.1 (14) Mounting of high temperature sensor on pipe

① By loosening lock nuts, slide the sensor to fit the mounting size displayed on the converter. Tighten the lock nuts.

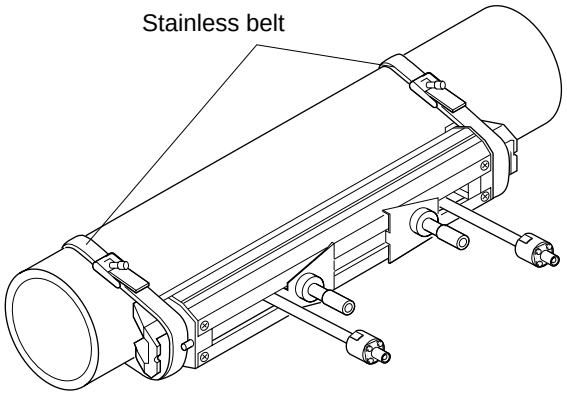


② Spread high-temperature grease over the whole transmitting surface of the sensor.

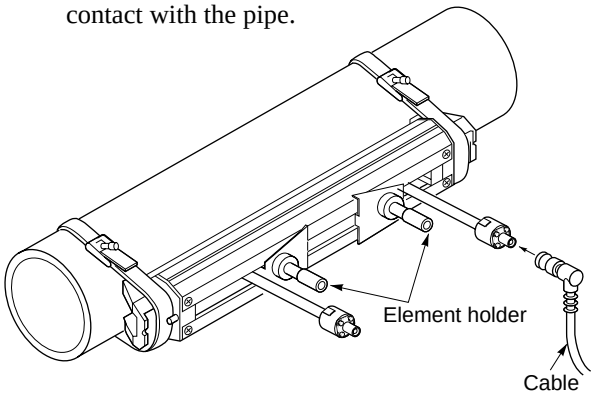


Turn the element holder counterclockwise to return the sensor. Clean the surface of the pipe and mount the sensor on the pipe.

③ Mount the sensor saddles on the pipe with stainless belt.

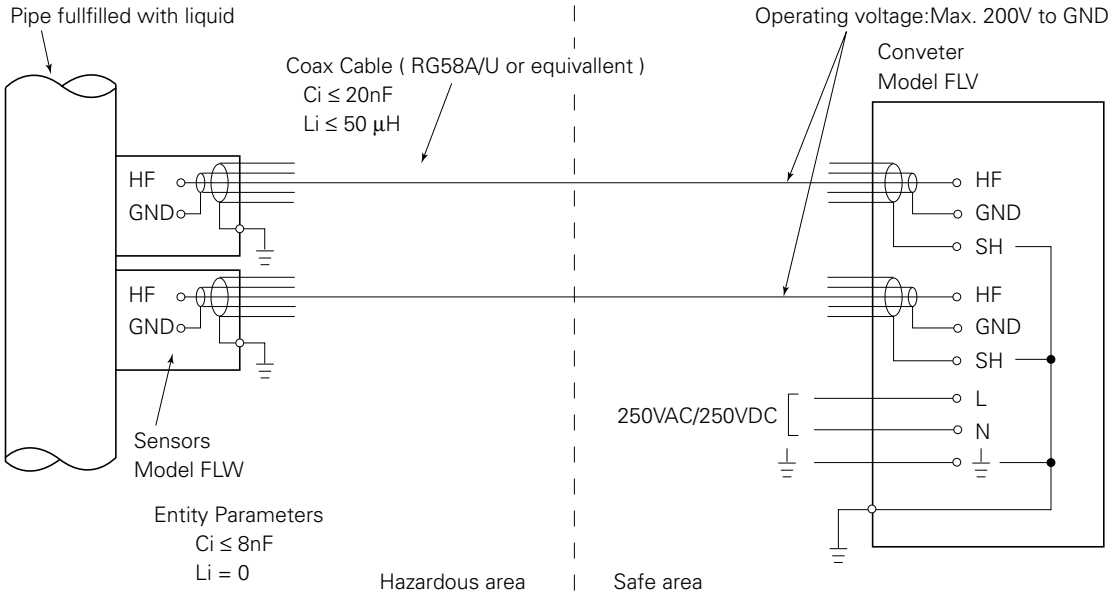


④ Check that the sensor is properly attached in parallel to the pipe and it is mounted according to the mounting dimension. Then, turn the element holder clockwise, so that the sensor makes a close contact with the pipe.



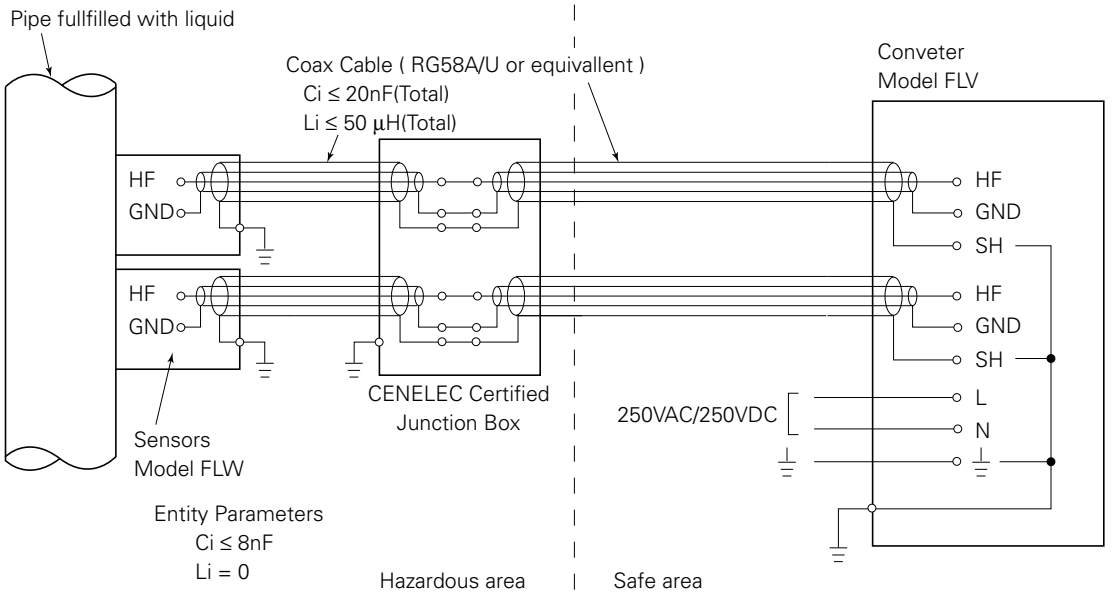
Stop turning the element holder where the transmitting surface contact the surface of pipe, and thus the element holder won't rotate. Don't turn it excessively.

8.2 Installation instruction for explosion-proof sensor



Note : All groundings are in accordance with class D (less than 100 ohm)

System certification: EEx m II T6
Ambient temperature: -20 to +60˚C for all units
Liquid temperature: -40 to +60˚C



Note : Any certified junction box conforming to the types of protection listed in EN50014 can be used to relay the co-axial signal cables.

APPENDIX 1. SPECIFICATIONS

(1) Specifications
Operational specifications

- System configuration : The system is composed of a sensor (Model FLW…2 or FLD…1) and a converter (Model FLV…3)
  As for explosion-proof type, the converter should be located in safe area.
- Application : Liquid flow through which ultrasonic signal can be transmitted
  (Water, sea water, oil and fluid of unknown sound velocity)
  Turbidity; 10000deg(mg/L) or less
  Fluid temperature;
  –40 to +80°C for small (FLW12), middle (FLW41) and large sensor (FLW5)
  –40 to +60°C for explosion-proof sensors (FLW1, 4 & 5)
  –40 to +100°C for small diameter sensor (FLD22)
  –40 to +200°C for high temperature sensor (FLD32)
  Type of flow;
  Well-developed turbulent or laminar flow in a full-filled pipe
- Measurable flow pipe : Size; 13mm to 100mm dia. with small diameter sensor (FLD22)
  50mm to 400mm dia. with small sensor (FLW12) and high temp. sensor (FLD32)
  200mm to 1200mm dia. with middle sensor (FLW41)
  200mm to 6000mm dia. with large sensor (FLW5)
  Material; Carbon steel, SS, cast iron, PVC, FRP, asbestos, copper, aluminum, etc.
  Lining; Tar epoxy, mortar, rubber, or others
  Straight pipe length (min);
  10 × D upstream and 5 × D down stream required (D: Pipe diameter)
  Refer to JEMIS-032 for details.
  JEMIS: Japan Electric Measuring Instruments Manufactures' Association's standard.
- Velocity : 0 to ±32m/s (bidirectional flow)
- Power supply : Two models are availble
  100 to 240V AC ±10% 50/60Hz, or 20 to 30V DC
- Power consumption : Approx. 20VA
- Maximum cable length for sensor: 150m
- Ambient Temperature : Converter ; –10 to +60°C
  Sensor ; –20 to +60°C
- Ambient humidity : 90%RH or less.
- Hazardous condition : Nemko 00ATEX0054X
  Ex. Ⅱ2G, EExmⅡT6, Tamb=60°C per CENELEC Std. EN50014 & EN50028 for explosion-proof sensors FLW1, 4 & 5 combined with the converter FLV specific to them.

- Grounding : Class D (less than 100 ohm) in case of need
  As for explosion-proof type, groundings of sensors and converter should be done.

Function/performance specifications

- Analog output signal : One 4 to 20mA DC current output
  Max. load resistance 1kΩ
- Digital status output : 2 transistor outputs available
  Open collector output; 30V DC, 0.1A
  Configurable to provide following information selected.
  – Total pulse
  – Flow switch
  – Over flow
  – Range change-over
  – Flow direction
  – Range over
  – Memory alarm
  – Receiving signal abnormal
- Measuring accuracy : Pipe size/13mm to under 50mm
  ±0.03m/s for flow rate: under 2m/s
  ±0.75% to ±1.5% of rate for flow rate: 2m/s to 32m/s
  Pipe size/50mm to under 300mm
  ±0.02m/s for flow rate: under 2m/s
  ±0.5% to ±1.0% of rate for flow rate: 2m/s to 32m/s
  Pipe size/300mm up to 6000mm
  ±0.01m/s for flow rate: under 1m/s
  ±0.5% to ±1.0% of rate for flow rate: 1m/s to 32m/s
  (Note) Reference conditions are based on JEMIS-032.
- Response time : 0.5s or less
- Communication interface: RS232–C equivalent
  Baud rate: 2400 to 9600bps
  Distance: 15m max.
  Following information can be sent.
  – Velocity
  – Flow rate
  – Total
  – Alarm output status
- Indicator display : LCD with back light, 16 letters 2 lines
- Display language : English, German, French or Japanese (Katakana) selectable

• Flow rate display function:

Display of velocity and flow rate (with flow direction) are selectable, Max: 8 digits

Unit: Metric/Inch system selectable

	Metric system	Inch system
Velocity	m/s	ft/s
Flow rate	L/s, L/min, L/h, ML/d, m^3/s m^3/min, m^3/h, Mm^3/d, BBL/s, BBL/min, BBL/h, MBBL/d	gal/s, gal/min, gal/h, Mgal/d, ft^3/s, ft^3/min, ft^3/h, Mft^3/d, BBL/s, BBL/min, BBL/h, MBBL/d

Note : The "gal" means US gal.

• Total value display function:

Display of forward or reverse total, are selectable, Max: 9 digits

Unit; Metric/Inch system, selectable

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

• Configuration : The flowmeter is fully configurable from front keyboard by menu-driven software

• Zero adjustment : Two methods are available

Set zero/Manual zero adjustment for zero flow

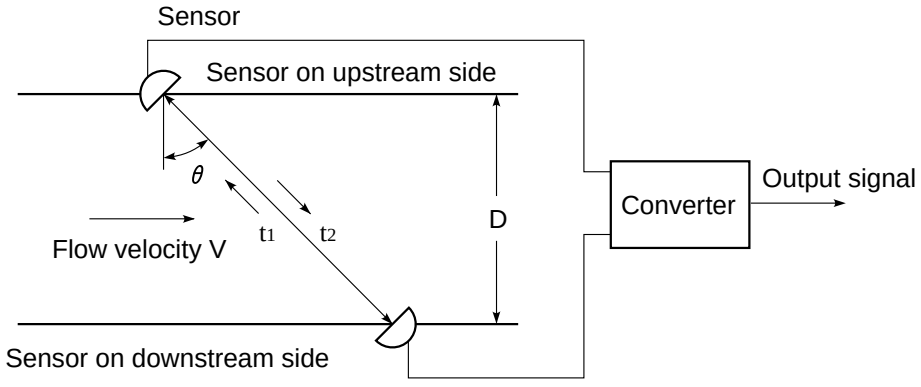
• Damping for analog output and indication:

0 to 100s, configurable

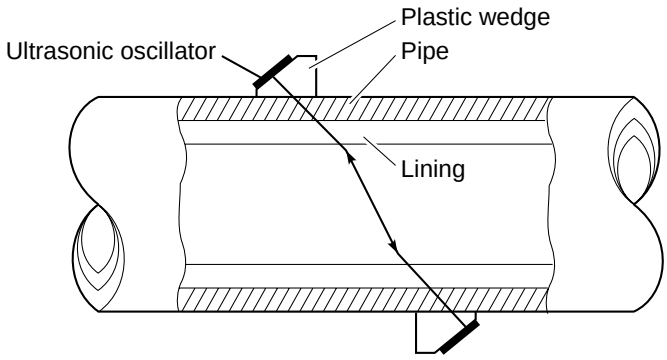
• Low flow cut-off : 0 to 5m/s, configurable

(2) Principle of measurement

With ultrasonic pulses propagated diagonally from the upstream and downstream sides, flow rate is measured by detecting the time difference obtained by the flow of fluid.

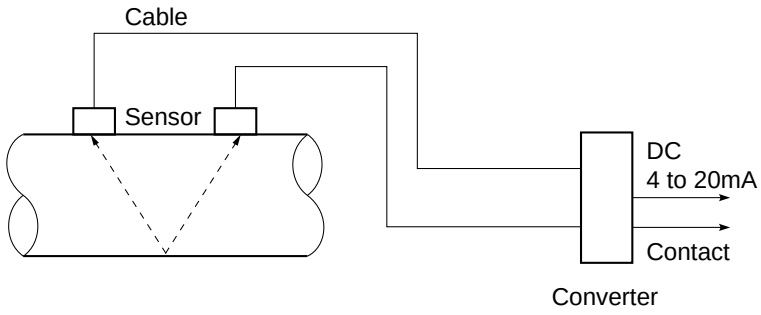


(3) Mounting of sensor

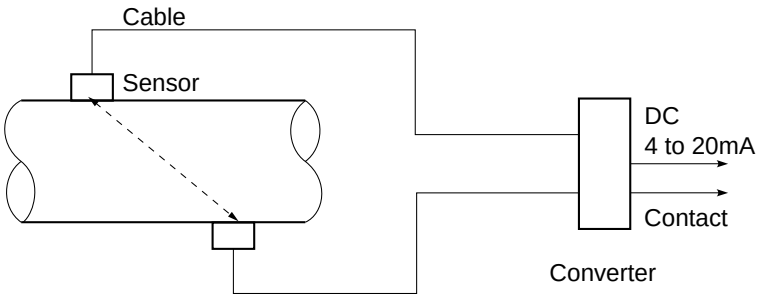


(4) Construction

(1) Single-measuring-path system (V method)

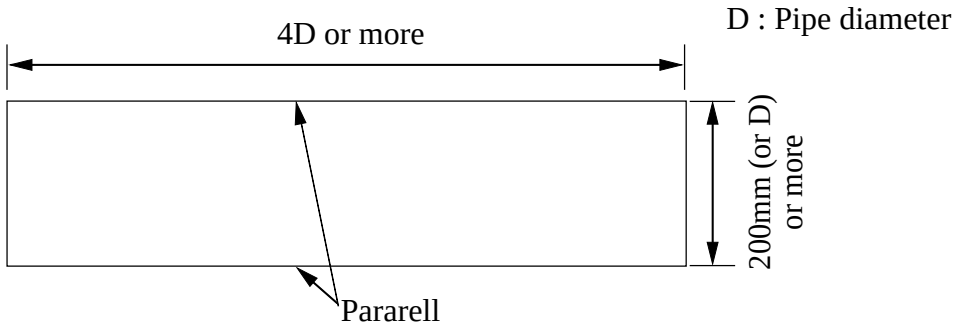


(2) Single-measuring-path system (Z method)

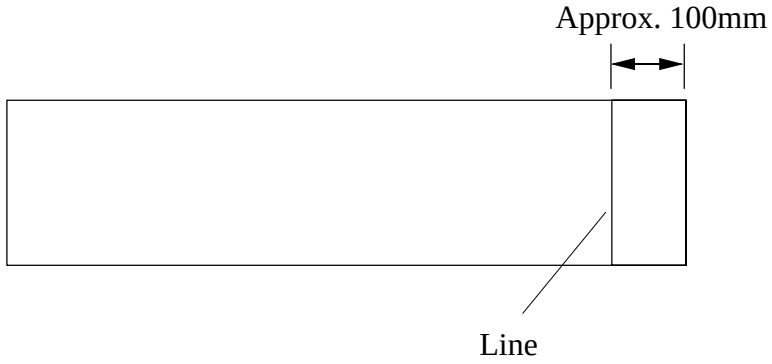


APPENDIX 2. HOW TO MAKE GAUGE PAPER

① Prepare a rectangular sheet of paper (or vinyl sheet) with its length of more than 4D and width of 200mm (D, if possible).



② Draw a line perpendicular to the long side at a point about 100mm from one end.

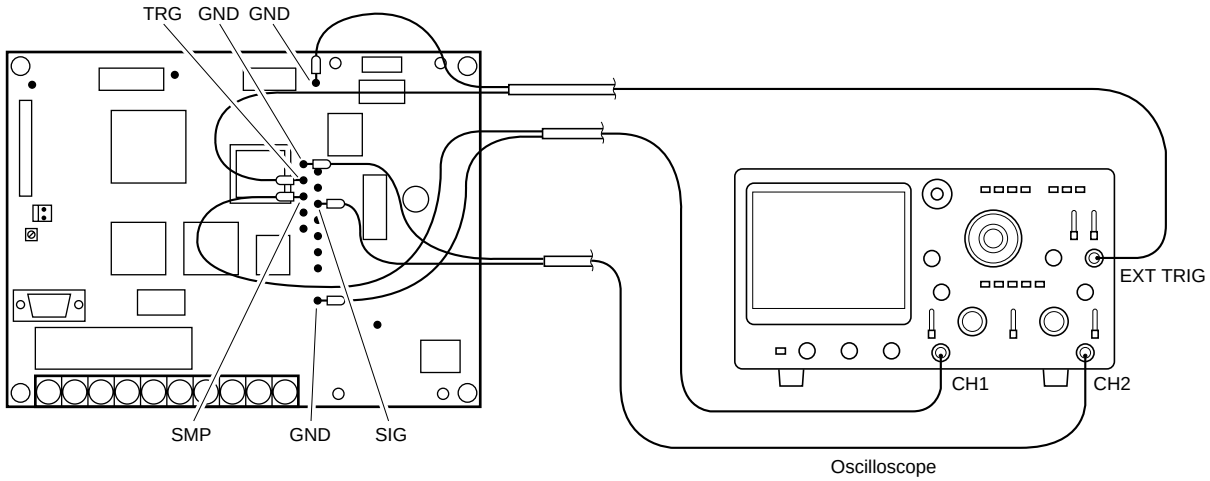


APPENDIX 3. CHECK OF RECEIVED WAVE FORM

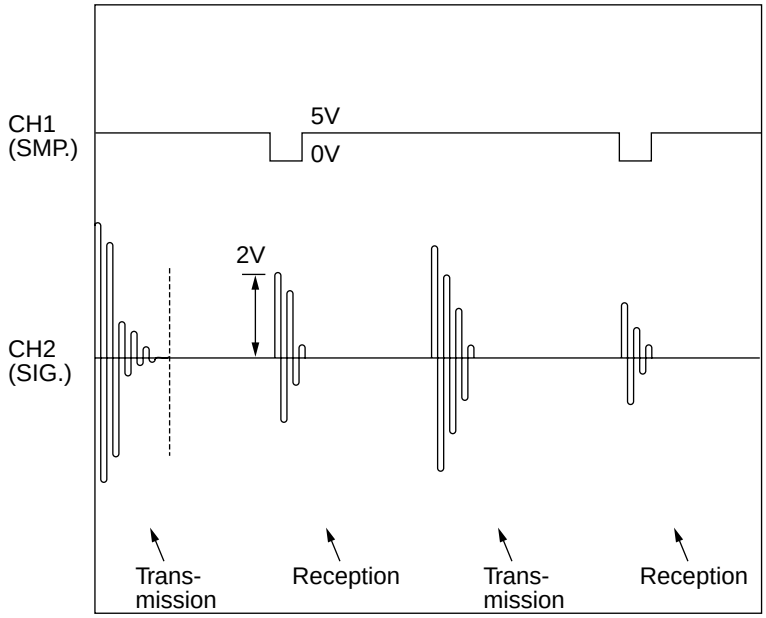
Carry out the following in this status.

(1) Check of transmission and reception

1) How to connect oscilloscope



2) Observe the waveforms on the oscilloscope.

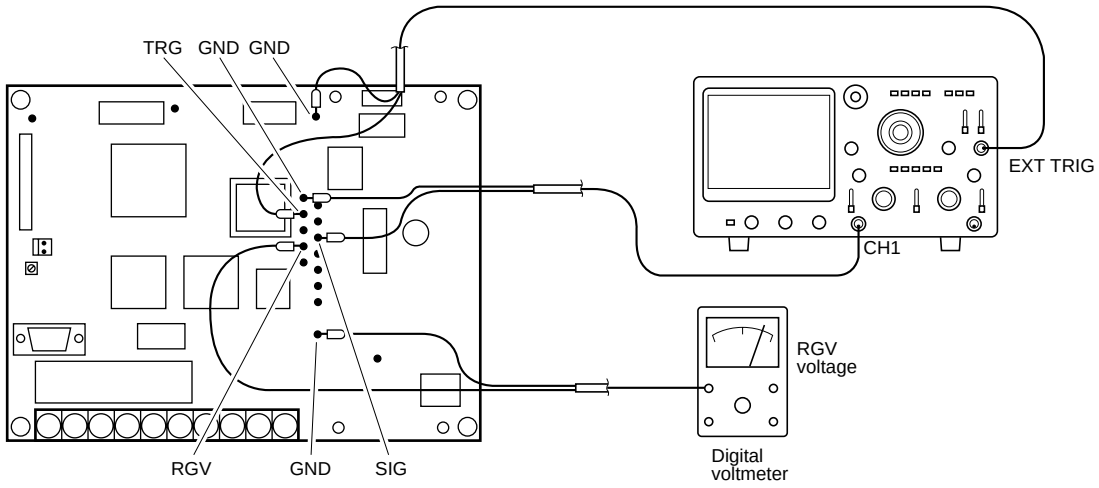


Items to be confirmed:

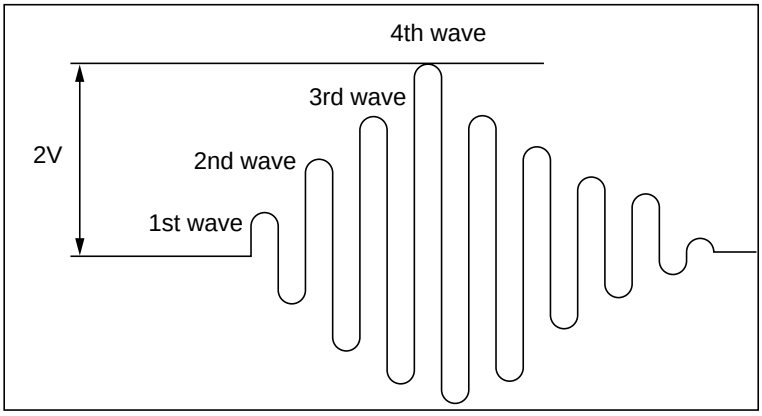
1. The received wave should be nearly at the center of the Low (0V) section of CH1 SMP.
   Measurement is disabled if the wave deviates from the Low section.
   - Check of piping specifications
   - Check of mounting dimensions
2. The received wave level should be at about 2V on the positive side.
   If lower than 2V, the received wave is weak and AGC becomes impossible.
   - Change the “TRANS. VOLTAGE” to × 8 (refer to 5.4 (1)).
   - Check the detector mounting.
   - Check for air inside the pipe.

(2) Check of received wave form on oscilloscope

1) Connection of oscilloscope



2) Expand the received wave portion via delayed sweep and check it.



Check:

1. The waveform reaches a peak by the 4th wave.
2. “RGV” voltage should be 4.5V or more.

APPENDIX 4. SPECIFICATIONS FOR SERIAL TRANSMISSION

(1) General specifications

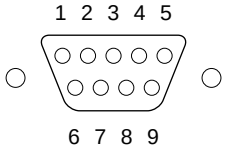
- Communication system : Semi-duplex
- Synchronizing system : Start-stop synchronizing
- Transmission speed : 300/600/1200/2400/4800/9600/19200 BPS (selectable)
- Parity : Even/odd/none (selectable)
- Data length : 8 bits
- Stop bit : 1 bit/2 bits (selectable)
- Data code : ASCII

(2) Interface specifications

- Electric characteristics : Based on EIA RS-232C
- Signal connection :

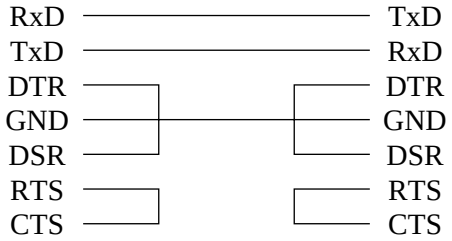
Pin No.	Signal	Meaning	Signal direction
2	RxD	Receive data	Input
3	TxD	Send data	Output
4	DTR	Data terminal unit ready	—
5	GND	Signal ground	(Not used)
6	DSR	Data set ready	(Not used)
7	RTS	Send request	(Not used)
8	CTS	Send ready	(Not used)

Connector pin layout diagram



- Cable length : Within 15m
- Connector : D-SUB 9-pin plug
- Connection : 1:1 connection

[FLV] [Host computer]



(3) Wiring

Use cables and connectors for transmission.

Connect cables to the FLV transmitter using D-SUB 9-pin jack and connector as shown in Item (2) above.

Connect cables to the host computer referring to the instruction manual for the computer.

(Note that the connection of control signal cable may vary depending on the type of computer.)

(4) Setting

Be sure to set transmission speed, parity and stop bit prior to transmission to FLV.

These should be set as follows.

Transmission speed : 1200 BPS

Parity : Odd

Stop bit : 1 bit

(5) Communication control

① Method

When a request command is received from the host computer, data are transmitted from FLV. FLV is set in standby mode until a command is received. Upon receiving a command from the host computer, data for the command is transmitted from FLV.

② Command

Using ASCII code, command is transmitted from the host computer.

The last code of one command denotes “carriage return (0DH)”.

List of FLV RS-232C transmission commands

Data	Command	Data format
Flow velocity	:UP0000[CR]	:UP0000[CR][LF]±DDDDD.DDDDD [unit][RAS][CR][LF]
Flow rate	:UP0001[CR]	:UP0001[CR][LF]±DDDDD.DDDDD [unit][RAS][CR][LF]
RANGE % (Ratio of analog output to range)	:UP0002[CR]	:UP0002[CR][LF]±DDDDD.DDDDD [%][RAS][CR][LF]
F:TOTAL (Forward integral value)	:UP0003[CR]	:UP0003[CR][LF]#D DDDDDDD [unit][CR][LF]
R:TOTAL (Reverse integral value)	:UP0004[CR]	:UP0004[CR][LF]#D DDDDDDD [unit][CR][LF]
F:TOTAL PULSE (Froward integral pulse counter)	:UP0005[CR]	:UP0005[CR][LF]DDDDDDD [FPL][CR][LF]
R:TOTAL PULSE (Reverse integral pulse counter)	:UP0006[CR]	:UP0006[CR][LF]DDDDDDD [RPL][CR][LF]
STATUS INF. (Refer to page E-6)	:UP0007[CR]	:UP0007[CR][LF]DDDDDDDDDDDDDDDD [CR][LF]

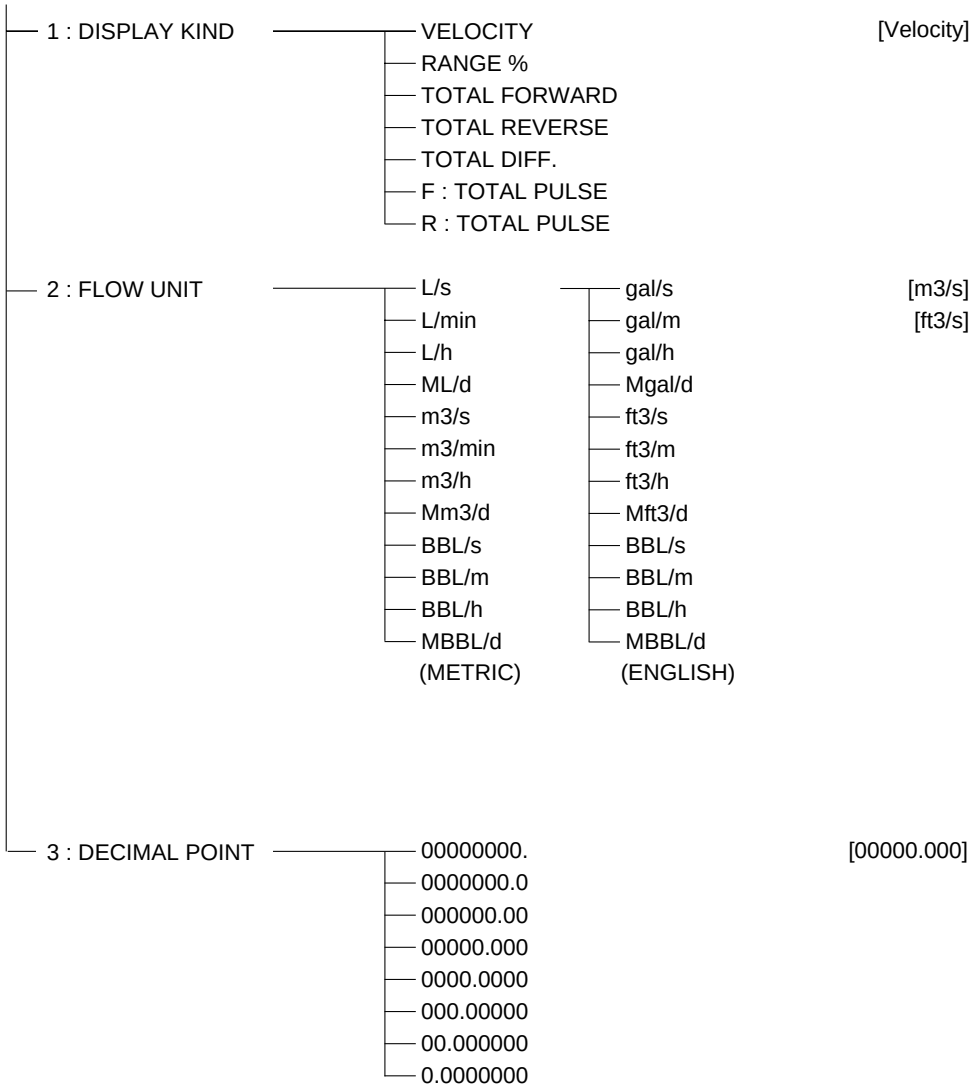
[CR] : Carriage Return

[LF] : Line Feed

APPENDIX 5. COMPOSITION OF KEY OPERATION

(1) SETTING OF MEASURE DISPLAY

FUNC ⇨ DISP [Initial value]



(2) SETTING OF PIPING SPECIFICATIONS

FUNC⇨ PIPE

- SENSOR SPACING
- OUTER DIAMETER (13 to 6100 mm) (0.52 to 240 inch) [Entry of dimension of outer circumstance]⇨ Press "/π" key. ⇨ Converted into outer diameter — [13 mm] [0.52 inch]
- PIPE MATERIAL — [Carbon steel]
  - CARBON STEEL
  - STAINLESS STEEL
  - PVC
  - COPPER
  - CAST IRON
  - ALUMINUM
  - FRP
  - ASBESTOS
  - DUCTILE IRON
  - PEEK
  - PVDF
  - ACRYLIC
  - OTHERS
- PIPE S.V. (1000 to 3700 m/s) (3281 to 12140 ft/s) — Note) Displayed when selecting "OTHERS" from the pipe materials. — [1000 m/s] [3281 ft/s]
- WALL THICKNESS (0.1 to 100 mm) (0.01 to 4 inch) — [0.1 mm] [0.01 inch]
- LINING MATERIAL — [NO LINING]
  - NO LINING
  - TAR EPOXY
  - MORTAR
  - RUBBER
  - TEFLON
  - PYREX GLASS
  - PVC
  - OTHERS
- LINING S.V. (1000 to 3700 m/s) (3281 to 12140 ft/s) — Note) Displayed when selecting "OTHERS" from the lining materials. — [1000 m/s] [3281 ft/s]
- LINING THICKNESS (0.01 to 100 mm) (0.01 to 4 inch) — Note) Displayed when selecting "OTHERS" from the lining materials. — [0.01 mm] [0.01 inch]
- KIND OF FLUID — [WATER]
  - WATER
  - SEAWATER
  - OTHERS
- FLUID S.V. (500 to 2500 m/s) (1641 to 8208 ft/s) — Note) Displayed when selecting "OTHERS" from the lining materials. — [500 m/s] [1641 ft/s]
- VISCOSITY (0.001E−6 to 999.999E−6 m2/s) (0.1E−6 to 999.9E−6 ft2/s) — [1.003E−6 m2/s] [10.7E−6 ft2/s]
- SENSOR MOUNTING — [V METHOD]
  - V METHOD
  - Z METHOD
- SENSOR TYPE — [FLW12]
  - FLW11
  - FLW12
  - FLD22
  - FLD32
  - FLW41
  - FLD12
  - FLW50
  - FLW51
- TRANS. VOLTAGE — [4 TIMES]
  - 1TIME
  - 2TIMES
  - 4TIMES
  - 8TIMES

(3) SETTING OF FLOW SWITCH

FUNC ⇨ FLOW SW

- FLOW SW LOW (0 to ±32 m/s) [0 m/s]
  (0 to ±105 ft/s) [0 ft/s]
- FLOW SW HIGH (0 to ±32 m/s) [32 m/s]
  (0 to ±105 ft/s) [105 ft/s]
- FLOW SW HYS. (0 to 20%) [10 %]

(4) SETTING OF OUTPUT

FUNC ⇨ OUTPUT

- RANGE UNIT
  - (METRIC): m/s, L/s, L/min, L/h, ML/d, m3/s, m3/mim, m3/h, Mm3/d, BBL/s, BBL/m, BBL/h, MBBL/d
  - (ENGLISH): ft/s, gal/s, gal/m, gal/h, Mgal/d, ft3/s, ft3/m, ft3/h, Mft3/d, BBL/s, BBL/m, BBL/h, MBBL/d
  - [m/s] / [ft/s]
- RANGE TYPE
  - SINGLE RANGE [SINGLE RANGE]
    - BASE SCALE (0 to ±32 m/s) [0 m/s]
      (0 to ±105 ft/s) [0 ft/s]
    - FULL SCALE (±0.3 to ±32 m/s) [32 m/s]
      (±1 to ±105 ft/s) [105 ft/s]
  - AUTO 2 RANGES
    - BASE SCALE (0 to ±32 m/s) [0 m/s]
      (0 to ±105 ft/s) [0 ft/s]
    - FULL SCALE1 (±0.3 to ±32 m/s) [32 m/s]
      (±1 to ±105 ft/s) [105 ft/s]
    - FULL SCALE 2 (±0.3 to ±32 m/s) [32 m/s]
      (±1 to ±105 ft/s) [105 ft/s]
    - RANGE HYSTERESIS (0 to 20%) [10 %]
  - BI-DIR. RANGE
    - Same as AUTO 2 RANGES
- OUTPUT LIMIT LOW (−20 to 120 %) [−20 %]
- OUTPUT LIMIT HIGH (−20 to 120 %) [120 %]
- OUTPUT BURNOUT [NOT USED]
  - NOT USED
  - HOLD
  - UPPER
  - LOWER
  - ZERO
- BURNOUT TIMER (0 to 900 sec) [0 sec]

(5) SETTING OF DAMPING

FUNC ⇨ DAMP

- DAMPING (0 to 100 sec) [5 sec]

(6) SETTING OF LOW FLOW OUTPUT CUT

FUNC ⇨ CUT OFF

- CUT OFF (0 to 5 m/s) [0 m/s]
  (0 to 16.4 ft/s) [0 ft/s]

(7) SETTING OF TOTAL OUTPUT

FUNC ⇨ TOTAL

- TOTAL MODE — TOTAL STOP [TOTAL STOP]
  - TOTAL RUN
  - TOTAL RESET
- TOTAL UNIT — mL, L, m3, km3, Mm3, mBBL, BBL, kBBL (METRIC) [m3]
  - gal, kgal, ft3, kft3, Mft3, mBBL, BBL, kBBL (ENGLISH) [ft3]
- TOTAL RATE (0 to 9999999) [0]
- F : TOTAL PRESET (0 to 9999999) [0]
- F : TOTAL SW (0 to 9999999) [0]
- R : TOTAL PRESET (0 to 9999999) [0]
- R : TOTAL SW (0 to 9999999)
- PULSE WIDTH — 50 msec [50 msec]
  - 100 msec

(8) ZERO ADJUSTMENT

FUNC ⇨ ZERO

- ZERO MODE — SET ZERO [SET ZERO]
  - CLEAR

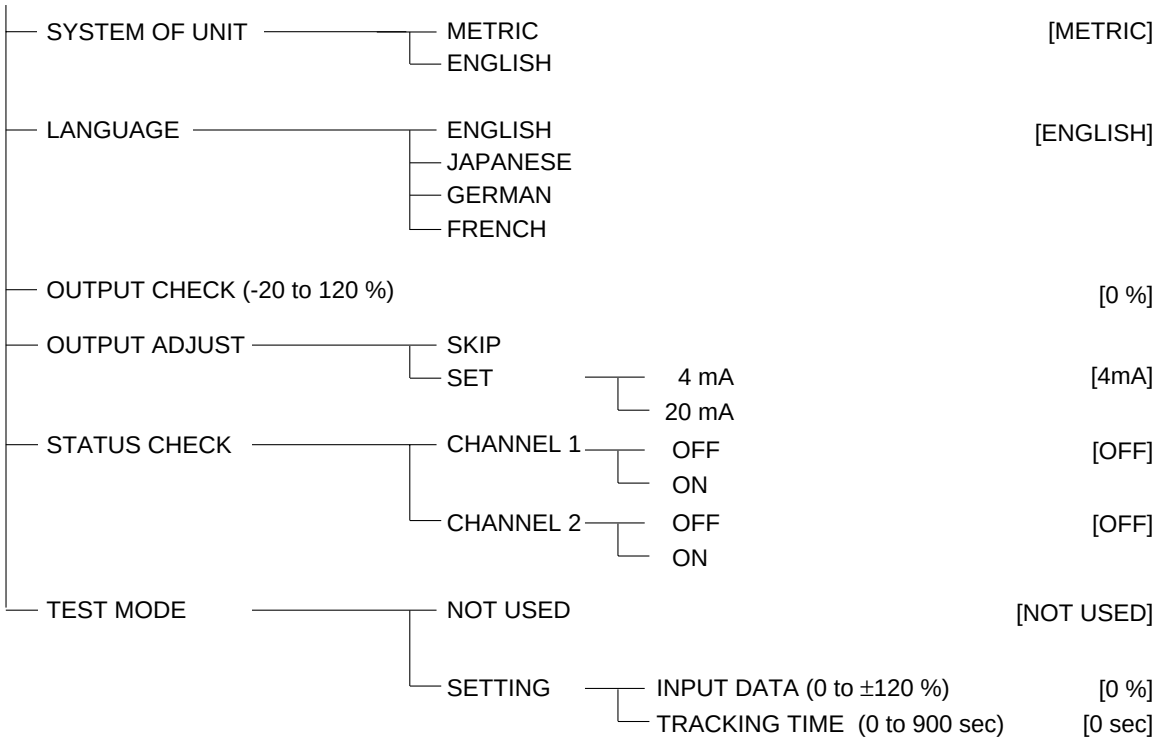
(9) CALIBRATION OF MEASUREMENT VALUE

FUNC ⇨ CAL (2)

- CALIBRATON ZERO (0 to ±5 m/s) [0 m/s]
  (0 to ±16.4 ft/s) [0 ft/s]
- CALIBRATION SPAN (0 to 200%) [100 %]

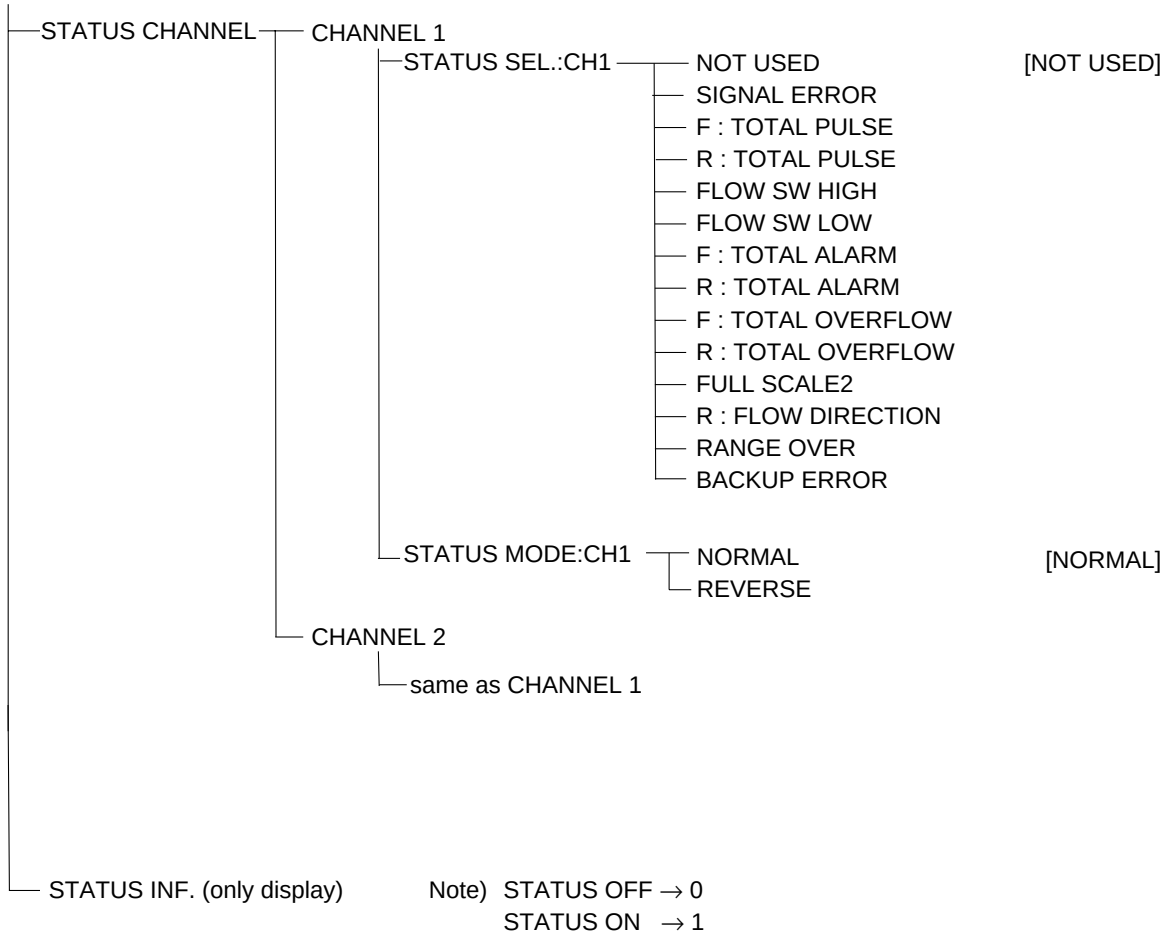
(10) SETTING OF SYSTEM CONDITION

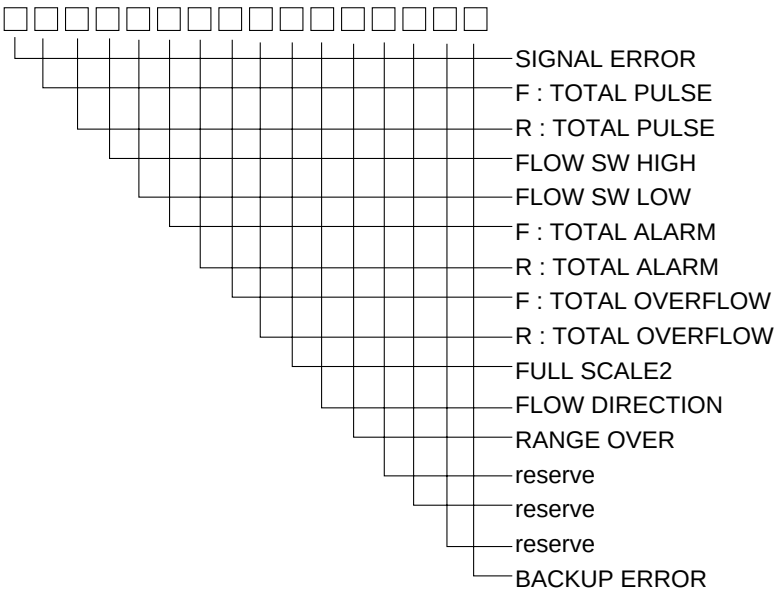
FUNC ⇨ SYSTEM



(11) SELECTING OF STATUS

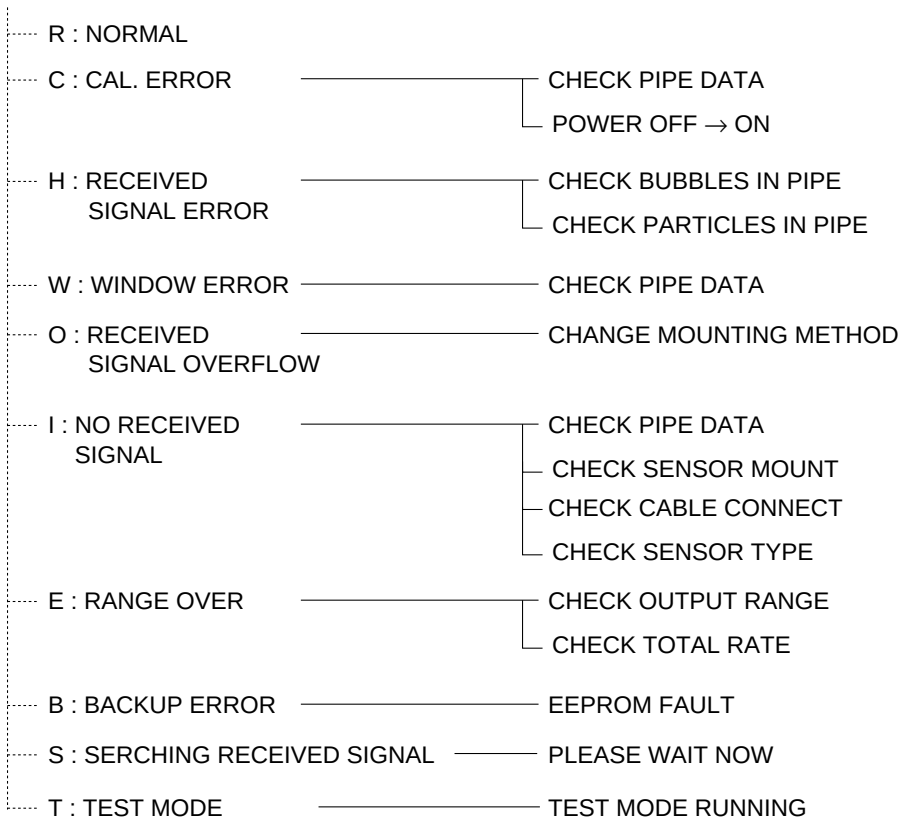
FUNC ⇨ STATUS





(12) ERROR CHECK

FUNC ⇨ CHECK



APPENDIX 6. PIPING DATA

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

Nominal diameter (mm)		Outer diameter (mm)	Normal 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 pipe		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 portion (mm)	Outer diameter of connected portion (mm)	Thickness of connected portion (mm)	Outer diameter of connected portion (mm)	Thickness of connected portion (mm)	Outer diameter of connected portion (mm)	Thickness of connected portion (mm)	Outer diameter of connected portion (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

Polyethlene pipe for general use (JIS K6761-1979)

Nominal diameter (mm)	Outer diameter (mm)	1st type	2nd type
		Thickness (mm)	Thickness (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 pipe	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 type cast iron pipe (JISG5521)

Nominal pipe 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 pipe		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
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)

Section / Nominal pipe (mm)	VP		VU	
	Outer diameter	Thickness	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

Steel pipe coated for city water STPW (JIS G3443-1968)

Nominal diameter (A)	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

Steel pipe coated for city water STW (JIS G3443 1987)

Nominal diameter A	Outer diameter mm	Kinds of symbol				Kinds of symbol			
		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	Thickness of pipe			Actual outer diameter
D	T			D1
	1st type pipe	2nd type pipe	3rd type pipe	
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	Thickness of pipe			Actual outer diameter
D	1st type pipe	2nd type pipe	3rd type pipe	D1
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

Ductile iron specials

Nominal diameter (mm)	Thickness of pipe (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 D	Thickness of pipe T			Actual outer diameter D_2
	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
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

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

Nominal diameter		Outer diameter (mm)	Nominal thickness			
			Schedule 5S	Schedule 10S	Schedule 20S	Schedule 40S
A	B		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

Arc welded carbon steel pipe (JIS G3457-1976)

Nominal diameter (A)	Nominal diameter (B)	Outer diameter (mm) \ Thickness (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
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

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

Nominal diameter (mm)	Thickness of pipe T		Actual outer diameter D_1
	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

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

Nominal diameter	Outer diameter	Thickness
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

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

PVDF-HP

Nominal diameter (mm)	SDR33 S16 PN10	SDR21 S10 PN16	SDR17 S8 PN20
	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 of temperature in water (0 to 100°C)

T°C	Vm/s	T°C	Vm/s	T°C	Vm/s	T°C	Vm/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) Velocity of sound and density of various liquids

Name of liquid	T°C	ρg/cm^3	Vm/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-xylene	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
Dithionic acid	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 disulfide	20	1.2634	1158
Chloroform	20	2.8904	931
n-propyl alcohol	20	0.8045	1225
n-pentane	20	0.6260	1032
n-hexane	20	0.654	1083
Light 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
Sea water (salinity: 35%)	16	1.	1510

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

(c)Velocity of sound per piping material

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

Note) V: velocity of sound

(d) Dynamic viscosity coefficient of various liquids

Name of liquid	T°C	ρg/cm^3	Vm/s	ν (× 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 disulfide	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: velocity of sound
ν: kinematic viscosity

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