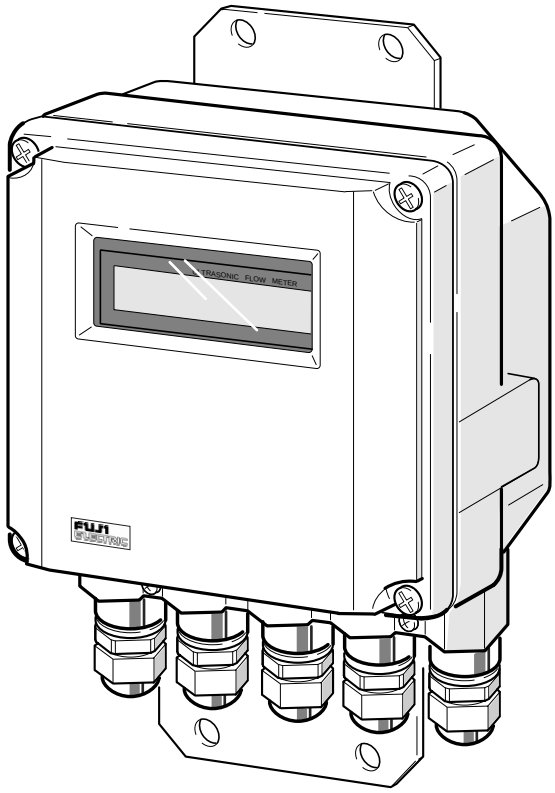
FUJI ELECTRIC

Instruction Manual

ULTRASONIC FLOWMETER

TYPE: **FLV**
FLW



Fuji Electric Co.,Ltd.

INF-TN2FLVa-E

PREFACE

We are grateful for your purchase of Fuji Electric's Ultrasonic flowmeter.

- 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 flowmeter. Wrong handling may cause an accident or injury.
- The specifications of this flowmeter will be changed without prior notice for further product improvement.
- Modification of this flowmeter is strictly prohibited unless a written approval is obtained from the manufacturer. Fuji Electric 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.

Manufacturer:	Fuji Electric Co.,Ltd.
Type:	Described in Fuji Electric's company nameplate on main frame
Date of manufacture:	Described in Fuji Electric's company nameplate on main frame
Product nationality:	Japan

Request

- It is prohibited to transfer part or all of this manual without Fuji Electric's permission in written format.
- Description in this manual will be changed without prior notice for further improvement.

Issued in July, 1998

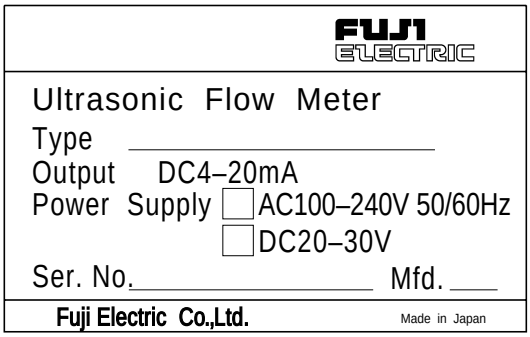
About ultrasonic flowmeter

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.

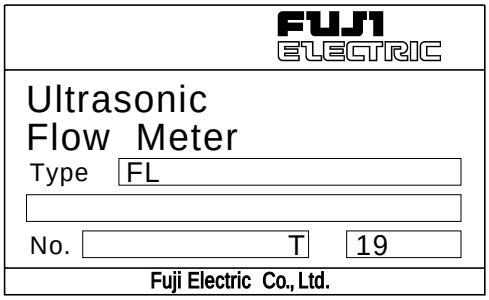
Check on type and specifications

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).

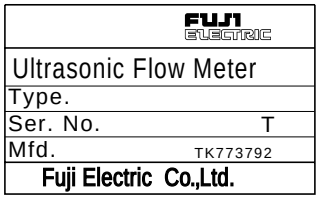
(1) Specification nameplate



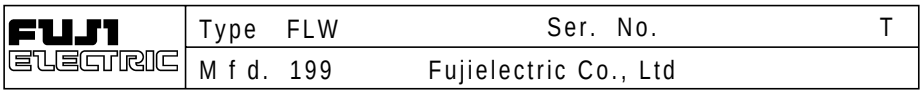
Converter



Large type sensor



Small type sensor



High temperature sensor

CAUTION ON SAFETY

- The cautionary descriptions listed here contain important information about safety, so they should always be observed. Those safety precautions are ranked 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.

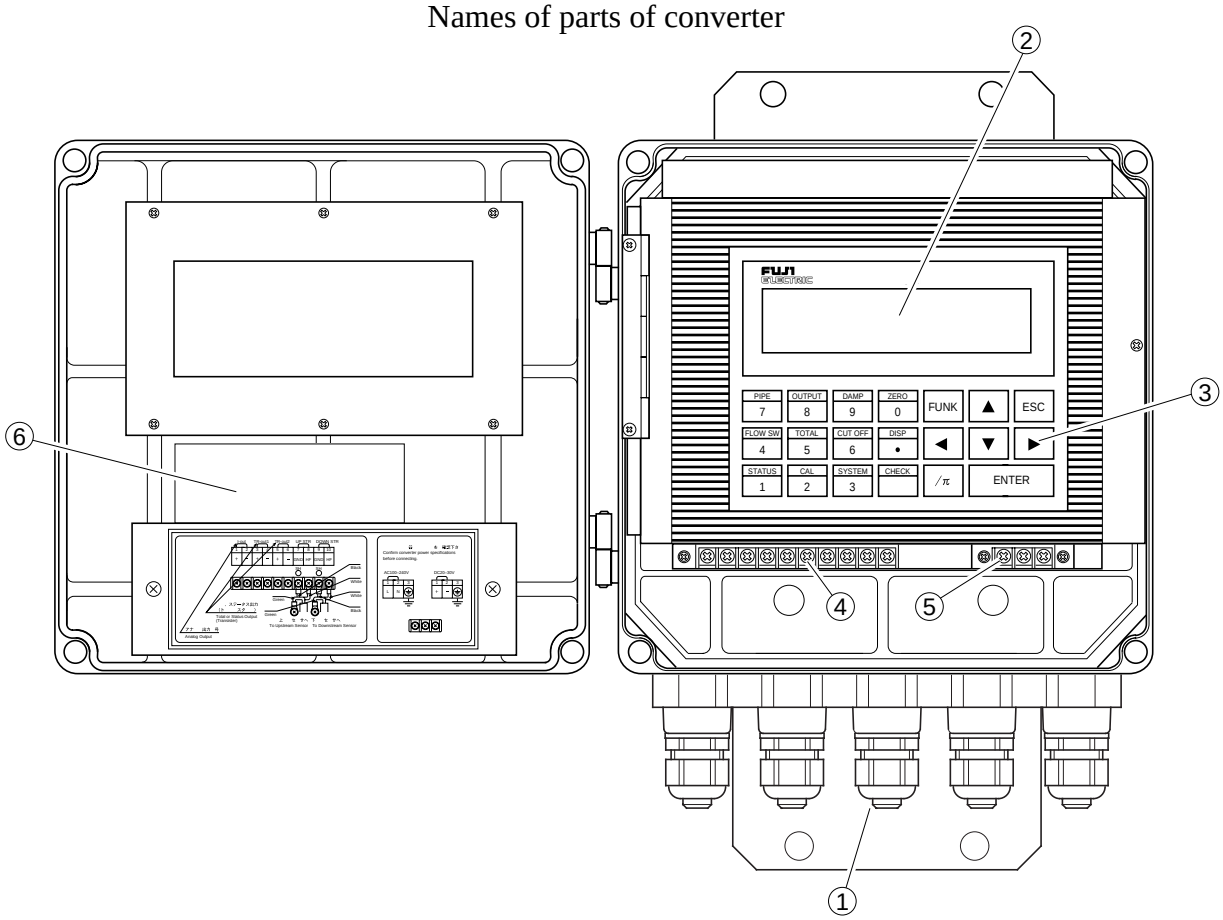
Caution on installation and wiring	
DANGER	• This unit is not explosion-proof type. Do not use it in a place with explosive gases to prevent explosion, fire or other serious accidents.
CAUTION	• The flowmeter should be installed in a place that meets the operating conditions shown in this instruction 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 funcitons 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 +14°F to +140°F. 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.

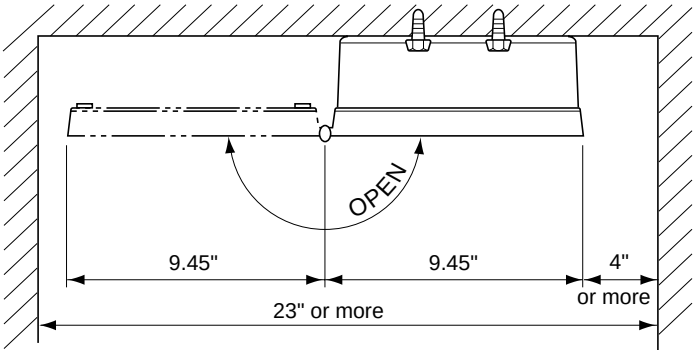


Fig. 2-1 Installation space (top view)

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.

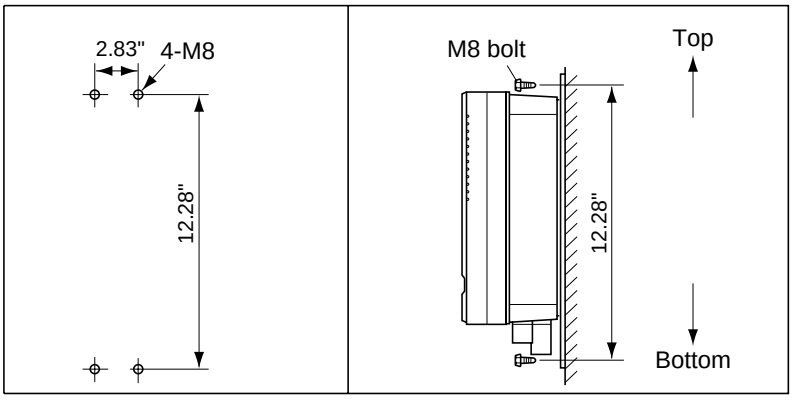
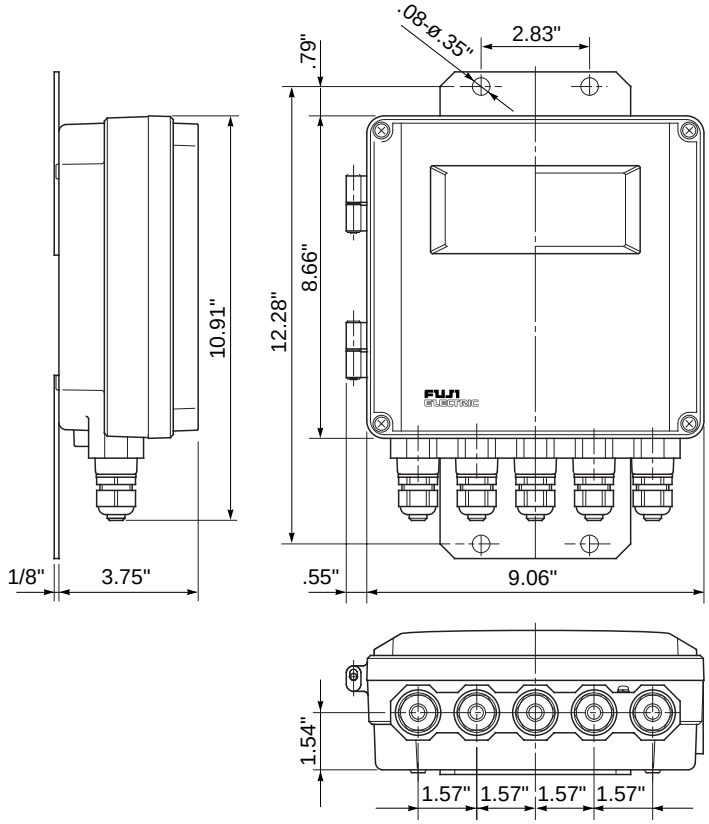


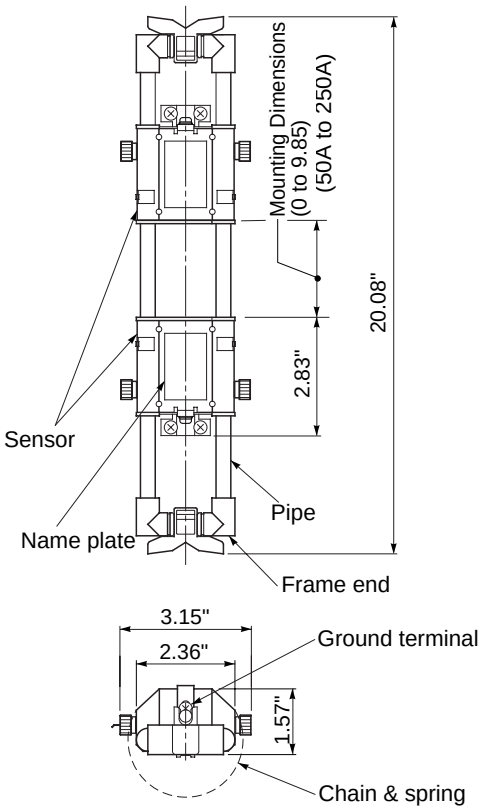
Fig. 2-2 Mounting method

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

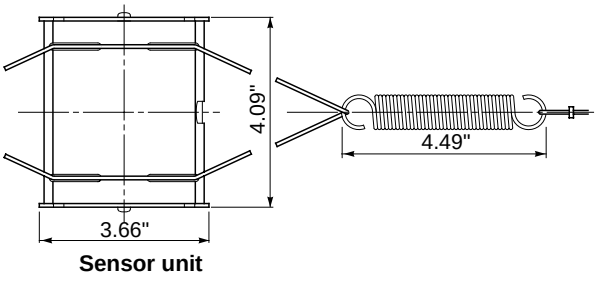
2.3 Outline diagram (unit: in.)



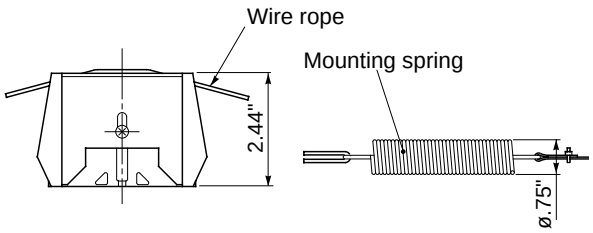
Converter FLV



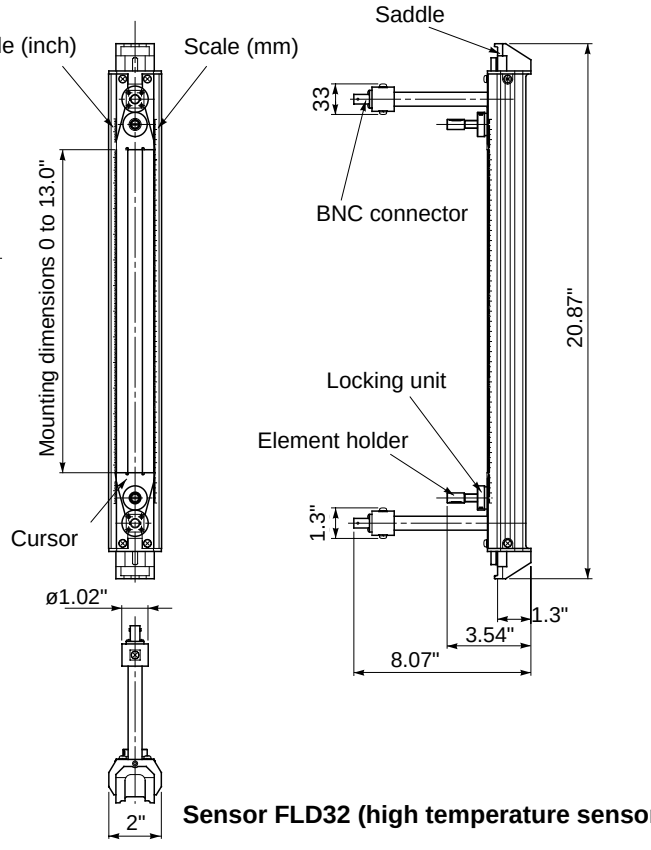
Sensor FLW1 (small type sensor)



Sensor unit



Sensor FLW5 (large type sensor)



Sensor FLD32 (high temperature sensor)

3. WIRING OF THE CONVERTER

3.1 Before wiring

1. **For signal cable between the sensor and converter, use double-shielded coaxial cables specified by Fuji Electric.** 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 : 0.30 in.^{2} or more,
  Finished outside diameter : ø.43 in.
- Output signal cable: 2 core cable or multi-core cabtyre cable as needed.
  Finished outside diameter : ø.43 in.
- Cable between sensor and converter:
  Signal cable specified by Code Symbols
  (High frequency coaxial cable with characteristic impedance of 50Ω)
  Finished outside diameter : ø.29 in.

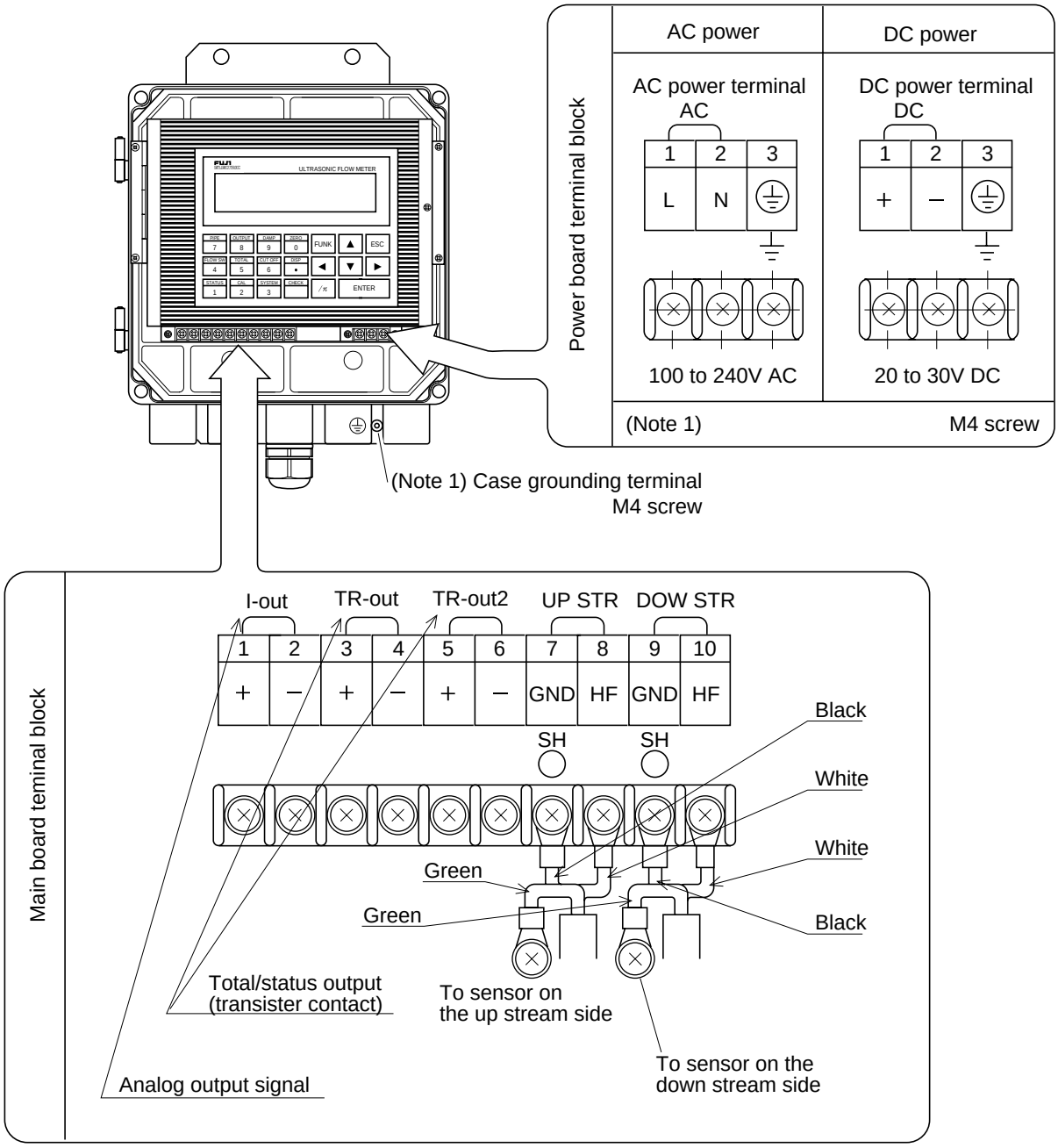
3.3 Treatment of the wiring port

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
3) Check of grounding terminal

} See Item 3.4

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).

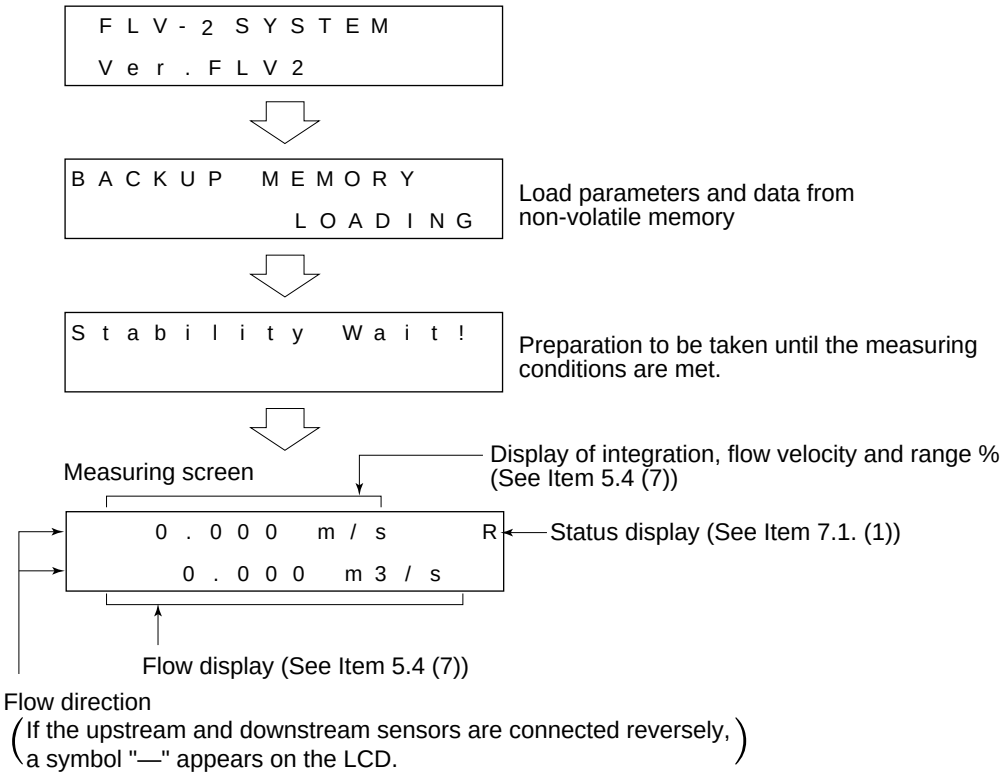
2) DC power

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.

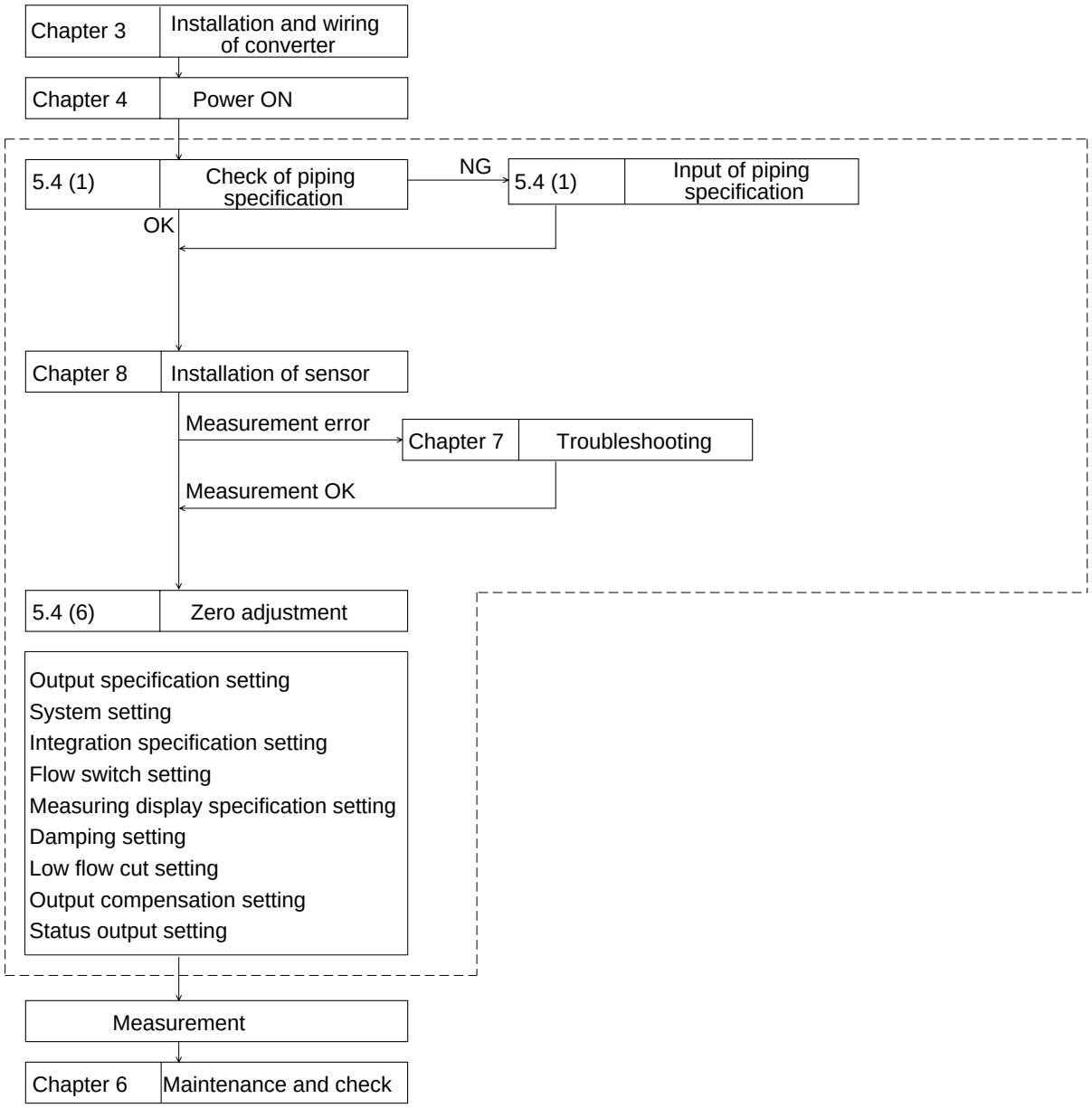
The numerical values and symbols being displayed are as described below:



5. SETTING OF PARAMETERS

5.1 Outline of operating procedures

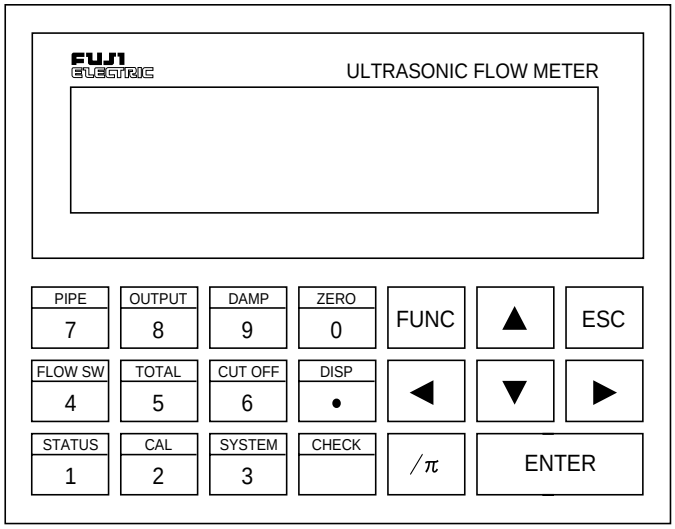
Proceed to the following procedure before starting measurements.



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.



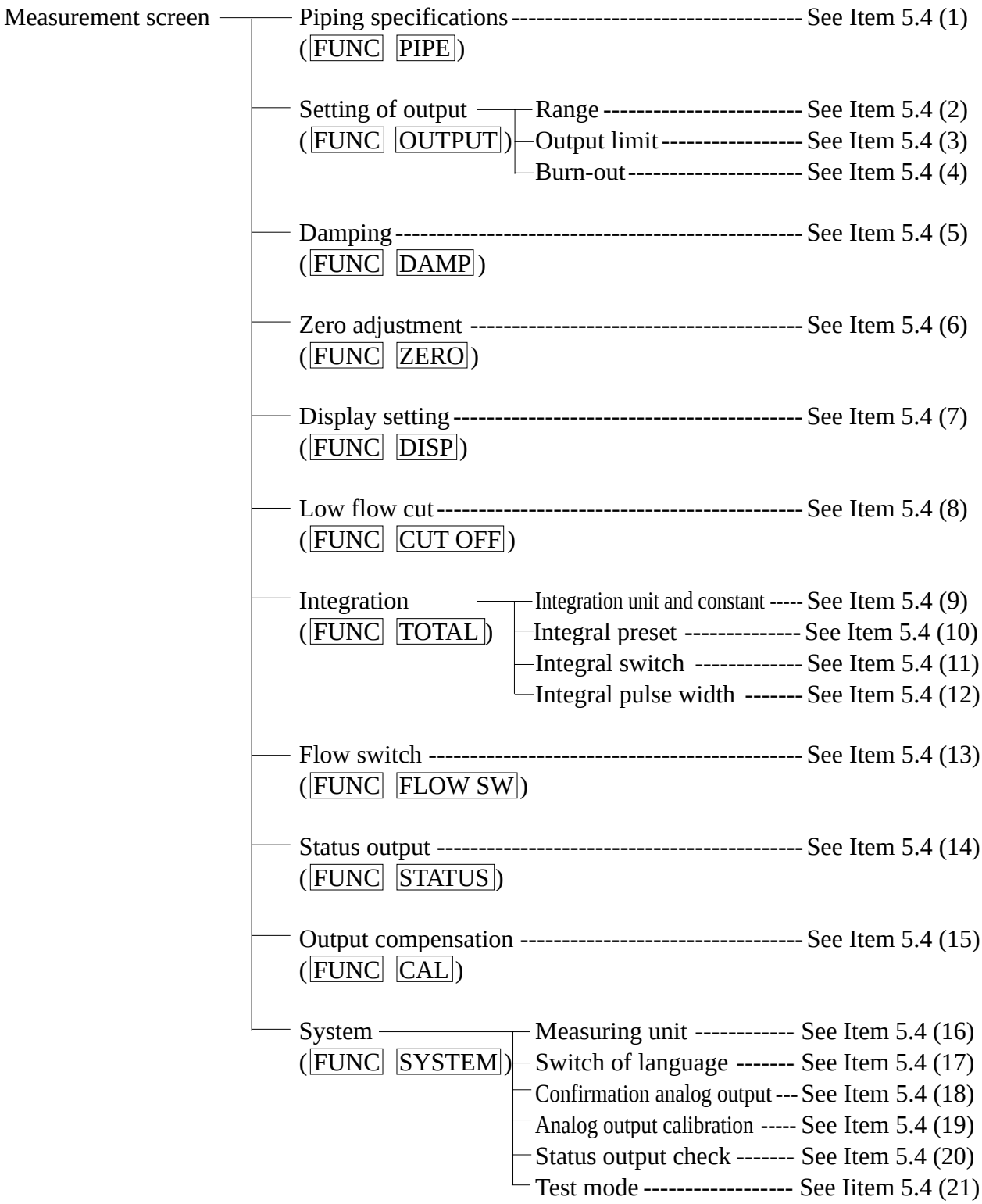
Description of key (1/2)

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
/pi	/pi	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 (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 (Damping)	FUNC DAMP	To set the damping.
ZERO (Zero)	FUNC ZERO	To use when zero adjustment is performed.
DISPLAY (Display panel)	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 (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 (System)	FUNC SYSTEM	To switch the measuring unit system and language, or confirm or calibrate analog output.
CHECK (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
Outside diameter of pipe	Numeric value	2 in. to 236 in.
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	0.0039 in. to 3.937 in.
Lining (with/without) and material	Selectable	NO LINING, TAR EPOXY, MORTAR, RUBBER, TEFLON, PYREX GLASS, OTHERS *1
Type of fluid	Selectable	WATER, SEAWATER, OTHERS *1
Dynamic viscosity coefficient of fluid	Numeric value	0.001E−19.68 ft.^{2}/s to 999.999E−19.68 ft.^{2}/s *2
Mounting method of sensor	Selectable	V METHOD, Z METHOD
Type of sensor	Selectable	FLW12, FLW41, FLW50
Transmission voltage of sensor	Selectable	1 TIME, 2 TIME, 4 TIME, 8 TIME

*1) Selection of “OTHERS”
Materials of piping and lining should be selected within the range of 3281 to 12,139 ft./sec. of sound velocity and 1640 to 8202 ft./sec. of flow velocity (see Appendix).

*2) Dynamic viscosity coefficient is expressed in water (68°F: 1.004E−19.68 ft.^{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, dynamic viscosity coefficient: 1.129 x $10^{-6}m^2/s$, 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 TIME”.	TRANS. VOLTAGE 8 TIME
	The sonsor mounting dimension is displayed.	SENSOR SPACING 80.56 mm V
ESC ESC	Press the key twice.	(Measurement display)

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

5.4 (2) Setting of analog output range

Description

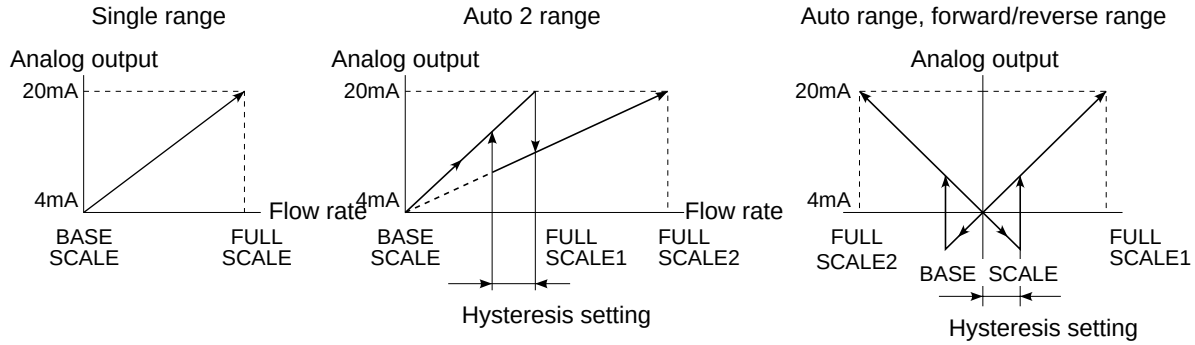
An analog output range is set to provide an output of 4 to 20mA in the specified range of measured values (flow rate or flow velocity).

[Measurement items]

1. Selection of range unit ..... m/s

   Note 1) l/s, l/m l/h, Ml/d
   m^3/s, m^3/m, m^3/h, Mm^3/d
   BBL/s, BBL/m, 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

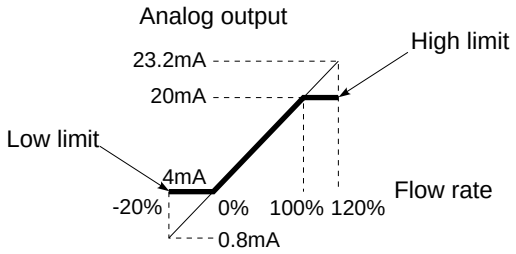
   Note 1) Flow units of low flow cut, flow switch and output compensation flow units are changed with the selection of the range unit.

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 “Forward/reverse 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%).



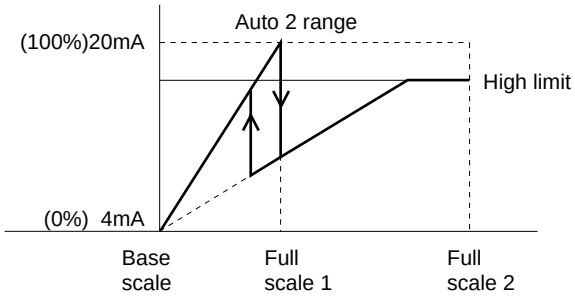
Operation (example)	Low limit : -10% (2.4mA), high limit : 110% (21.6mA)	
Key operation	Description	Display
FUNC OUTPUT		
▲ or ▼	Select “Output limitter”.	OUTPUT LIMIT LOW – 20 %
± 1 0, ENTER	Enter “–10”with ten keys.	OUTPUT LIMIT LOW – 10 %
1 1 0, ENTER	Enter “110” with ten keys.	OUTPUT LIMIT HIGH 110 %
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 forward/reverse 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
- HIGH : 120%t output (23.2mA) is obtained.
- LOW : –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.

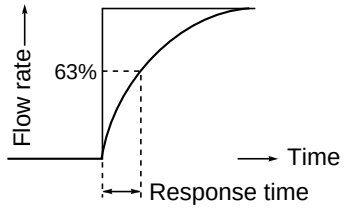
Operation (example)	When setting the burnout to the “LOW” limit and burnout timer to 15 seconds.	
Key operation	Description	Display
FUNC OUTPUT		
▲ or ▼	Select “Burn-out”.	OUTPUT BURNOUT NOT USED
◀ or ▶, ENTER	Select “Low limit”.	OUTPUT BURNOUT LOWER
1 5, ENTER	Enter “15” with ten keys.	BURNOUT TIMER 15 sec
ESC ESC	Press the key twice.	(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)

- ZERO POINT ADJUST : Stop the flow of fluid and adjust zero point.
  The zero pont is the state of measurement at set point.
- ZERO 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 “Zero point adjustment”.	ZERO MODE SET ZERO (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/m l/h, Ml/d, m^3/s, m^3/m, m^3/h, Mm^3/d
   BBL/s, BBL/m, BBL/h, MBBL/d
   } (metric system)

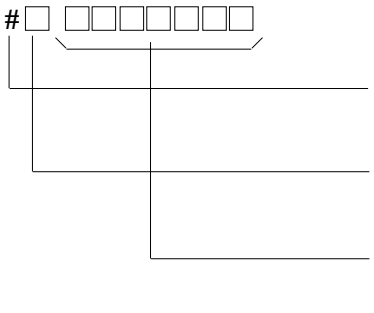
3. Setting of decimal point position of instantaneous flow rate display
   Setting of digit display after the decimal point is available.

   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



Overflow mark
When the integral value exceeds the overflow mark.
Overflow times
0 to 9, # (exceeding 9)
Integral value
0 to 9999999

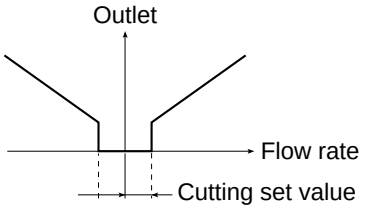
2. Display of forward/reverse difference between integral values
   Difference of integrated value = forward integral value – reverse integral value.
   Note : If any of integral values in the forward and reverse directions exceeds the over flow mark, ####### is displayed.

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 “Flow 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
ESC ESC		(Measurement display)

5.4 (8) Low flow output 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 16.4 ft./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.

2. Integral 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 “START”.	TOTAL MODE TOTAL RUN
[ESC] [ESC]	Press the key twice.	(Measurement display)

Integral mode

Stop: Integration is stopped.

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

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.]

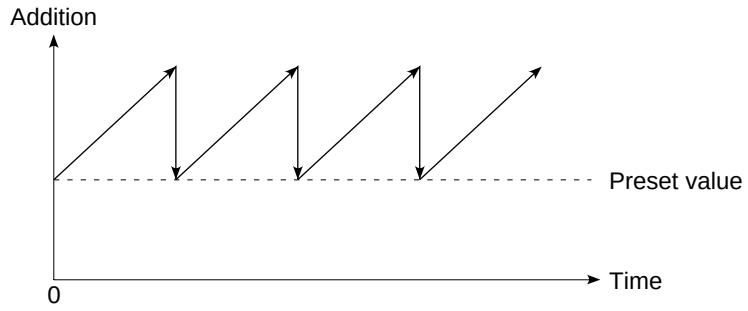
5.4 (10) Setting of integral preset value

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

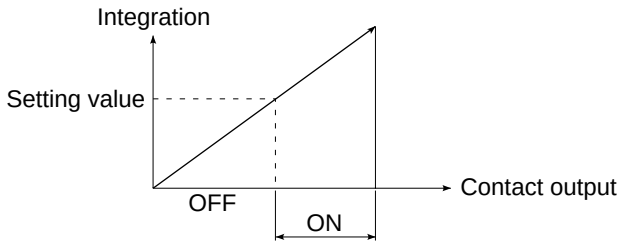
Description

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 output pulse width

Description

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

- 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
		(Measurement display)

5.4 (13) Setting of measured value high and low limit switch

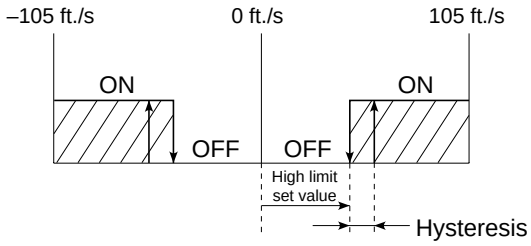
Description

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

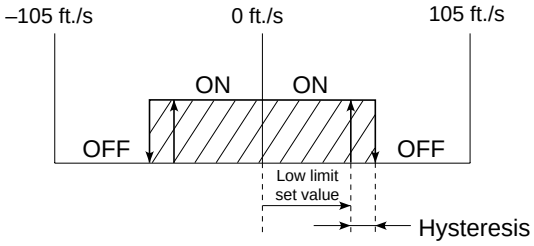
   Setting range : 0 to ±105 ft./s of flow velocity

   [Relation between status output and set value]

   • High limit setting and high limit flow



   • Low limit setting and low limit flow



2. Setting 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. BACK UP ABNORMAL : ON when the backup non-volatile memory is abnormal.

• Setting of status output pulse mode
Normal: effective when status output is ON.
Spot: effective when status output is OFF.

Operation (example)	When setting the forward integral pulse and contact output in the normal mode.	
Key operation	Description	Display
FUNC STATUS		
◀ or ▶, ENTER	Select “CHANNEL 1”.	STATUS CHANEL CHANNEL 1
◀ or ▶, ENTER	Select “F: TOTAL”.	STATUS SEL : CH1 F : TOTAL
◀ 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 normal mode.	
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 “SPOT”.	STATUS MODE : CH2 SPOT
ESC ESC	Press the key twice.	(Measurement display)

5.4 (15) Calibration of measured value

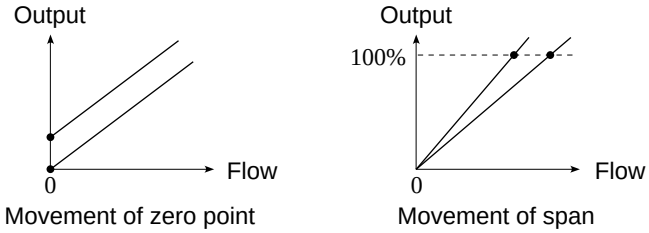
Description

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

Calibration range: Zero point: ±16.4 ft./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 %
ESC ESC	Press the key twice.	(Measurement display)

5.4 (16) Switch of measurement unit system

Description

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

(Setting contents)

• Metric system

Pipe dimension	mm
Flow velocity unit	m/s
Flow rate unit	l/s, l/m l/h Ml/d m^3/s, m^3/m, 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 system

Pipe dimension	inch
Flow velocity unit	ft/s
Flow rate unit	gal/s, gal/m, gal/h, gal/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 “Inch system”.	SYSTEM OF UNITS ENGLISH
ESC ESC	Press the key twice.	(Measurement display)

5.4 (17) Selection of language (English/Japanese)

Description

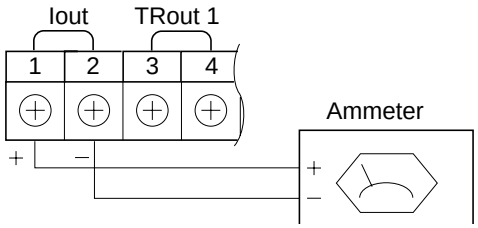
2 kinds of language, English and Japanese (Katakana) can be selected on this display, at the time of setting.

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 ammeter to the Iout terminal as shown below.



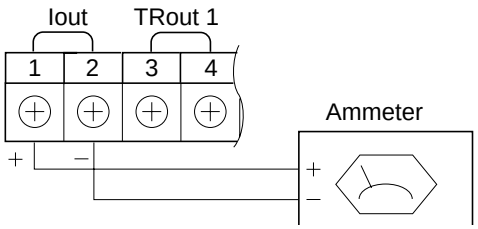
Operation (example)	Check of analog output of 4mA, 8mA, 12mA, 16mA, 20mA	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select “Analog output check”.	OUTPUT CHECK 0 %
0, ENTER	Enter “0” with ten keys. [0% (4mA) check]	OUTPUT CHECK 0 %
2 5, ENTER	Enter “25” with ten keys. [25% (8mA) check]	OUTPUT CHECK 25 %
5 0, ENTER	Enter “50” with ten keys. [50% (12mA) check]	OUTPUT CHECK 50 %
7 5, ENTER	Enter “75” with ten keys. [75% (16mA) check]	OUTPUT CHECK 75 %
1 0 0, ENTER	Enter “100” with ten keys. [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 ammeter to Iout terminal as shown below.



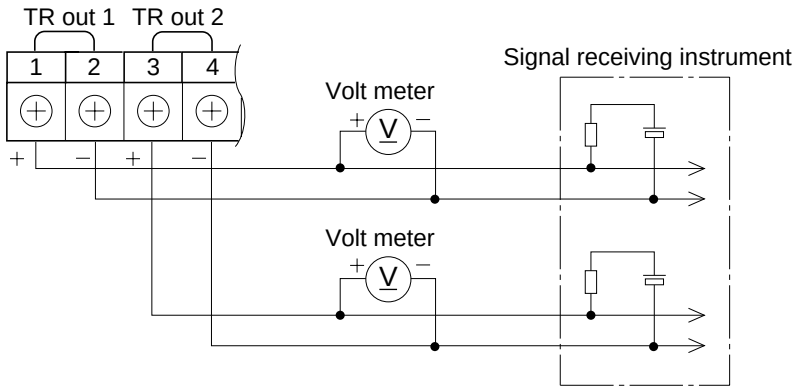
Operation (example)	Calibration of output of 4mA, 20mA	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select “Analog output calibration”.	OUTPUT ADJUST SKIP
◀ or ▶, ENTER	Select “Setting”.	OUTPUT ADJUST SETTING
▲ (up) or ▼ (down) ◀ (down) or ▶ (up) , ENTER	Fine calibration Coarse calibration } Ammeter should indicate 4mA.	OUTPUT ADJUST 4mA
▲ (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 check”.	STATUS CHECK Channel *
◀ 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)

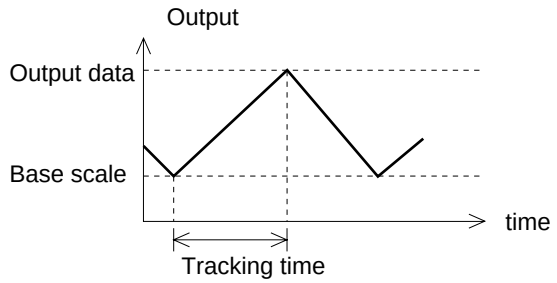
Note: Status output changes depending upon “normal” or “Reverse” specified under the status mode conditions.

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
0, ENTER	Enter “0” with ten keys.	OUTPUT DATA 0%
2, 5, ENTER	Enter “15” with ten keys.	TRACKING TIME 15 sec
1, 0, 0, ENTER	Enter “100” with ten keys.	OUTPUT DATA 100%
ESC ESC	Press the key twice.	(Measurement display)

6. MAINTENANCE AND INSPECTION

6.1 Maintenance

(1) LCD display unit

Expected service life 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

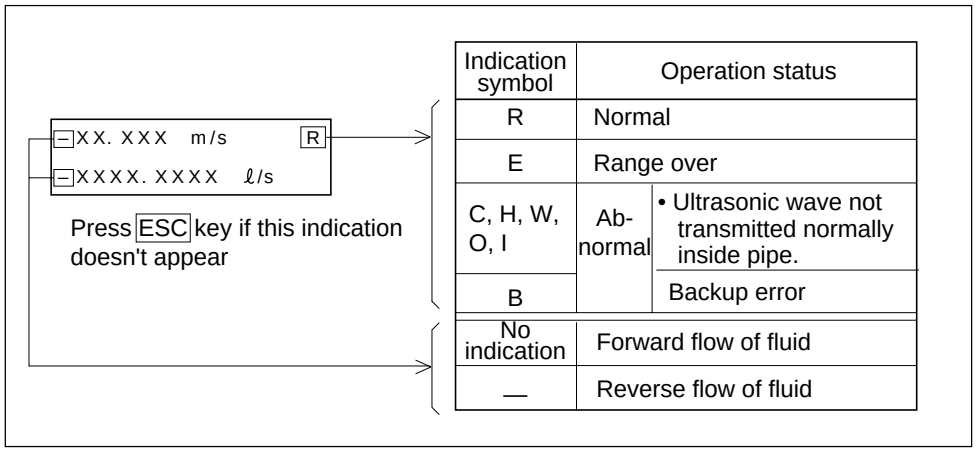
(1) Daily check

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
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 Fuji Electric.

7.1 (3) Detail check for abnormal status

Description

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

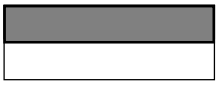
(Status display)	(Contents of display)	(Detailed Contents)
R :	NORMAL	
C :	CAL. ERROR	• Check for piping input data. • Turn ON/OFF the power.
H :	RECEIVED SIGNAL ERROR	• Check for air bubbles in pipe • Check for particles in pipe
W :	WINDOW ERROR	• Check for piping input data.
O :	RECEIVED SIGNAL OVERFLOW	• 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.
B :	BACKUP ERROR	• Non-volatile memory fault.

Operation (example) | I appears at the upper right of the measurement screen.

Key operation	Description	Display
FUNC CHECK	(Contens of display)	I : NO RECEIVED SIGNAL
ENTER	(Detailed contents)	CHECK INPUT 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)

7.2 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 pulsation 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 incorrect • 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%.
	• Scale deposits on old pipe	➡ • Input the correct specifications • 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 Fuji Electric.

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

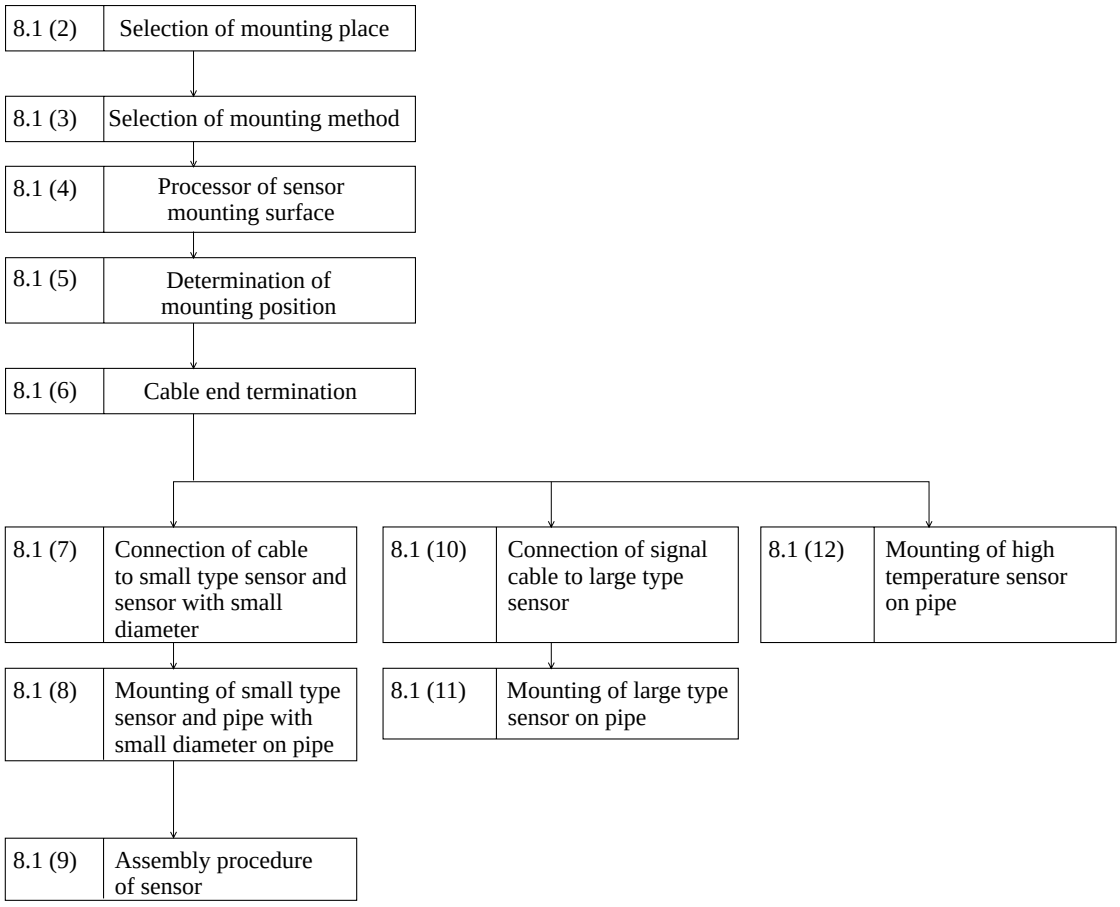
When hardware is in trouble after following "6. Maintenance and inspection" and "7. Troubleshooting", details of trouble and self-check should be notified to Fuji Electric.

8. MOUNTING METHOD

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.



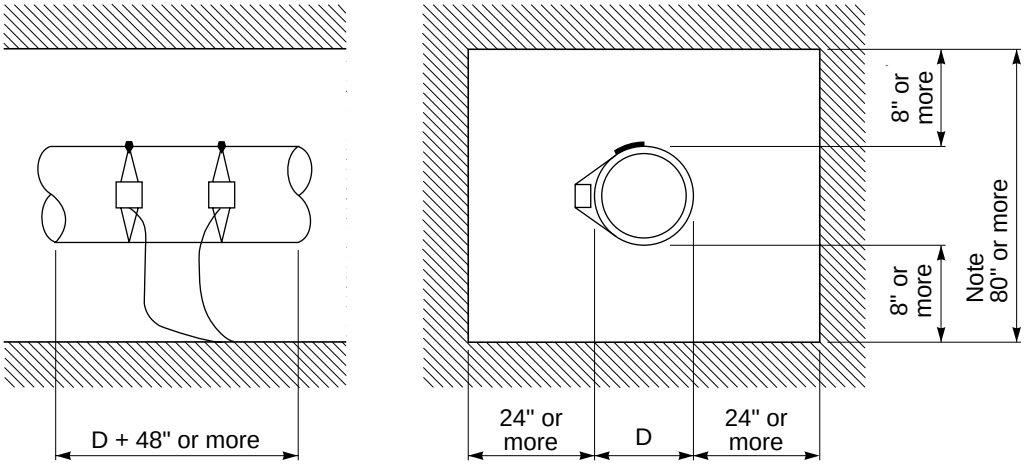
8.1 (2) Selection of mounting place

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.



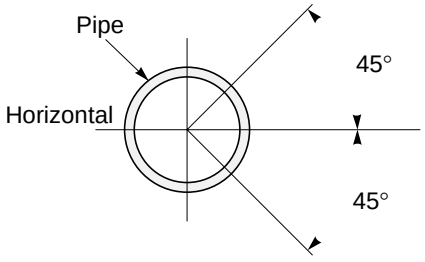
D : Pipe diameter

Fig.8-1 Space required for mounting sensor

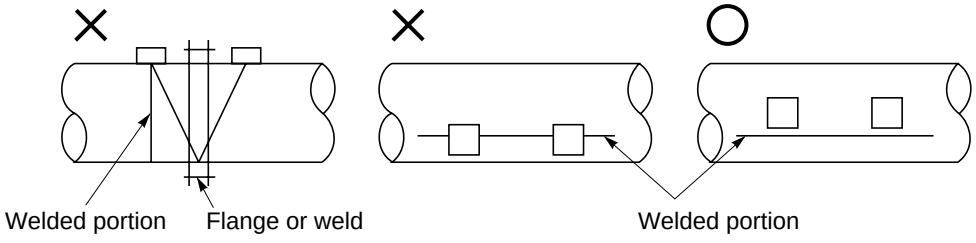
⚠ CAUTION

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).

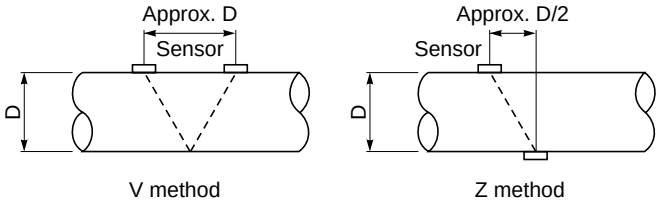


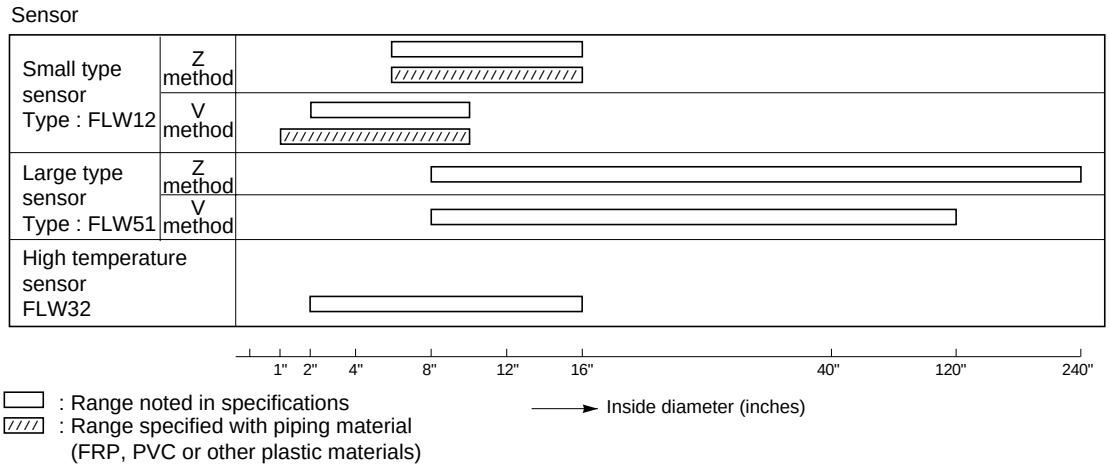
Fig. 8-2 Mounting method

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

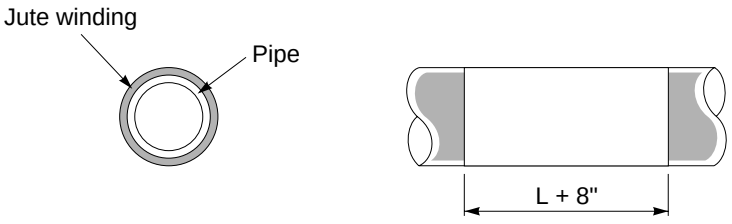
For a large size sensor with inside diameter of more than 12 in., the Z method is recommended for mounting.



8.1 (4) Processing of sensor mounting surface

Using thinner and/or sandpaper, remove pitch, rust and unevenness over a width of (L) + 8 in. 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.

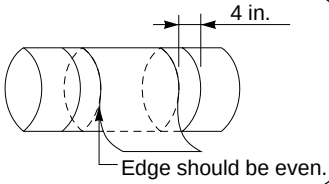


8.1 (5) Determination of mounting position (with Z method for large and small types)

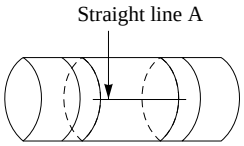
Carry out the following to determine the mounting position.

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

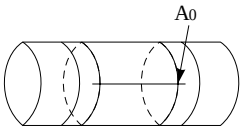
1. Align the edge of gauge paper with a point about 4 in. from one end of the processed section, and wrap the paper around the pipe so that the line drawn on the paper is parallel with the pipe shaft. (The paper should be taped to prevent slipping.) At this time, make sure that the paper edge is even.



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

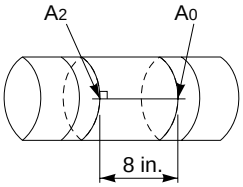


3. Mark a line along on edge of the paper. Assume the intersection of the line and the straight line A is A_0.



V method

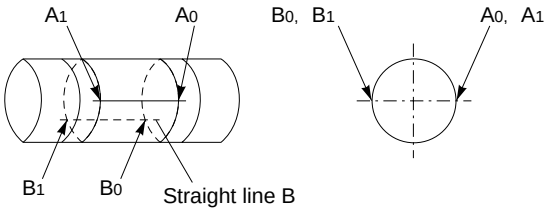
Example) L = 8 in.



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).

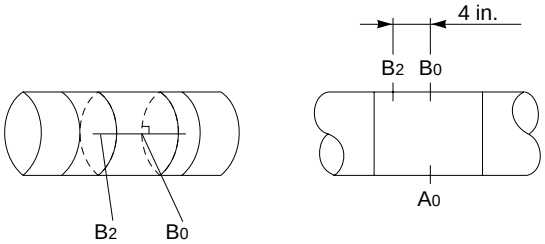
A_0 and A_2 are the mounting position.

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 = 4 in.

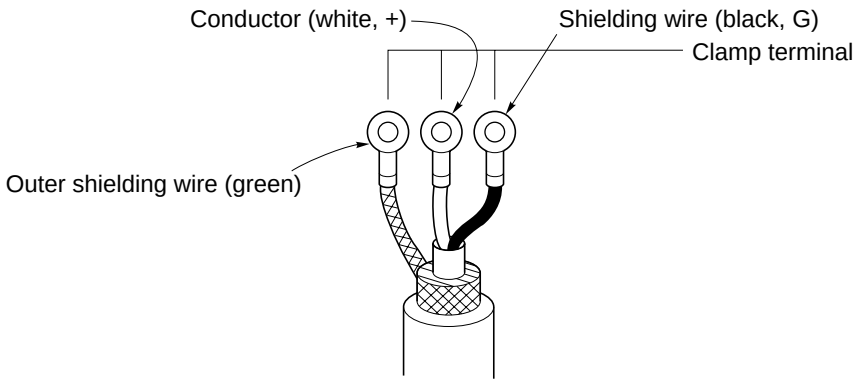


5. Put a mark at point B_0 and remove the gauge paper.
Measure the mounting dimension from B_0 and mark a line crossing the straight line B (determine the position B_2).
In this way, the mounting position is determined.

A_0 and B_2 are the mounting position.

8.1 (6) Cable end treatment

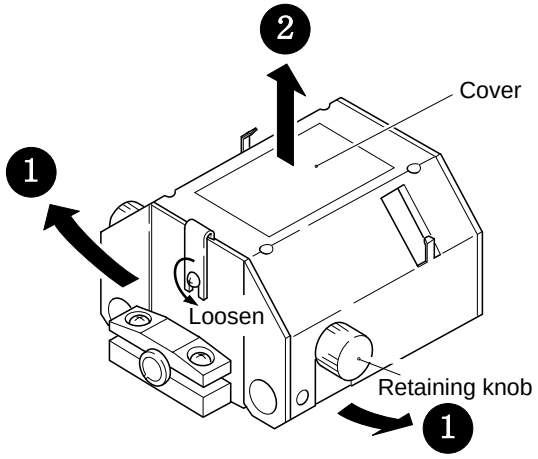
The end of coaxial cable is treated at the factory prior to delivery. If the cable needs to be cut before use, the conductor and the shielding wires should be treated using clamp terminals.



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

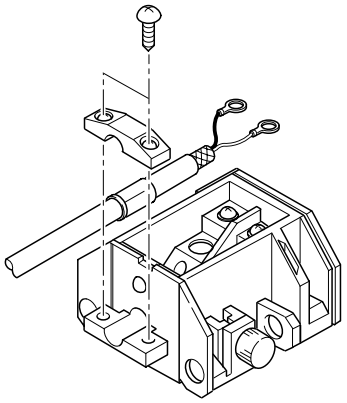
8.1 (7) Connection of cable to small type sensor

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



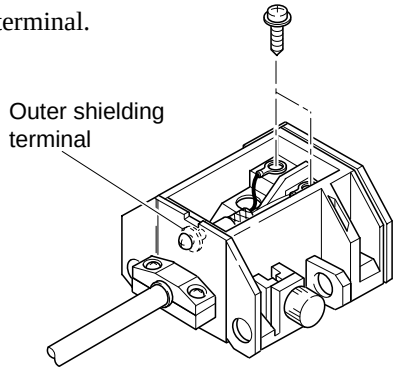
2. Select a mounting position on the pipe.

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.

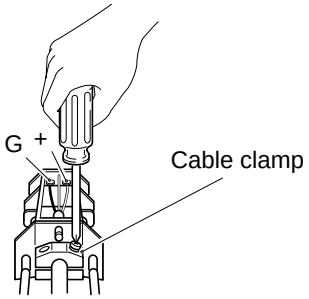


3. Connect the cable to the terminal (G, +) and the earth screw.

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

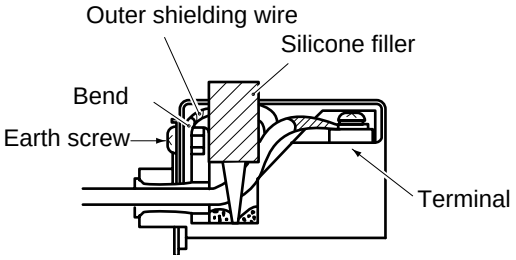


4. Secure the coaxial cable with the cable clamp.

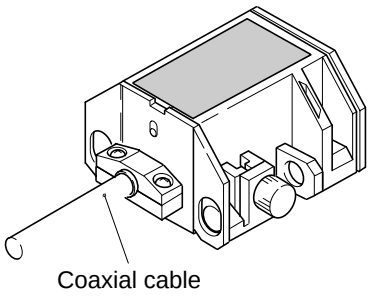


5. Remove foreign matters from the terminals, and mold the while terminal block with silicone filler.

- 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.

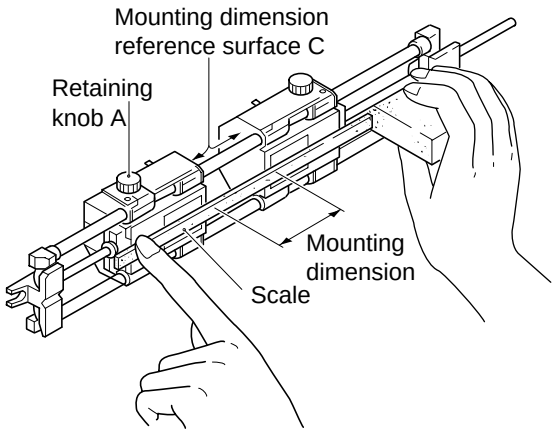


8.1 (8) Mounting of small type sensor on pipe

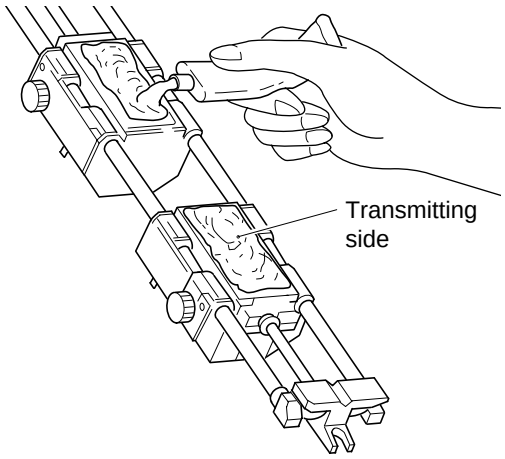
The small type sensor is mounted on pipe with a diameter of ø50 to 250 (V method) or ø150 to 400 (Z method) for measurements.

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.

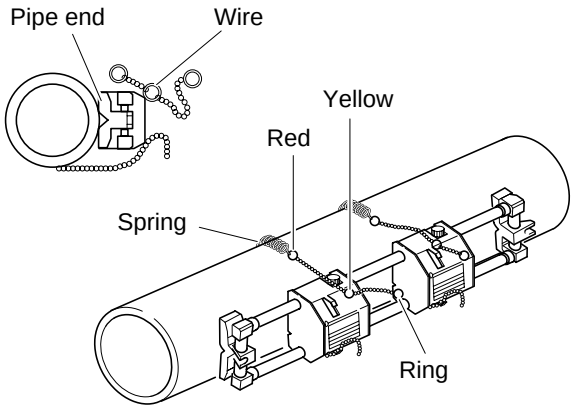


2. Spread silicone filler over the whole transmitting side of the sensor. Care should be taken to prevent entry of air bubbles.



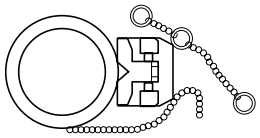
Clean the surface of the pipe and mount the sensor.

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

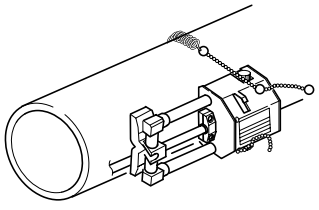


Attach the other chain to the other hook of sensor, and secure it loosely.

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



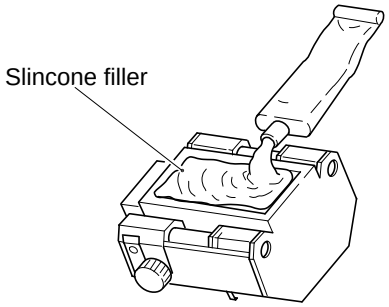
Turn over the frame end so that the sensor makes a close contact with the pipe.



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

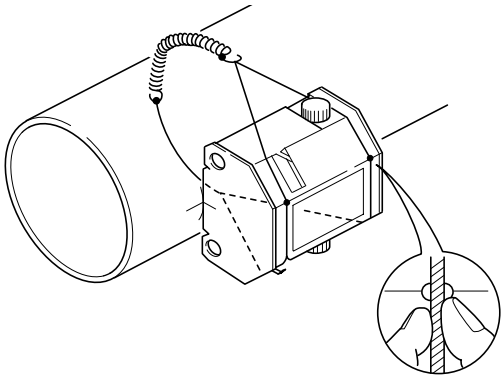
2. Mounting of sensor (Z method)
Mounting the sensor using the following procedure

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

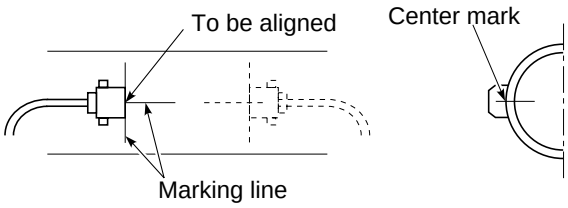


Clean the surface of the pipe, then mount the sensor.

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.

8.1 (9) Assembling procedure of the sensor

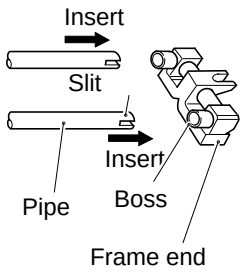
When the small type sensor (FLW1) is shipped with cables of more than 32.8 ft. in length, it is delivered, disassembled since cable weight is applied to the stand or piping of the sensor during shipment.

Follow the procedure given below.

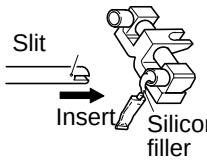
Assemble of parts

1. Be sure to read the “Cautions” before assembling the parts.

   Insert the frame end onto one side of 2 pipes.

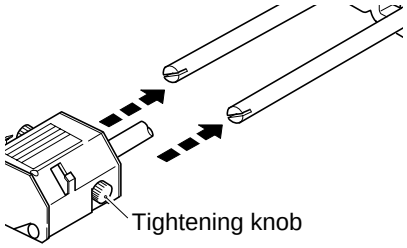


Apply a coat of silicone to the frame end. Take care of the direction of the frame end and the slit of pipe.



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

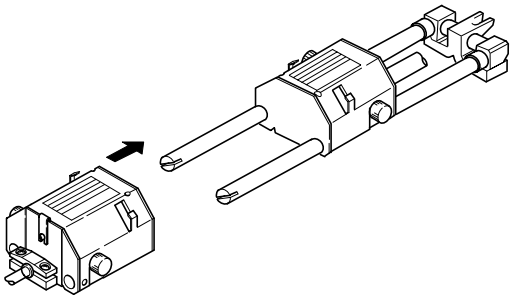
2. Loosen the tightening knob on the sensor and insert the pipes.



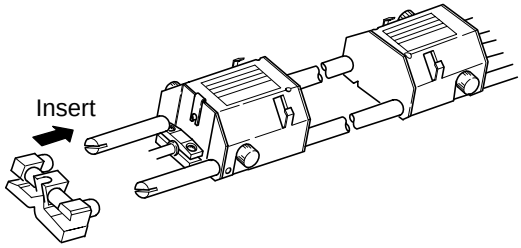
The sensor should be inserted in the correct direction.

3. Insert another sensor onto the pipes.

   Insert it in the correct direction.



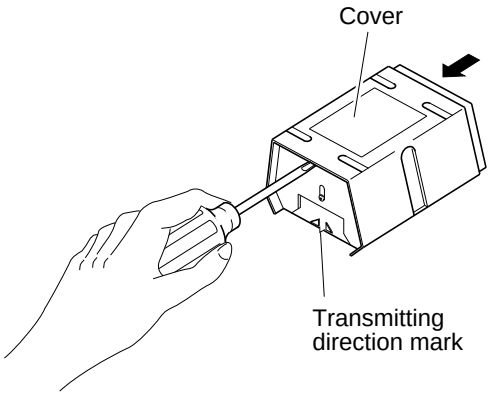
4. Insert the frame end onto the other side of pipes. Assembling method is the same as 1.



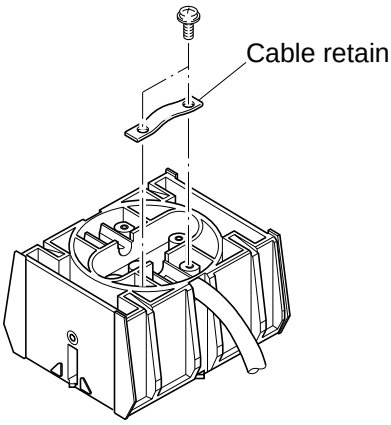
Note) After assembling the sensor, leave it at room temperature for a day to harden the filler (to obtain the required assembling strength).

8.1 (10) Connection of cable to large type sensor

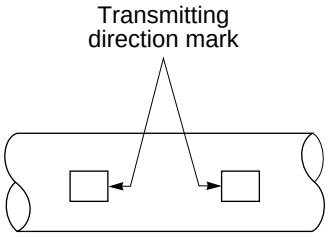
1. Slightly move the sensor cover and remove it using an screwdriver or the like.



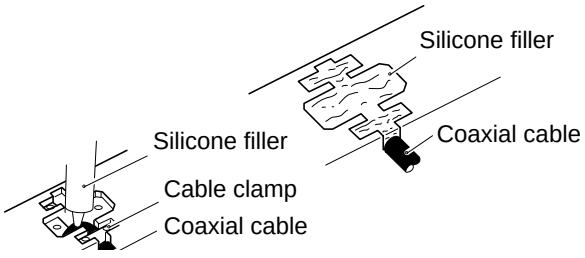
3. Connect the coaxial cable to the terminals (G, +) and secure the cable with the cable clamp.



3. Confirm the mounting position on the pipe.
   - Align the transmitting direction marks so that they are facing with each other.



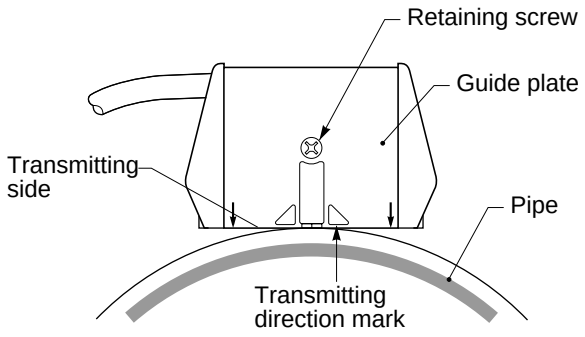
4. Remove foreign objects from the terminal section, and mold the whole terminal section with silicone filler.
   - Cut the tip of the silicone filler tube. Apply silicone while pressing the head of the tube against the bottom of the terminal section
     Be careful not to let babbles form.



8.1 (11) Mounting of large type sensor on pipe

1. Adjustment of guide plate height

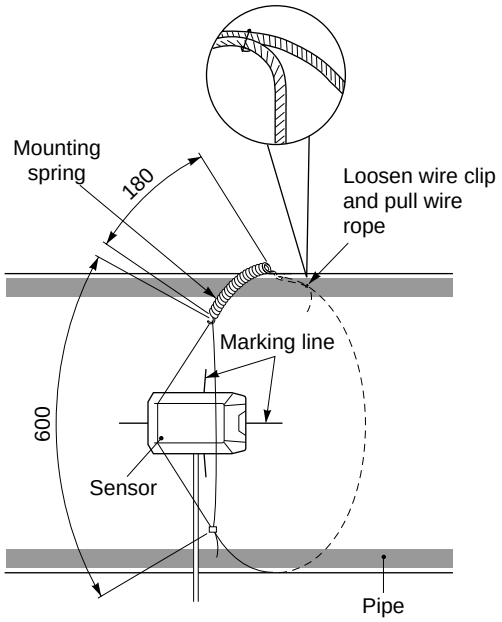
   Attach the sensor to the pipe. Make sure that it is parallel with the pipe shaft.



   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

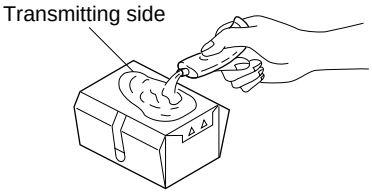
   Place the sensor on the marking line and attach the wire rope and mounting spring.



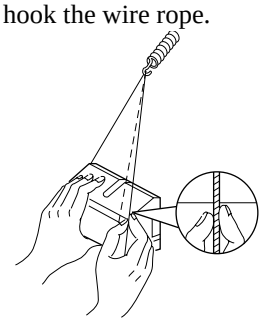
   Loosen the wire clip, stretch the wire rope until the overall length of the mounting spring becomes 180mm, and secure the wire clip (free length of the mounting spring is 110mm).
   Remove the sensor with the wire rope fixed in place.

3. Mounting of sensor

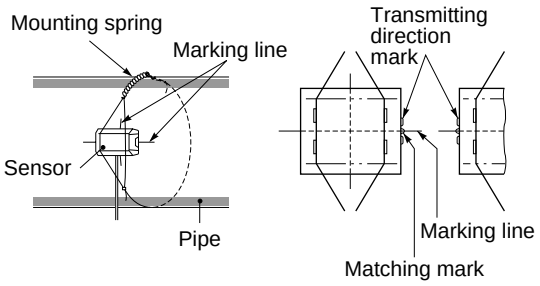
   - Clean the sensor transmitting surface and pipe mounting surface.
   - Spread silicone filler over the whole transmitting surface of the sensor.
   - The thickness of silicone filler should be about 3mm.



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



   - 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.

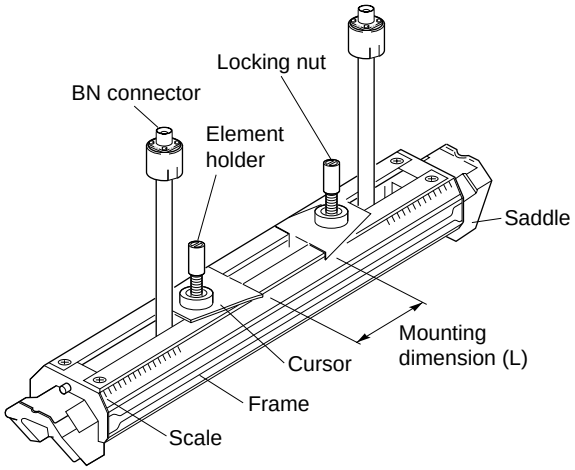


   - Confirm that the sensor matching mark is aligned with the marking line, then connect the coaxial cable to sensor.

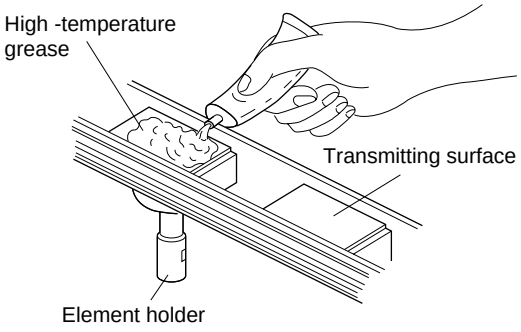
Note) Do not pull the coaxial cable. If it is pulled, the sensor may move from its mounting position which affects correct measurements.

8.1 (12) 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.

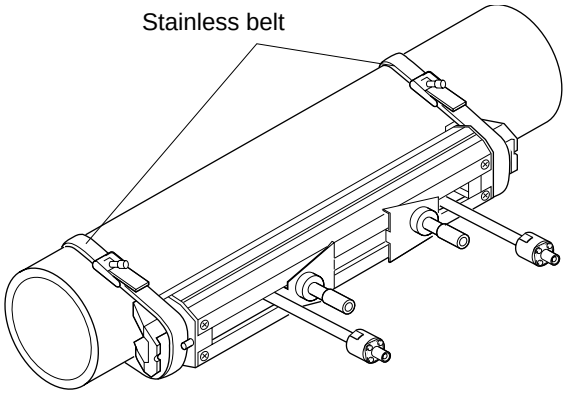


2. Spread high-temperature grease over the whole transmitting surface of the sensor.

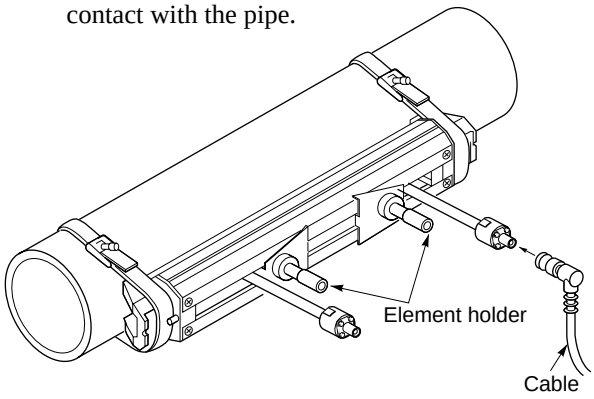


Turn the element holder counterclockwise to return the sensor. Clean the surface of the pipe and mount the sensor on the pipe.

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.

APPENDIX 1. SPECIFICATIONS

(1) Specifications

Services

- Measuring fluid : Homogeneous liquid suitable for the pass of ultrasonic wave (water, sea water or oil Even liquid of which sound velocity is not clear is measurable)
- Turbidity of fluid : 10,000 deg. (mg/l) or less
- Flow : Uniform flow, free from drift in pipe filled with fluid.
- Fluid temperature : Small type sensor ; −40 to +176°F
  Large type sensor ; −40 to +176°F
  High temperature sensor ; −40 to +392°F
- Measuring range : −105 to 0 to +105 ft./s

Piping conditions

- Material of piping : Carbon steel, stainless steel, cast iron, FRP, asbestos, copper, aluminum, acrylic, etc.
- Diameter of pipe : Small type sensor ø2 to ø16 in.
  Large type sensor ø8 to ø236 in.
  High temperature sensor ø2 to ø16 in.
- Lining material : None, tar epoxy, mortar, rubber, or material with known sound velocity
- Length of straight pipe : Upstream side : 10D or more
  Downstrem side : 5D or more (D:inner diameter of pipe)

Accuracy rating

Diameter	Flow velocity	Accuracy
ø2 to ø12 in. or less	6.56 to 105 ft./s	1.0% of rate
	0 to 6.56 ft./s	3.3 ft./s
ø12 to ø236 in.	3.26 to 105 ft./s	1.0% of rate
	0 to 3.26 ft./s	0.03 ft./s

Converter (Type : FLV)

- Measuring method : Propagation delay time system
- Power supply : 100 to 240V ±10% AC, 50/60Hz
- Electric power : Approx. 20VA (about 10W)
- LCD : Character display (16th digits, 2 lines) with back light
- Operation unit : Seat key (20 keys)
- Reset after power interruption : Backup by non-volatile memory (available for 10 years)
- Response speed : 0.5 sec or less
- Output signal : Analog signal 4 to 20mA DC, 1point (load resistance:0 to1kΩ)
  Contact signal open collector (30V DC, 0.1A), 1 point
- Ambient temperature : +14 to +140°F
- Ambient humidity : 90%RH or less
- Enclosure : Immersion-proof (aluminum casting case), IP65 or equivalent
- Color of paint : Cover (blue), case (silver)
- Dimensions : H10.91 × W9.61 × D3.74 ft.
- Mass : Approx. 10 lbs.

Sensor (Type : FLW)

- Mounting method : Pipe-mounting
- Mounting method of sensor: V method or Z method
- Attaching belt/wire : Small type sensor: stainless chain
  Large type sensor: stainless wire
  High temperature sensor: stainless belt
- Sound coupler : Silicon rubber
- Signal cable : Dedicated coaxial cable (standard 16 ft., max.492 ft.)
- Connection : Terminal screw
  High temperature sensor: BNC connector
- Ambient temperature : –4 to +140°F
- Ambient humidity : 100%RH or less
- Enclosure : Immersion-proof type (IP67 or equivalent)
  High temperature sensor: Drip-proof type (IP52 or equivalent)
- Material :
- Dimensions and mass :

Types	Sensor case	Guide rail
Small type sensor	Plastic	SUS304 + plastic
Large type sensor	Plastic	————————
High temperature sensor	SUS304	Aluminum alloy + SUS304

Types	Dimensions (H × W × D)	Mass
Small type sensor	1.67 × 2.62 × 1.31 ft.	Approx. 2.2 lbs.
Large type sensor	.34 × .3 × .2 ft.	Approx. 3.1 lbs.
High temperature sensor	1.74 × .17 × .67 ft.	Approx. 3.6 lbs.

(2) Function

- Display language : Japanese (Katakana)/English selectable
- Instantaneous value display function : Flow velocity/flow rate (with flow direction) selection
  Unit : metric system/inch system selectable

	Metric system	English sytem
Flow velocity	m/s	ft/s
Flow rate	l/s, l/m, l/h, Ml/d m^3/s, m^3/m, m^3/h, Mm^3/d BBL/s, BBL/m, BBL/h, MBBL/d	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

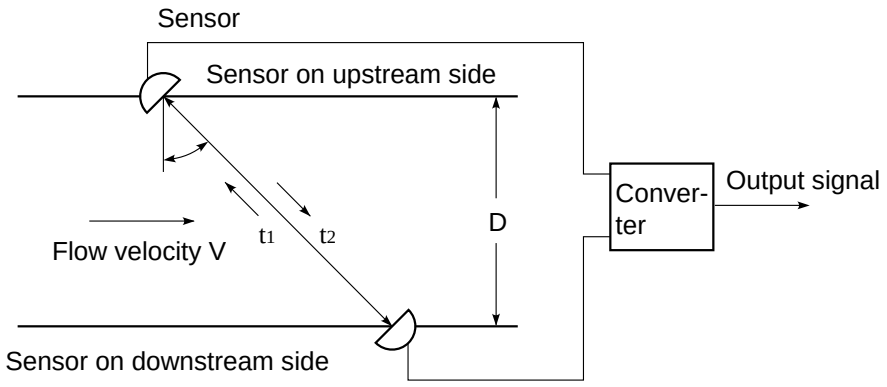
- Integral value display function : forward integral value selection
  Unit : metric/inch selectable

	Metric system	English sytem
Integral value	ml, l, m^3, km^3, Mm^3 mBBL, BBL, kBBL	gal, kgal, ft^3, kft^3, Mft^3 mBBL, BBL, kBBL

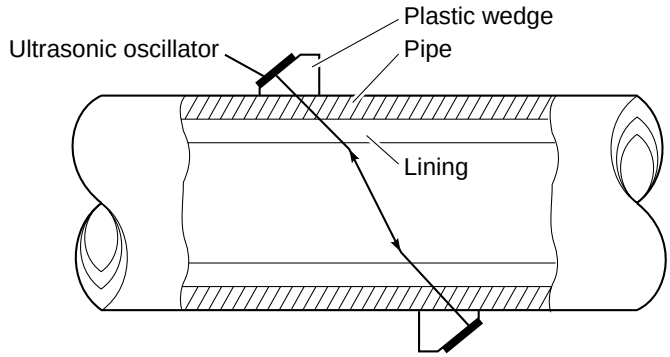
- Instantaneous value output function : analog signal 4 to 20mA DC
- Damping : 0 to 100 sec (time constant)
- Low flow cut : 0 to 16.4 ft./s
- Output setting function : Scaling/limit of current output, burnout setting
  Current output calibration available
- Communication function : nstantaneous flow velocity, instantaneous flow rate, integral value, status
- Auto range selection : Judgement of range by 2 range and contact output
- Forward/reverse selection : Judgement of flow direction by forward/reverse range and contact output
- Integrated pulse output: 5P/s, max. pulse width (50, 100ms selectable)
- Others : Self diagnosis function

(3) 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.

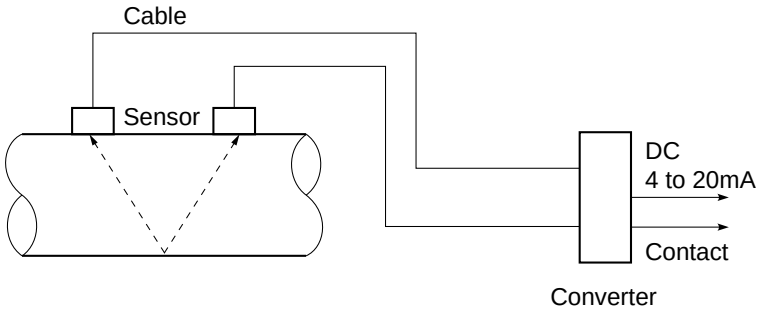


(4) Mounting of sensor

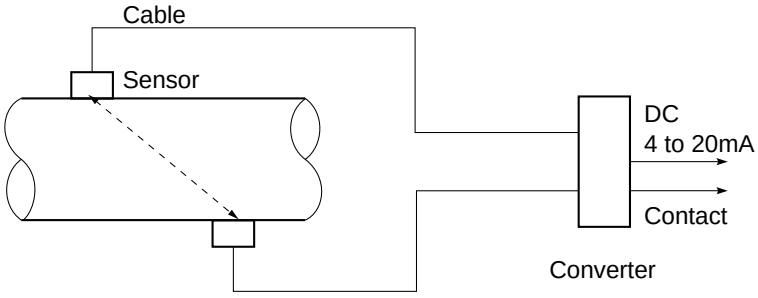


(5) Construction

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

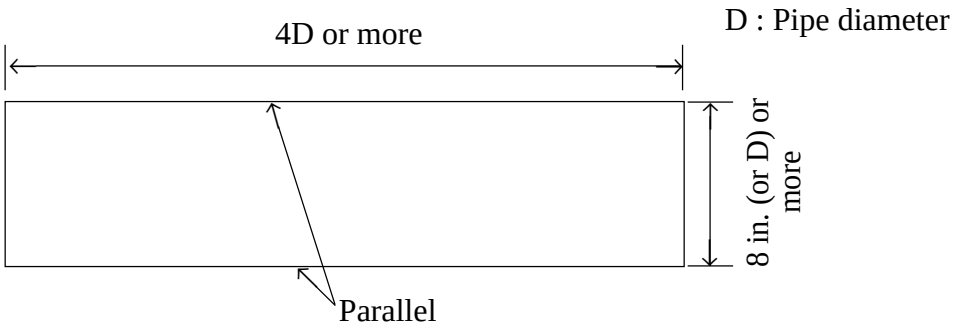


(2) Single-measuring-path system (Z method)

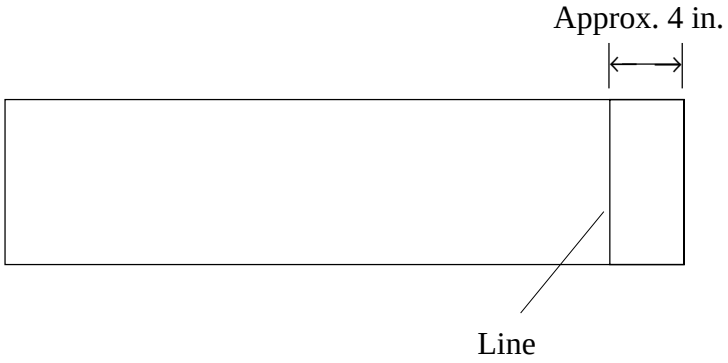


APPENDIX 2. HOW TO MAKE GAUGE PAPER

1. Prepare a rectangular sheet of paper (or vinyl sheet) with its length of more than 4D and width of 8 in. (D, if possible).



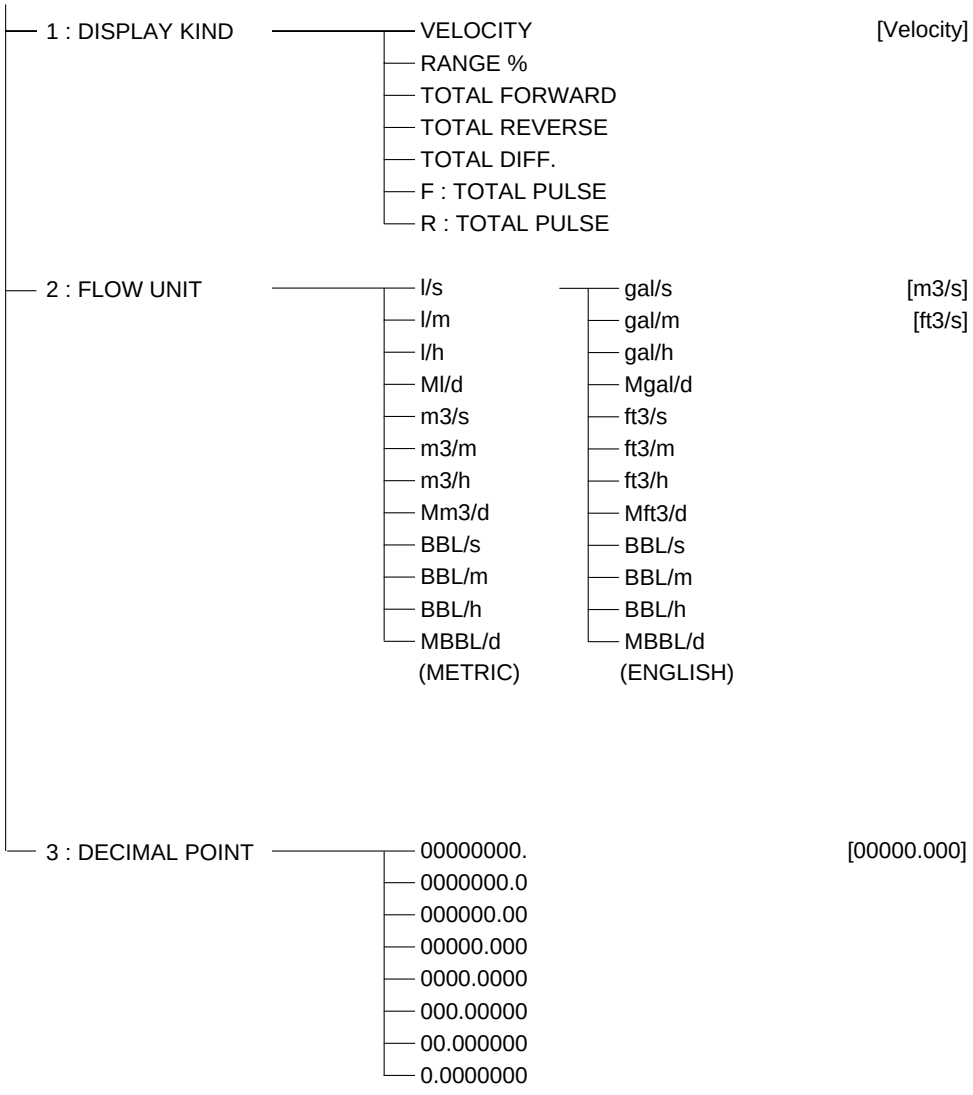
2. Draw a line perpendicular to the long side at a point about 4 in. from one end.



APPENDIX 3. 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
  - OTHERS
  - 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
  - FLW22
  - FLW32
  - FLW50
  - FLW51
- TRANS. VOLTAGE — [4 TIME]
  - 1TIME
  - 2TIME
  - 4TIME
  - 8TIME

(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

- RANGE UNIT
  - (METRIC): m/s, l/s, l/m, l/h, Ml/d, m3/s, m3/m, m3/h, Mm3/d, BBL/s, BBL/m, BBL/h, MBBL/d
  - (ENGLISH): ft/s [m/s], gal/s [ft/s], gal/m, gal/h, Mgal/d, ft3/s, ft3/m, ft3/h, Mft3/d, BBL/s, BBL/m, BBL/h, MBBL/d
- 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]

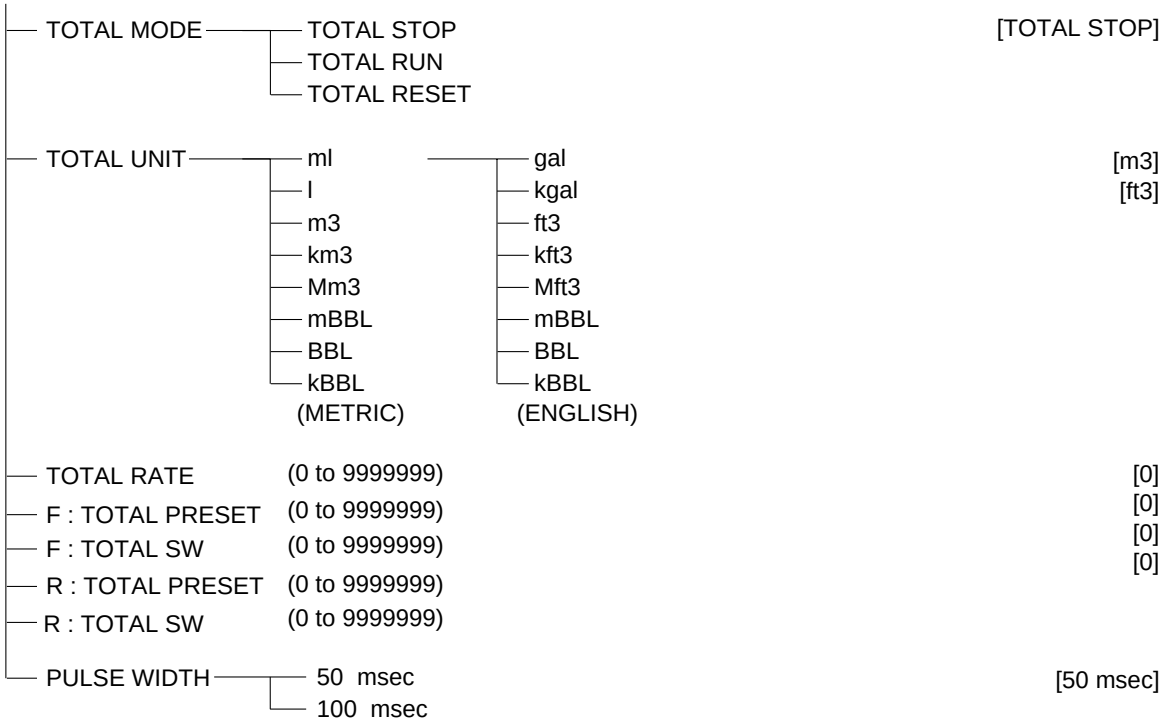
(6) SETTING OF LOW FLOW OUTPUT CUT

FUNC ⇨ CUT OFF

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

(7) SETTING OF TOTAL OUTPUT

FUNC ⇨ TOTAL



(8) ZERO ADJUSTMENT

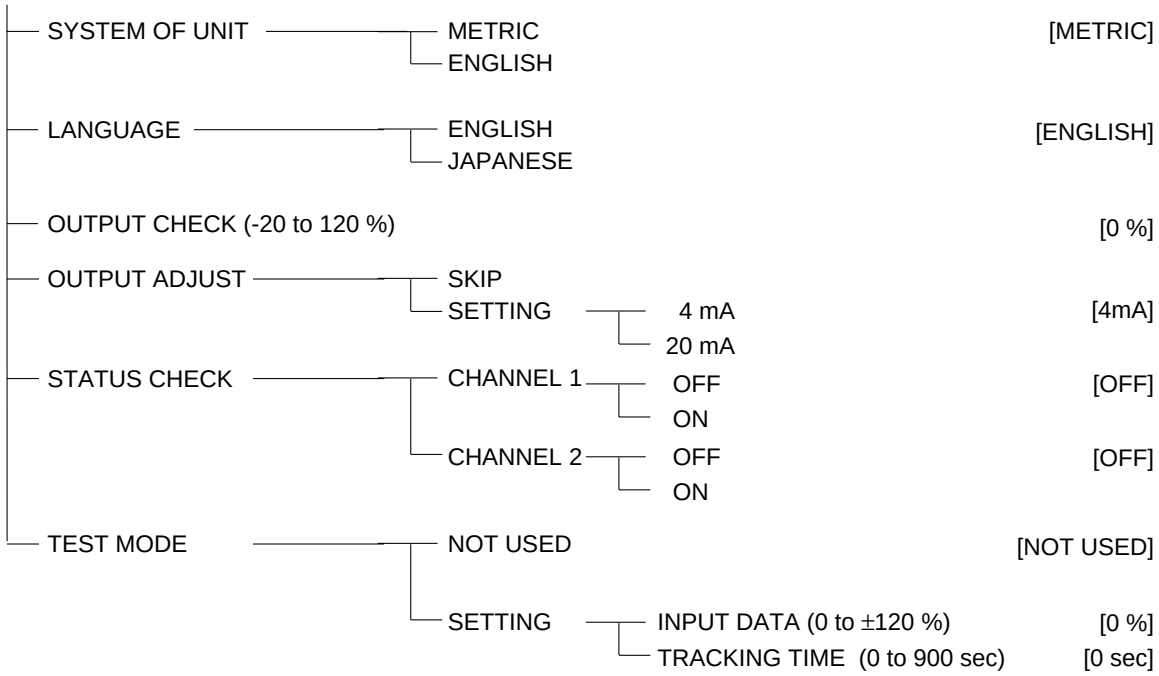
FUNC ⇨ ZERO

(9) CALIBRATION OF MEASUREMENT VALUE

FUNC ⇨ CAL (2)

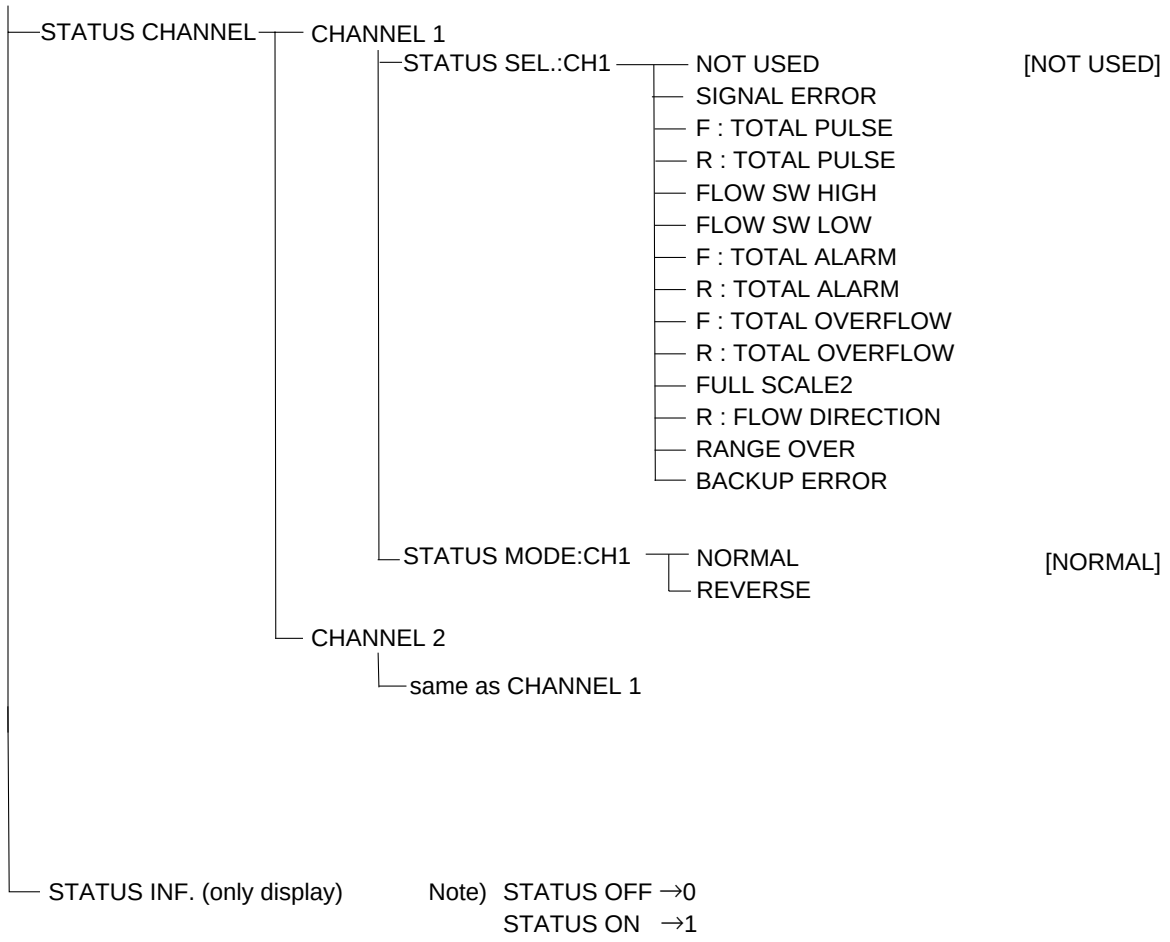
(10) SETTING OF SYSTEM CONDITION

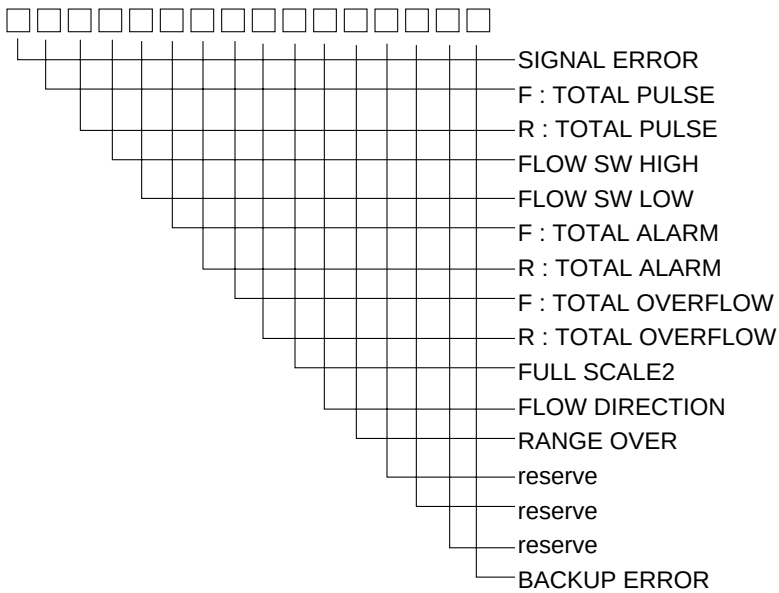
FUNC ⇨ SYSTEM



(11) SELECTING OF STATUS

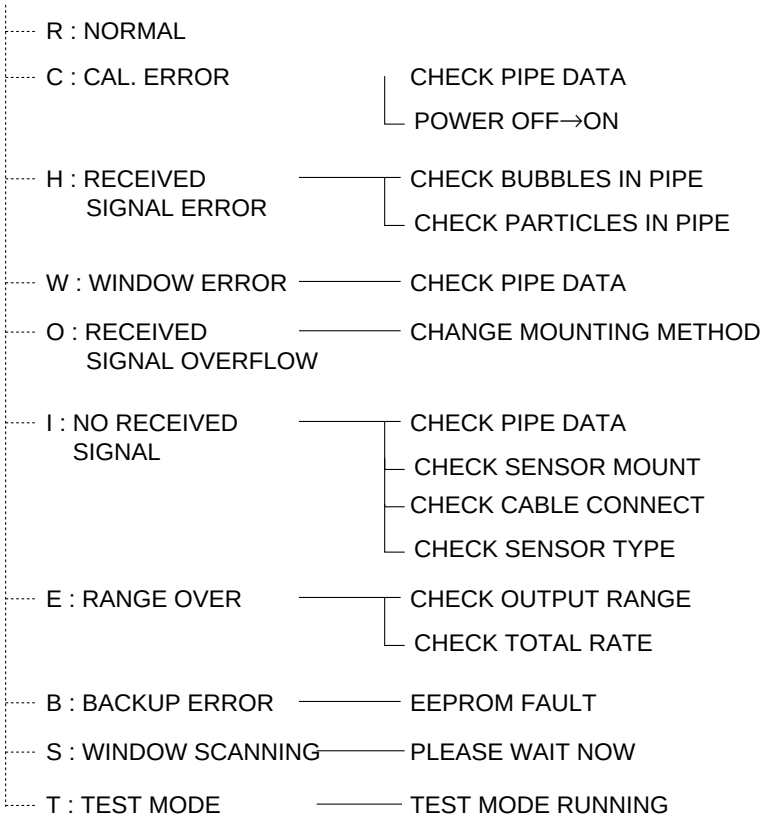
FUNC ⇨ STATUS





(12) ERROR CHECK

FUNC ⇨ CHECK



APPENDIX 4. PIPING DATA

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

Nominal diameter (in.)		Outer diameter (in.)	Normal thickness						
			Schedule 5S	Schedule 10S	Schedule 20S	Schedule 40	Schedule 80	Schedule 120	Schedule 160
A	B		Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)
.6	.02	.9	.06	.08	.10	.11	.15	—	.22
.8	.03	1.1	.06	.08	.10	.11	.15	—	.22
1.0	.04	1.3	.06	.11	.12	.13	.18	—	.25
1.3	.05	1.7	.06	.11	.12	.14	.19	—	.25
1.6	.06	1.9	.06	.11	.12	.15	.20	—	.28
2.0	.08	2.4	.06	.11	.14	.15	.22	—	.34
2.6	.10	3.0	.08	.12	.14	.20	.28	—	.37
3.1	.12	3.5	.08	.12	.16	.22	.30	—	.44
3.5	.14	4.0	.08	.12	.16	.22	.32	—	.50
4.0	.16	4.5	.08	.12	.16	.24	.34	.44	.53
4.9	.20	5.5	.11	.13	.20	.26	.37	.50	.63
5.9	.24	6.5	.11	.13	.20	.28	.43	.56	.72
8.0	.32	8.5	.11	.16	.26	.32	.50	.72	.91
10.0	.39	10.5	.13	.16	.26	.37	.59	.84	1.13
12.0	.47	12.5	.16	.18	.26	.41	.69	1.00	1.31
13.8	.55	14.0	—	—	—	.44	.75	1.09	1.41
15.7	.63	16.0	—	—	—	.50	.84	1.22	1.59
17.7	.70	18.0	—	—	—	.56	.94	1.37	1.78
19.7	.79	20.0	—	—	—	.59	1.03	1.50	1.97
21.7	.87	22.0	—	—	—	.63	1.13	1.63	2.13
23.6	.94	24.0	—	—	—	.69	1.34	1.81	2.34
25.6	1.02	26.0	—	—	—	.74	1.34	1.93	2.53

Polyethylene pipe for city water (JIS K6762-1982)

Nominal diameter (in.)	Outer diameter (in.)	1st type (Soft pipe)		2nd type (Hard pipe)	
		Thickness (in.)	Weight (lb./ft.)	Thickness (in.)	Weight (lb./ft.)
.5	.85	.14	1.33	.10	1.03
.8	1.06	.16	1.95	.12	1.57
1.0	1.34	.20	3.06	.14	2.33
1.2	1.65	.22	4.24	.16	3.31
1.6	1.89	.26	5.70	.18	4.27
2.0	2.36	.31	8.75	.20	6.00

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

Nominal pipe		Outer diameter (in.)	Thickness (in.)
(A)	(B)		
.6	.02	.9	.11
.8	.03	1.1	.11
1.0	.04	1.3	.13
1.3	.05	1.7	.14
1.6	.06	1.9	.14
2.0	.08	2.4	.15
2.6	.10	3.0	.17
3.1	.12	3.5	.17
3.5	.14	4.0	.17
4.0	.16	4.5	.18
4.9	.20	5.5	.18
5.9	.24	6.5	.20
8.0	.32	8.5	.23
10.0	.39	10.5	.26
12.0	.47	12.5	.27

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

Nominal diameter (in.)	1st type		2nd type		3rd type		4th type	
	Thickness of connected portion (in.)	Outer diameter of connected portion (in.)	Thickness of connected portion (in.)	Outer diameter of connected portion (in.)	Thickness of connected portion (in.)	Outer diameter of connected portion (in.)	Thickness of connected portion (in.)	Outer diameter of connected portion (in.)
2.0	.39	2.76	—	—	—	—	—	—
3.0	.39	3.74	—	—	—	—	—	—
4.0	.47	4.88	.39	4.72	.35	4.65	—	—
4.9	.55	6.02	.43	5.79	.37	5.67	—	—
5.9	.62	7.17	.47	6.85	.39	6.69	—	—
8.0	.83	9.53	.59	9.06	.51	8.90	.43	8.74
10.0	.91	11.65	.75	11.34	.61	11.06	.47	10.79
12.0	1.02	13.86	.87	13.54	.71	13.23	.55	12.91
13.8	1.18	16.14	.98	15.75	.81	15.39	.62	15.04
15.7	1.38	18.50	1.14	18.03	.91	17.56	.71	17.17
17.7	1.54	20.79	1.26	20.24	1.02	19.76	.79	19.29
19.7	1.69	23.07	1.38	22.44	1.12	21.93	.87	21.42
23.6	2.05	27.72	1.65	26.93	1.34	26.30	1.02	25.67
27.6	—	—	1.93	31.42	1.54	30.63	1.18	29.92
31.5	—	—	2.20	35.91	1.73	34.96	1.34	34.17
35.4	—	—	—	—	1.93	39.29	1.50	38.43
39.4	—	—	—	—	2.13	43.62	1.65	42.68
43.3	—	—	—	—	2.32	47.95	1.81	46.93
47.2	—	—	—	—	2.56	52.36	1.97	51.18
51.2	—	—	—	—	2.87	58.90	2.24	57.64
59.1	—	—	—	—	3.19	65.43	2.48	64.02

Polyethlene pipe for general use (JIS K6761-1979)

Nominal diameter (in.)	Outer diameter (in.)	1st type	2nd type
		Thickness (in.)	Thickness (in.)
.5	.85	.11	.09
.8	1.06	.12	.09
1.0	1.34	.12	.10
1.2	1.65	.14	.11
1.6	1.89	.14	.12
2.0	2.36	.16	.14
2.6	3.00	.20	.16
3.0	3.50	.22	.20
4.0	4.49	.24	.22
4.9	5.51	.26	.26
5.9	6.50	.28	.28
8.0	8.50	.31	.31
10.0	10.51	.35	.35
12.0	12.52	.39	.39

Hi vinyl chloride pipe (city water pipe size)

Nominal diameter	Outer diameter	Thickness of pipe
.5	.71	.10
.8	1.02	.12
1.0	1.26	.14
1.2	1.50	.14
1.6	1.89	.16
2.0	2.36	.18
3.0	3.50	.23
4.0	4.49	.28
4.9	5.51	.30
5.9	6.50	.33

Hi vinyl chloride pipe (conduit size)

Nominal pipe	Outer diameter	Thickness of pipe
1.1	1.34	.12
1.4	1.65	.14
1.6	1.89	.14
2.1	2.36	.16
2.6	2.99	.18
3.1	3.50	.22

Vertical type cast iron pipe (JISG5521)

Nominal pipe D	Thickness T		Actual outer diameter D1
	Normal pressure pipe	Low pressure pipe	
3.0	.35	—	3.66
4.0	.35	—	4.65
5.9	.37	.35	6.65
8.0	.39	.37	8.66
10.0	.43	.39	10.69
12.0	.45	.40	12.71
13.8	.47	.42	14.72
15.7	.50	.43	16.73
17.7	.53	.45	18.77
19.7	.55	.47	20.79
23.6	.61	.51	24.83
27.6	.65	.54	28.86
31.5	.70	.58	32.91
35.4	.77	.61	36.97
39.4	.87	—	40.98
43.3	.93	—	45.04
47.2	.98	—	49.06
53.2	1.08	—	55.12
59.1	1.18	—	61.18

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

Nominal pipe		Outer diameter (in.)	Thickness (in.)
(A)	(B)		
.6	.02	.85	.11
.8	.03	1.07	.11
1.0	.04	1.34	.13
1.3	.05	1.68	.14
1.6	.06	1.91	.14
2.0	.08	2.38	.15
2.6	.10	3.00	.17
3.1	.12	3.51	.17
3.5	.14	4.00	.17
4.0	.16	4.50	.18
4.9	.20	5.50	.18
5.9	.24	6.50	.20
6.9	.28	7.51	.21
8.0	.32	8.52	.23
8.9	.35	9.52	.24
10.0	.39	10.53	.26
12.0	.47	12.54	.27
13.8	.55	14.00	.31
15.7	.63	16.00	.31
17.7	.70	18.00	.31
19.7	.79	20.00	.31

Hard vinyl chloride pipe (JIS K6741-1984)

Section / Nominal pipe (in.)	VP		VU	
	Outer diameter	Thickness	Outer diameter	Thickness
.5	.70	.09	—	—
.6	.79	.11	—	—
.8	1.02	.11	—	—
1.0	1.26	.12	—	—
1.2	1.50	.12	—	—
1.6	1.89	.14	1.89	.07
2.0	2.36	.16	2.36	.07
2.6	2.99	.16	2.99	.09
3.0	3.50	.22	3.50	.11
4.0	4.49	.26	4.49	.12
4.9	5.51	.28	5.51	.16
5.9	6.50	.35	6.50	.20
8.0	8.50	.41	8.50	.26
10.0	10.51	.50	10.51	.31
12.0	12.52	.59	12.52	.36
13.8	—	—	14.57	.41
15.7	—	—	16.54	.46
17.7	—	—	18.50	.52
19.7	—	—	20.47	.57
23.6	—	—	24.80	.70
27.6	—	—	28.82	.83
31.5	—	—	32.87	.94

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

Nominal diameter (A)	Outer diameter (in.)	Thickness (in.)
3.1	3.51	.17
4.0	4.50	.18
4.9	5.50	.18
5.9	6.50	.20
8.0	8.52	.23
10.0	10.53	.26
12.0	12.54	.27
13.8	14.00	.24
15.7	16.00	.24
17.7	18.00	.24
19.7	20.00	.24
23.6	24.00	.24
27.6	28.00	.24
31.5	32.00	.28
35.4	36.00	.31
39.4	40.00	.34
43.3	44.00	.41
47.2	48.00	.44
53.1	54.00	.47
59.1	60.00	.50

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

Nominal diameter A	Outer diameter in.	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 (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)
3.1	3.51	.17	.18	—	—	.17	.18	—	—
4.0	4.50	.18	.19	—	—	.18	.19	—	—
4.9	5.50	.18	.20	—	—	.18	.20	—	—
5.9	6.50	.20	.22	—	—	.20	.22	—	—
8.0	8.52	.23	.25	—	—	.23	.25	—	—
10.0	10.53	.26	.25	—	—	.26	.25	—	—
12.0	12.54	.27	.25	—	—	.27	.25	—	—
13.8	14.00	—	—	.24	—	—	—	.24	—
15.7	16.00	—	—	.24	—	—	—	.24	—
17.7	18.00	—	—	.24	—	—	—	.24	—
19.7	20.00	—	—	.24	—	—	—	.24	—
23.6	24.00	—	—	.24	—	—	—	.24	—
27.6	28.00	—	—	.28	.24	—	—	.28	.24
31.5	32.00	—	—	.31	.28	—	—	.31	.28
35.4	36.00	—	—	.31	.28	—	—	.31	.28
39.4	40.00	—	—	.35	.31	—	—	.35	.31
43.3	44.00	—	—	.39	.31	—	—	.39	.31
47.2	48.00	—	—	.43	.35	—	—	.43	.35
53.2	54.00	—	—	.47	.39	—	—	.47	.39
59.1	60.00	—	—	.55	.43	—	—	.55	.43
63.0	63.98	—	—	.59	.47	—	—	.59	.47
65.0	66.00	—	—	.59	.47	—	—	.59	.47
70.9	72.00	—	—	.63	.51	—	—	.63	.51
74.8	76.00	—	—	.67	.55	—	—	.67	.55
78.7	80.00	—	—	.71	.59	—	—	.71	.59
82.7	84.00	—	—	.75	.63	—	—	.75	.63
86.6	88.00	—	—	.79	.63	—	—	.79	.63
90.6	92.00	—	—	.83	.67	—	—	.83	.67
94.5	96.00	—	—	.87	.71	—	—	.87	.71
98.4	100.00	—	—	.91	.71	—	—	.91	.71
102.4	104.00	—	—	.94	.75	—	—	.94	.75
106.3	108.00	—	—	.98	.79	—	—	.98	.79
110.2	112.00	—	—	1.02	.83	—	—	1.02	.83
114.2	116.00	—	—	1.06	.83	—	—	1.06	.83
118.1	120.00	—	—	1.14	.87	—	—	1.14	.87

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	
3.0	.30	—	.24	3.66
4.0	.30	—	.24	4.65
5.9	.37	—	.24	6.65
8.0	.30	—	.24	8.66
10.0	.30	—	.24	10.69
12.0	.30	—	.26	12.71
13.8	.30	—	.26	14.72
15.7	.33	.30	.28	16.73
17.7	.35	.31	.30	18.77
19.7	.37	.33	.28	20.79

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
15.7	.33	.30	.28	16.76
17.7	.35	.31	.30	18.77
19.7	.37	.33	.31	20.79
23.6	.43	.39	.35	24.83
27.6	.47	.43	.39	28.86
31.5	.53	.47	.43	32.91
35.4	.59	.51	.47	36.97
39.4	.65	.57	.51	40.98
43.3	.71	.61	.55	45.04
47.2	.76	.67	.59	49.06
53.2	.85	.73	.65	55.12
59.1	.93	.81	.71	61.18

Ductile iron specials

Nominal diameter (in.)	Thickness of pipe (in.)
3.0	.33
4.0	.33
5.9	.35
8.0	.43
10.0	.47
12.0	.49
13.8	.51
15.7	.55
17.7	.57
19.7	.59
23.6	.63
27.6	.67
31.5	.71
35.4	.75
39.4	.79
43.3	.83
47.2	.87
53.2	.94
59.1	1.02
63.0	1.08
65.0	1.10
70.9	1.18
78.7	1.26
82.7	1.30
86.6	1.34
94.5	1.42

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	
3.0	.35	.30	—	3.66
4.0	.35	.30	—	4.65
4.9	.35	.31	—	5.63
5.9	.37	.31	.30	6.65
5.9	.37	.31	.30	6.65
8.0	.39	.35	.31	8.66
10.0	.43	.37	.33	10.69
12.0	.45	.39	.35	12.71
13.8	.47	.43	.37	14.72
15.7	.50	.45	.39	16.73
17.7	.53	.47	.41	18.77
19.7	.55	.50	.43	20.79
23.6	—	.56	.46	24.83
27.6	—	.61	.50	28.86
31.5	—	.66	.54	32.91
35.4	—	.72	.58	36.97

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

Nominal diameter		Outer diameter (in.)	Nominal thickness			
			Schedule 5S	Schedule 10S	Schedule 20S	Schedule 40S
A	B		Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)
5.9	.24	6.50	.11	.13	.20	.28
8.0	.31	8.52	.13	.16	.26	.37
10.0	.39	10.53	.16	.18	.26	.41
13.8	.55	14.00	.16	.20	.31	.44
15.7	.63	16.00	.18	.20	.31	.50
17.7	.70	18.00	.18	.20	.31	.56
19.7	.78	20.00	.20	.22	.37	.59
21.7	.87	22.00	.20	.22	.37	.59
23.6	.94	24.00	.22	.26	.37	.69
25.6	1.02	26.00	.22	.31	.50	.69
27.6	1.10	28.00	.22	.31	.50	.69
29.5	1.18	30.00	.26	.31	.50	.69
31.5	1.26	32.00	—	.31	.50	.69
33.5	1.34	34.00	—	.31	.50	.69
35.4	1.42	36.00	—	.31	.50	.75
39.4	1.57	40.00	—	.37	.56	1.03

Arc welded carbon steel pipe (JIS G3457-1976)

Nominal diameter (A)	Nominal diameter (B)	Thickness (in.) / Outer diameter (in.)	.24	.25	.28	.31	.34	.39	.41	.44	.47	.50	.52	.59	.63
13.8	.55	14.00	2.04	2.17	2.40	2.67									
15.7	.63	16.00	2.33	2.48	2.63	3.06									
17.7	.71	18.00	2.63	2.80	3.10	3.44									
19.7	.79	20.00	2.93	3.12	3.45	3.83	4.21	4.60							
21.7	.87	22.00	3.22	3.43	3.80	4.21	4.65	5.08	5.47	5.90	6.30	6.73			
23.6	.94	24.00	3.50	3.75	4.13	4.60	5.00	5.55	5.98	6.46	6.89	7.36			
25.6	1.02	26.00	3.81	4.06	4.49	5.00	5.51	5.98	6.50	7.01	7.48	7.99			
27.6	1.10	28.00	4.09	4.37	4.84	5.39	5.94	6.46	7.01	7.56	8.07	8.62			
29.5	1.18	30.00		4.69	5.20	5.79	6.38	6.93	7.52	8.11	8.66	9.25			
31.5	1.26	32.00		5.00	5.55	6.18	6.81	7.40	8.03	8.62	9.25	9.88	10.16	11.69	12.28
33.5	1.34	34.00		5.31		6.57	7.20	7.87	8.62	9.17	9.84	10.47	10.83	12.40	13.07
35.4	1.42	36.00		5.63		6.97	7.64	8.35	9.06	9.72	10.43	11.10	11.46	13.19	13.86
39.4	1.57	40.00				7.72	8.50	9.29	10.04	10.83	11.61	12.36	12.76	14.68	15.43
43.3	1.73	44.00						10.24	11.06	11.93	12.76	13.62	14.06	16.18	17.01
47.2	1.89	48.00						11.14	12.09	13.03	13.94	14.88	15.35	17.64	18.58
53.2	2.13	54.00									15.71	16.77	17.28	19.88	20.94
59.1	2.36	60.00									17.48	18.62	19.21	22.13	23.27
63.0	2.52	64.00											20.51	23.62	24.84
70.9	2.83	72.00											23.11	26.57	27.99
78.7	3.15	80.00												29.57	31.46

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

Nominal diameter (in.)	Thickness of pipe T		Actual outer diameter D_1
	High pressure pipe	Normal pressure pipe	
3.0	.35	.30	3.66
4.0	.35	.30	4.65
4.9	.35	.31	5.62
5.9	.37	.31	6.65
8.0	.39	.35	8.66
10.0	.43	.37	10.69
12.0	.45	.39	12.71

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

Nominal diameter	Outer diameter	Thickness
.5	.71	.10
.8	1.02	.12
1.0	1.26	.14
1.2	1.50	.14
1.6	1.89	.16
2.0	2.36	.18
3.0	3.50	.23
4.0	4.49	.28
5.9	6.50	.38

Cast iron pipe for waste water (JIS G5525)

Nominal diameter	Thickness of pipe	Actual inner diameter	Actual outer diameter
	T	D_1	D_2
2.0	.24	2.0	2.4
2.6	.24	2.6	3.0
3.0	.24	3.0	3.4
4.0	.24	4.0	4.4
4.9	.24	4.9	5.4
5.9	.24	5.9	6.4
8.0	.28	8.0	8.4

(a) Velocity of sound subject to change of temperature in water (32 to 212°F)

T°F	Vft./s	T°F	Vft./s	T°F	Vft./s	T°F	Vft./s
32	4600.99						
33	4617.29	79	4918.82	124	5064.09	169	5101.71
36	4632.90	81	4927.22	126	5067.44	171	5101.42
37	4648.81	82	4935.35	127	5070.62	172	5100.99
39	4664.09	84	4943.29	129	5073.60	174	5100.47
41	4678.92	86	4950.96	131	5076.46	176	5099.78
43	4693.42	88	4958.41	133	5079.11	178	5098.99
45	4707.59	90	4965.62	135	5081.64	180	5098.10
46	4721.43	91	4972.64	136	5084.00	181	5097.05
48	4734.94	93	4979.43	138	5086.23	183	5095.91
50	4748.10	95	4985.99	140	5088.26	185	5094.66
52	4760.95	97	4992.36	142	5090.17	187	5093.25
54	4773.52	99	4998.49	144	5091.94	189	5091.77
55	4785.75	100	5004.43	145	5093.54	190	5090.17
57	4797.66	102	5010.17	147	5094.99	192	5088.43
59	4809.30	104	5015.71	149	5096.33	194	5086.59
61	4820.62	106	5021.02	151	5097.48	196	5084.66
63	4831.67	108	5026.17	153	5098.53	198	5082.62
64	4842.43	109	5031.13	154	5099.42	199	5080.46
66	4852.92	111	5035.88	156	5100.17	201	5078.19
68	4863.12	113	5040.44	158	5100.79	203	5075.80
70	4873.06	115	5044.84	160	5101.28	205	5073.34
72	4882.71	117	5049.04	162	5101.61	207	5070.75
73	4892.12	118	5053.07	163	5101.84	208	5068.92
75	4901.27	120	5056.91	165	5101.94	210	5065.27
77	4910.16	122	5060.61	167	5101.88	212	5062.38

Note) T: temperature, V: velocity of sound

(b) Velocity of sound and density of various liquids

Name of liquid	T°Fρ	ρ oz./in.^{3}	Vft./s
Acetone	68	0.4571	3903
Aniline	68	0.5907	5442
Alcohol	68	0.4564	3831
Ether	68	0.4125	3300
Ethylene glycol	68	0.6436	5464
n-octane	68	0.4060	3909
o-xylene	68	0.5036	4461
Chloroform	68	0.8598	3283
Chlorobenzene	68	0.6384	4228
Glycerin	68	0.7293	6307
Acetic acid	68	0.6068	3802
Methyl acetate	68	0.5366	3874
Ethyl acetate	68	0.5204	3818
Cyclohexane	68	0.4504	4212
Dithionic acid	68	0.5973	4556
Heavy water	68	0.6391	4553
Carbon tetrachloride	68	0.9218	3077
Mercury	68	7.8609	4759
Nitrobenzene	68	0.6979	4831
Carbon disulfide	68	0.7305	3798
Chloroform	68	1.6712	3054
n-propyl alcohol	68	0.4652	4018
n-pentane	68	0.3620	3385
n-hexane	68	0.3781	3552
Light oil	77	0.4683	4343
Transformer oil	90.5	0.4967	4674
Spindle oil	89.5	0.5233	4402
Petroleum	93	0.4770	4248
Gasoline	93	0.4643	4100
Water	56	0.5782	4789
Sea water (salinity: 35%)	61	0.5782	4953

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

(c)Velocity of sound per piping material

Material	Vft./s
Iron	10597
Steel	10519
Ductile cast iron	9843
Cast iron	8071
Stainless steel	10519
Copper	7415
Lead	7120
Aluminum	10106
Brass	6726
Vinylchloride	8662
Acrylics	8741
FRP	8219
Mortar	8203
Tar epoxy	8219
Polyethylene	6234
Teflon	4068

Note) V: velocity of sound

(d) Dynamic viscosity coefficient of various liquids

Name of liquid	T°Fρ	ρ oz./in.^{3}	Vft./s	ν (×10^{-6}ft.^{2}/s)
Acetone	68	0.4571	3903	1.33
Aniline	68	0.5907	5442	5.79
Ether	68	0.4125	3300	1.10
Ethylene glycol	68	0.6436	5464	69.25
Chloroform	68	0.8598	3283	1.26
Glycerin	68	0.7293	6307	38.98
Acetic acid	68	0.6068	3802	3.81
Methyl acetate	68	0.5366	3874	1.35
Ethyl acetate	68	0.5204	3818	1.64
Heavy water	68	0.6391	4553	3.70
Carbon tetrachloride	68	0.9218	3077	1.99
Mercury	68	7.8609	4759	0.37
Nitrobenzene	68	0.6979	4831	5.46
Carbon disulfide	68	0.7305	3798	0.95
n-pentane	68	0.3620	3385	1.20
n-hexane	68	0.3781	3552	1.60
Spindle oil	90	0.5233	4343	51.50
Gasoline	93	0.4643	4100	1.3 ~ 1.6
Water	56	0.5782	4789	3.29(68°F)

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