

SURPASS

Eddysonic Flowmeter

ESF

Operation Manual

Surpass Industry Co., Ltd.

Read Before Use

- Before using this product, check the compatibility of the type of liquid to use and the wetted parts material in this product.
- All users are required to carefully read and understand this manual before operation of the product.
- Keep this manual in good condition and close at hand for quick reference whenever necessary.
- Use the product only as intended, and only as directed in this manual.
- Cautionary notes in this manual must be fully understood and complied with at all times.

About This Operation Manual

- The contents of this manual are subject to change without prior notice, due to improvements in product functionalities and / or performance.
- No part of this manual may be reproduced in any form or by any means.
- Although this manual has been prepared with all possible care, please do not hesitate to contact Surpass Industry about errors, omissions, or any other points of doubt.

Important Safety Instructions

<Symbols in This Operation Manual>

Warnings and cautionary notes are provided in this manual to ensure this product is used correctly and to prevent personal injury and property damage. The meanings of the WARNING and CAUTION symbols in this manual are as described below. Read and understand these notes before reading the rest of this manual.

 DANGER	This symbol indicates warnings against impending danger which, if not observed, may cause death or severe injury to the user.
 WARNING	This symbol indicates warnings which, if not observed, may cause death or severe injury to the user.
 CAUTION	This symbol indicates warnings which, if not observed, may physically impair the user or damage surrounding objects.
	Provides important notices and instructions for correct operation of the product.

Specific Warnings

<p style="text-align: center;"> WARNING</p> <ul style="list-style-type: none"> ● <u>This product is not explosion-proof.</u> Never use it with flammable fluids such as solvents. Doing so may cause fire and or explosion and is highly dangerous. ● Never use with <u>gas-permeable liquids (hydrofluoric acid, hydrochloric acid, nitric acid, ozone, etc.).</u> Gas permeation may lead to product failure. ● Never disassemble or alter the product. Doing so will cause breakage of the product and possible liquid leakage. The use of dangerous chemicals, solvents, and gases may cause physical impairment. ● Do not insert screwdrivers, wires, or other objects into the tube parts. Doing so will cause product failure and possible liquid leakage. The use of dangerous chemicals, solvents, and gases may cause physical impairment. ● Refrain from excessive pulling or bending of the cables. Doing so may cause wiring disconnections, which may cause electrical shock and fire hazards. 	<p style="text-align: center;"> WARNING</p> <ul style="list-style-type: none"> ● When mounting connector parts, comply with the instructions issued by each connector manufacturer. Loose connections may result in disconnection or chemical leakage. The use of dangerous chemicals, solvents, and gases may cause physical impairment. ● Do not use the product in areas where corrosive gases are being ejected. Corrosion in the body and connector may result in liquid leakage. The use of dangerous chemicals, solvents, and gases may cause physical impairment. ● Obey these instructions. <ul style="list-style-type: none"> - Refrain from excessive tightening of the connector parts. - Do not install the product in areas of excessive vibration or shock. - Use the product only within the specified operating environment. Otherwise, damage to the body and connector may occur and result in liquid leakage. The use of dangerous chemicals, solvents, and gases may cause physical impairment. ● This product is designed for indoor-only use. Do not apply this product to outdoor use.
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Product Description

Eddysonic Flowmeter, that has the part in contact with liquid made of PFA and provides connection with no use of seal-tapes resulting in potentially leakage, is the ideal flowmeter used to measure the flow rates of chemical liquids.

<Operating Principle>

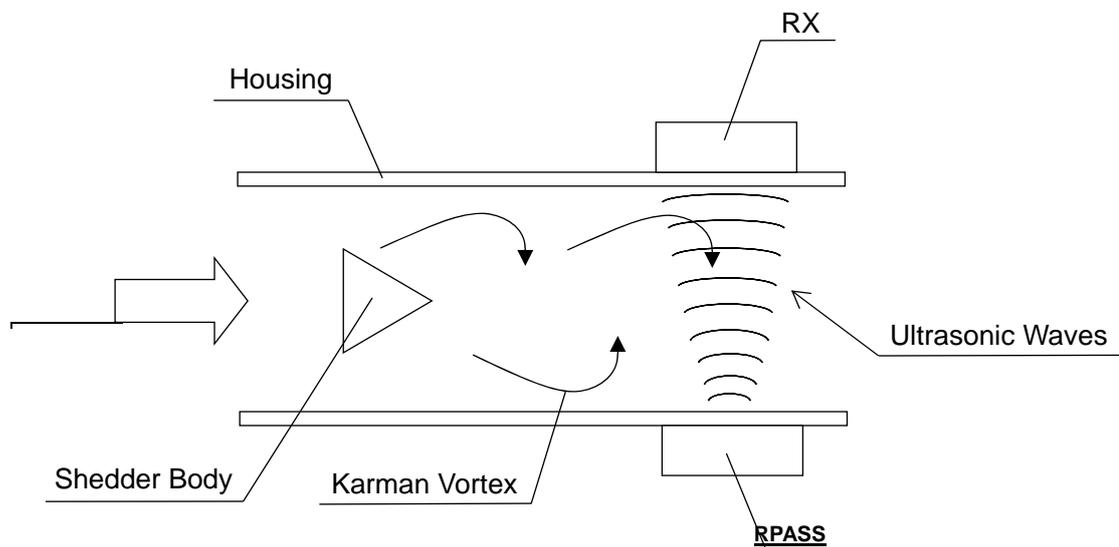
If a liquid flows past a shedder body, a regular pattern pf vortices called Karman Vortex Street alternately trails aft in the wake. Provided that the vortex shedding frequency is f , the width of shedder body is d , and the flow velocity is v , the relationship of them can be expressed by the following formula.

$$f = St \cdot v/d$$

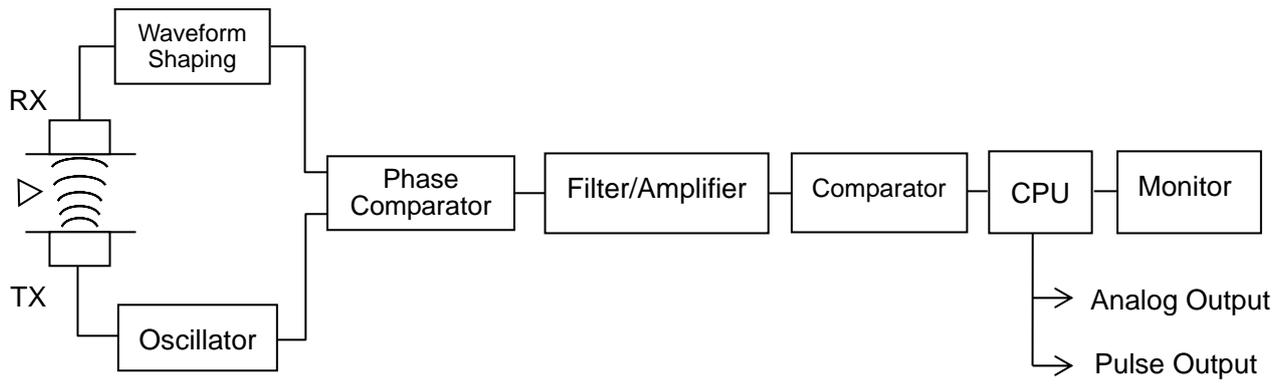
Where St , the Strouhal Number is a dimensionless constant which defines the quality of the vortex measurement. The Strouhal Number is constant over wide Reynolds Number ranges when the shedder body is designed with optimal dimensions. Therefore, we can obtain the value of v , by measuring the vortex shedding frequency f and then derive the volume flow value from the measured v .

This flowmeter, as shown below, is equipped with an ultrasonic sensor that consists of a pair of transmitter (TX) and receiver (RX). This sensor is mounted aft the wake of the shedder body. Ultrasonic waves that constantly are sent out from TX pass through the liquid for a certain time to reach the receiver. As shown in below, if a Karman vortex street trails in the contrary direction to the ultrasonic wave oscillating direction, it takes much time for ultrasonic waves to reach RX. Conversely, if a Karman vortex street trails in the same direction as ultrasonic wave oscillating direction, it takes less time for ultrasonic waves to reach RX. Since the ultrasonic wave oscillating time varies proportional to the vortex shedding frequency, we can obtain the measured flow by detecting any changes in ultrasonic wave oscillating time.

This ultrasonic sensor, mounted outside the tubes connected to flowmeter, allows non-touching measurement in which we can measure the flow rates without directly touching. Also, the ultrasonic sensor provides the excellent features, resistance to vibration and high sensibility.



Operating Principle of Eddysonic Flowmeter

<Circuit Block Diagram>

Specifications

Model		ESF-10	ESF-10V	ESF-15	ESF-15V
Applicable Fluid		Fluids not corrosive or permeable against fluorocarbon resin			
Flow Meter Range (at water) (※ ₁)		0.5 ~ 3.5 L/min (at 1x10 ⁻⁶ m ² /s)		1 ~ 16 L/min (at 1x10 ⁻⁶ m ² /s)	
Indicating Flow Rate		0.0 ~ 4.0 L/min		0.0 ~ 18.0 L/min	
Measurement Accuracy (※ ₂)	Monitor	±5%F.S. (DI Water at 25°C)		±2.5%F.S. (DI Water at 25°C)	
	Analog output	±6%F.S. (DI Water at 25°C)		±3.5%F.S. (DI Water at 25°C)	
Environment Humidity		5 ~ 80 %RH(Non-condensing)			
Environment Temperature		5 ~ 60°C (41 ~ 140°F)			
Fluid Temperature		5 ~ 85°C (41 ~ 185°F)			
Fluid Pressure (※ ₃)		Max. 800 kPa (at 25°C)			
Connecting Tube Diameter		φ 3/8"x φ 1/4" (φ 9.53x φ 6.35)		φ 1/2"x φ 3/8" (φ 12.7x φ 9.5)	
Wetted Parts		PFA			
Mounting Position		Horizontal, vertical, or diagonal			
Analog Output	Output	DC 4 ~ 20 mA			
	Response time	Approx. 2 seconds			
	Load Resistance	500 Ω or less	250 Ω or less	500 Ω or less	250 Ω or less
Pulse Output	Output	NPN open collector			
	Excitation Voltage/Current	Max. DC 30 V / 80 mA			
	Pulse Unit	10 mL/P			
	Pulse Range	5 ms			
High and Low Boundary Output	Output	NPN open collector			
	Excitation Voltage/Current	Max. DC 30 V / 80 mA			
Power Supply		DC 24 V ±10%	DC 12 V ±10%	DC 24 V ±10%	DC 12 V ±10%
Current Consumption		120 mA or less			
Standard cable length		2 m (78.8")			



Because the product is damaged on the condition that a fluid temperature change occurs rapidly, please don't use it in that condition.



To prevent abnormal output, please keep an inner pressure of pipes more than 100kPa when stops water flow.

Model		ESF-20	ESF-25
Applicable Fluid		Fluids not corrosive or permeable against fluorocarbon resin	
Flow Meter Range (at water) (※ ₁)		2 ~ 40 L/min (at 1x10 ⁻⁶ m ² /s)	5 ~ 130 L/min (at 1x10 ⁻⁶ m ² /s)
Indicating Flow Rate		0.0 ~ 44.0 L/min	0.0 ~ 145.0 L/min
Measurement Accuracy (※ ₂)	Monitor	±1.5%F.S. (DI Water at 25°C)	±2.5%F.S. (DI Water at 25°C)
	Analog output	±2.5%F.S. (DI Water at 25°C)	±3.5%F.S. (DI Water at 25°C)
Environment Humidity		5 ~ 80 %RH(Non-condensing)	
Environment Temperature		5 ~ 60°C (41 ~ 140°F)	
Fluid Temperature		5 ~ 85°C (41 ~ 185°F)	
Fluid Pressure (※ ₃)		Max. 600 kPa (at 25°C)	Max. 450 kPa (at 25°C)
Connecting Tube Diameter		ϕ 3/4" x ϕ 5/8" $\left[\begin{array}{l} \phi 19.05 \times \phi 15.8 \\ \text{or } \phi 19 \times \phi 16 \end{array} \right]$	ϕ 1" x ϕ 7/8" (ϕ 25.4 x ϕ 22.2)
Wetted Parts		PFA	
Mounting Position		Horizontal, vertical, or diagonal	
Analog Output	Output	DC 4 ~ 20 mA	
	Response time	Approx. 2 seconds	
	Load Resistance	500Ω or less	
Pulse Output	Output	NPN open collector	
	Excitation Voltage/Current	Max. DC 30 V / 80 mA	
	Pulse Unit	10 mL/P	100 mL/P
	Pulse Range	5 ms	
High and Low Boundary Output	Output	NPN open collector	
	Excitation Voltage/Current	Max. DC 30 V / 80 mA	
Power Supply		DC 24 V ±10%	
Current Consumption		120 mA or less	
Standard cable length		2 m (78.8")	



Because the product is damaged on the condition that a fluid temperature change occurs rapidly, please don't use it in that condition.



To prevent abnormal output, please keep an inner pressure of pipes more than 100kPa when stops water flow.

※₁ Instructions on range of flow rate

Kinetic viscosity of liquids [x 10 ⁻⁶ m ² /s]	1	2	3	4	5	6	7	Maximum flow rate [L/min]
ESF-10 Minimum flow rate of liquids [L/min]	0.5	1.0	1.5	2.0	2.5	3.0	-	3.5
ESF-15 Minimum flow rate of liquids [L/min]	1	2	3	4	5	6	7	16
ESF-20 Minimum flow rate of liquids [L/min]	2	4	6	8	10	12	14	40
ESF-25 Minimum flow rate of liquids [L/min]	5	10	15	20	25	30	35	130

◎The minimum flow rates of the liquids, of which kinetic viscosity are more than 2 [x10⁻⁶m²/s], are the theoretical values and may be different from the actual values.

※₂ Instructions on measurement accuracy

Because the measuring part of this flowmeter is made of resin, the temperature change of the target liquid affects the inner diameter of the measurement tube, causing some deviation in measurement characteristics. If the liquid temperature is higher than 50°C and the accuracy specified by the specifications is required, correct the displayed output of the flowmeter using the following formula:

Actual flow volume under your operating conditions = Displayed output of flowmeter x {1+(0.0006x(T-25))}

T : Liquid temperature under your operating conditions (°C)

※₃ Instructions on operating liquid pressure

The maximum operating pressure depends on the liquid temperature. To derive the maximum operating pressure for the specific liquid temperature, use the following formula:

- ESF-10,ESF-15

Maximum acceptable operating pressure = $800 \times \{1 - ((T-25) \times 0.0043)\}$ (kPa)

T : Liquid temperature (°C) at your usage

- ESF-20

Maximum acceptable operating pressure = $600 \times \{1 - ((T-25) \times 0.0043)\}$ (kPa)

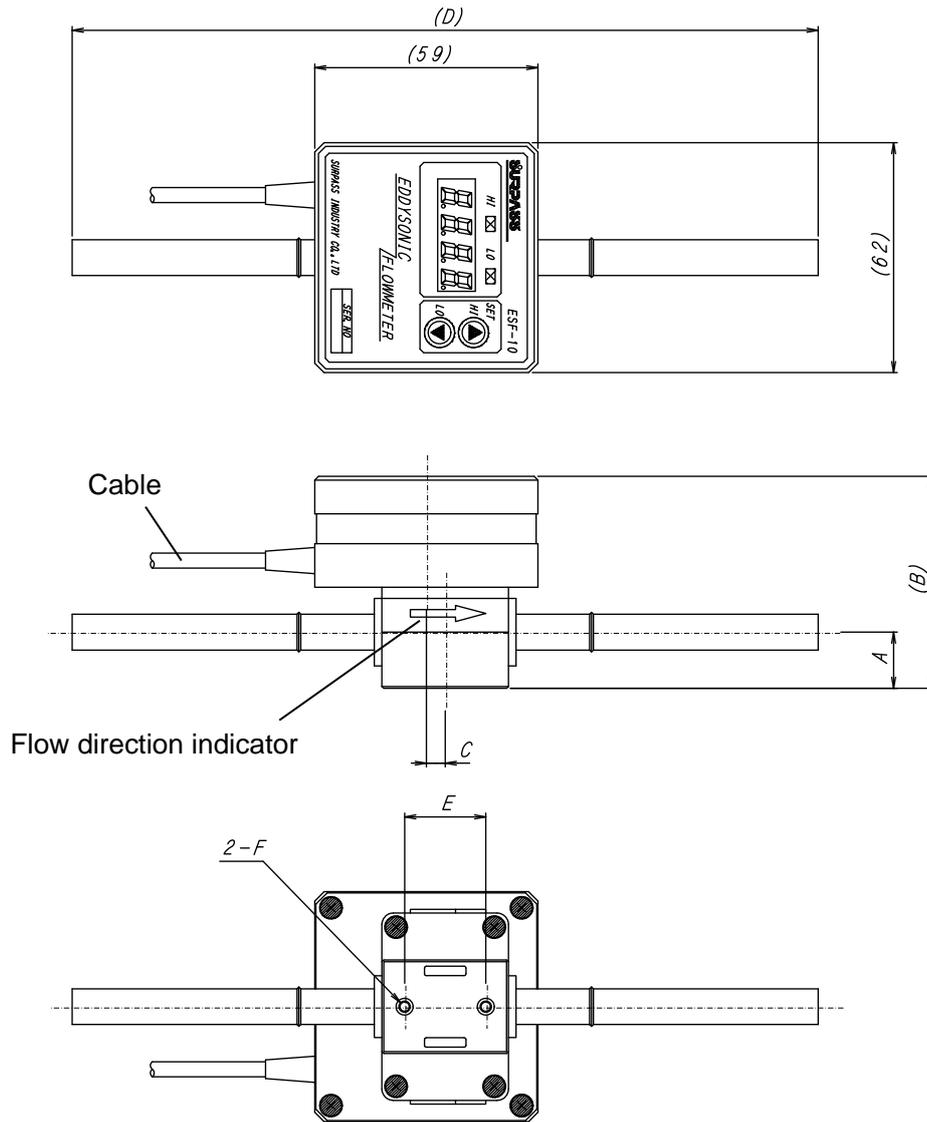
T : Liquid temperature (°C) at your usage

- ESF-25

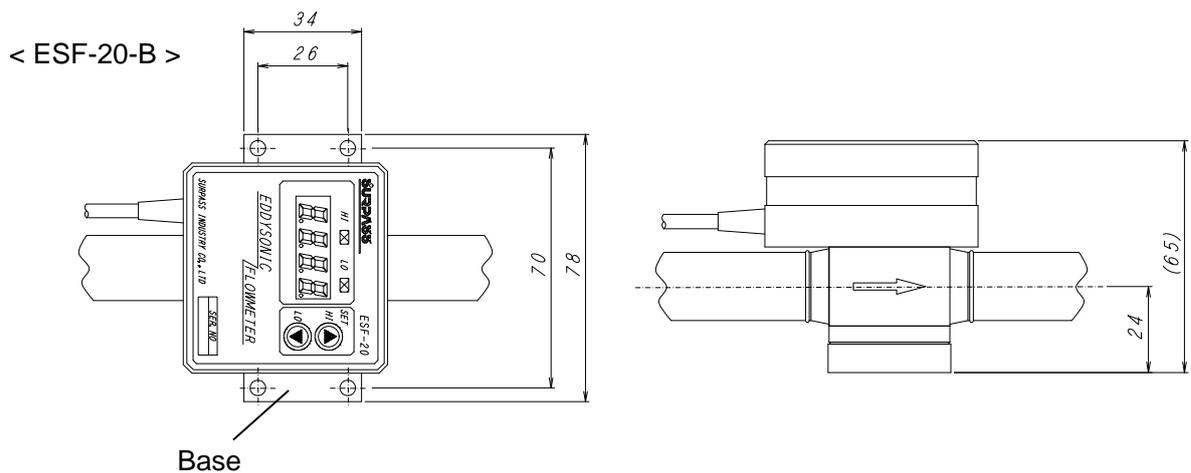
Maximum acceptable operating pressure = $450 \times \{1 - ((T-25) \times 0.0043)\}$ (kPa)

T : Liquid temperature (°C) at your usage

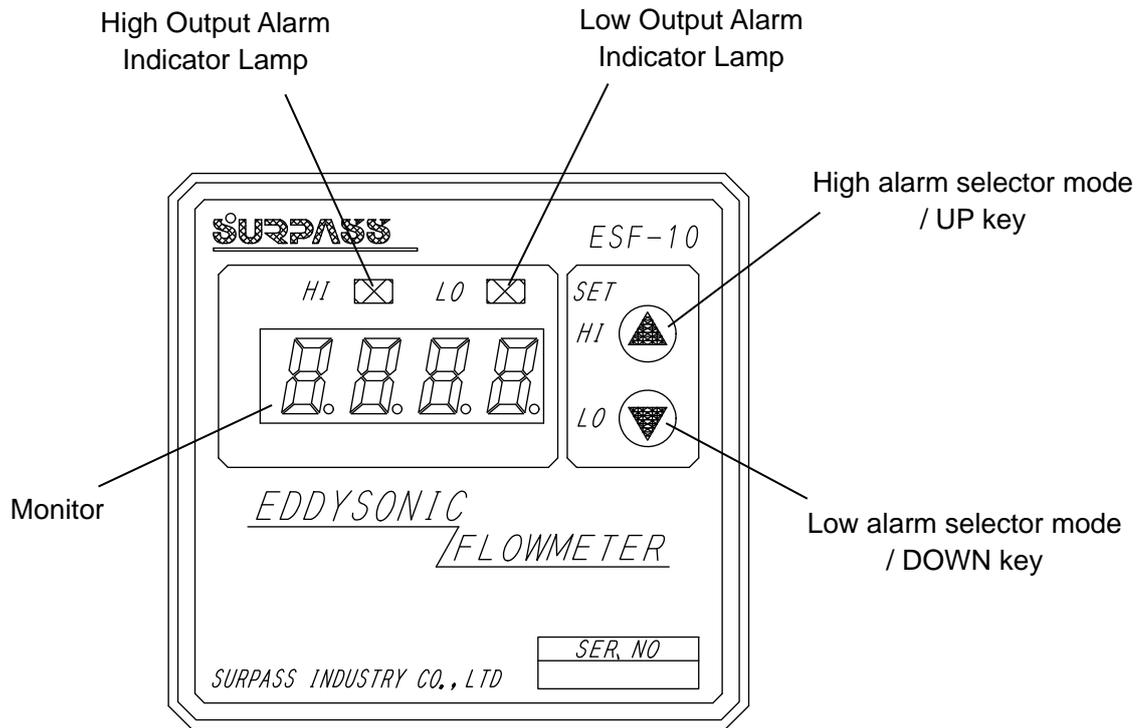
Outer Dimensions



Model	A	(B)	C	(D)	E	F
ESF-10	15	(57)	5	(195)	21.5	M3 depth 4.5
ESF-15	15	(57)	5	(210)	21.5	M3 depth 4.5
ESF-20	16	(57)	5	(229)	-	-
ESF-25	26	(72)	0	(352)	24	M4 depth 5



Names of Display Panel



Mounting and Connecting the Connector Parts

If you wish to anchor your Flowmeter, use the threaded holes of the bottom position or the mounting holes in the base.

When connecting the connector parts, tighten the connector while preventing the body from turning. In order to install connector parts correctly, always refer to the relevant catalog or operation manual issued by the connector manufacturer.

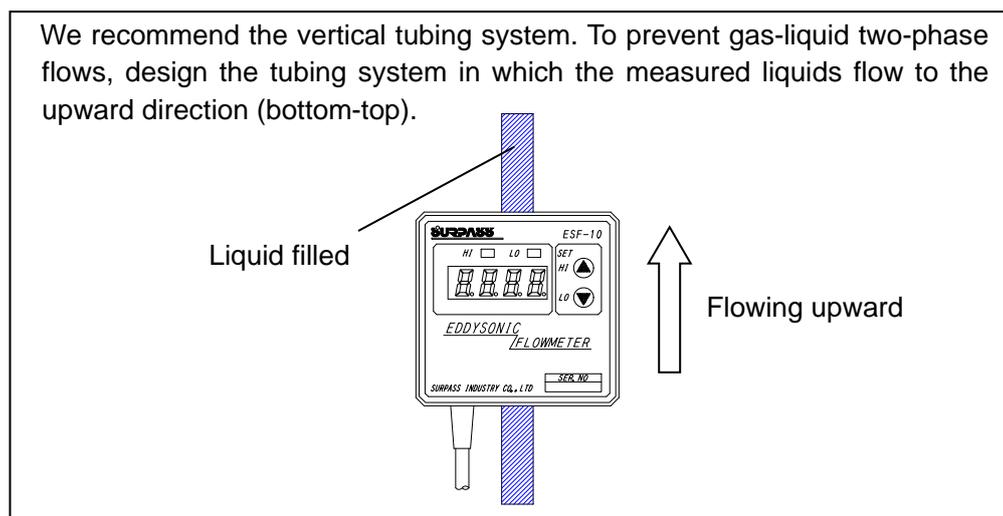
⚠ WARNING

- Before tubing, confirm the correct flow direction by checking the arrow direction of "IN→OUT" marked on the side of flowmeter unit. Incorrect tubing system may result in personal injury due to liquid leakage caused by damage of flowmeter unit.
- Before mounting, align the axes of tubes on both sides to avoid excessive stress to the flowmeter. Incorrect axial alignment may result in personal injury due to liquid leakage caused by damage of flowmeter unit.
- When tubing, use tubes of the specified size. Using other tubes may result in personal injury due to fluid leakage.
- When mounting connector parts, comply with the instructions issued by each connector manufacturer. Loose connections may result in disconnection or chemical leakage. The use of dangerous chemicals, solvents, and gases may cause physical impairment.
- Refrain from excessive tightening of the connector parts. Otherwise, damage to the body and connector may occur and result in liquid leakage. The use of dangerous chemicals, solvents, and gases may cause physical impairment.

⚠ CAUTION

- The IN or OUT side's tube of which bore diameter is smaller than that of flowmeter may generate an error in measurement.
- When using flowmeter, be sure to release the air inside its tube. An existence of air in tubing system may prevent the flowmeter from indicating a correct flow value.
- If air bubbles enter into the liquid, the bubbles may remain in the Karman vortex generating part of the main unit, resulting in incorrect measurement.

- The tube can be mounted in horizontal, vertical and diagonal. However, in any case, the tubing system must be filled with the liquid at all times.



- Design straight-tube parts on both sides of flowmeter. The straight-tube length of IN side must be at least 7 times longer than the bore diameter, and that of OUT side must be at least 5 times longer than the bore diameter.

<Pressure at Downstream Side>

To prevent the occurrence of cavitations(※₄), the pressure value at the downstream side should be more than one obtained from the following formula.

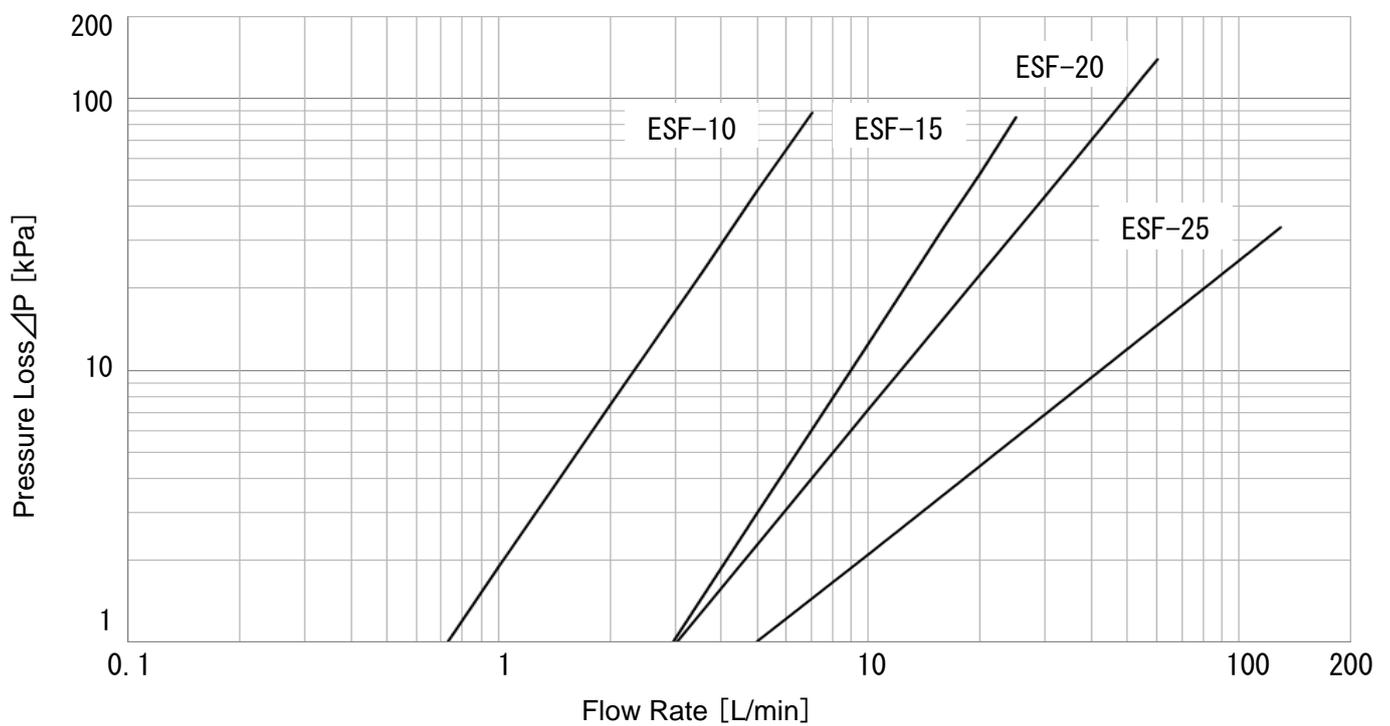
$$P_d = 2.7 \Delta P + 1.3 P_0$$

P_d : Pressure values at the downstream side [kPa]

ΔP : Pressure loss values [kPa]

P_0 : Vapor pressure values of liquids [kPa abs]

<Pressure Loss>

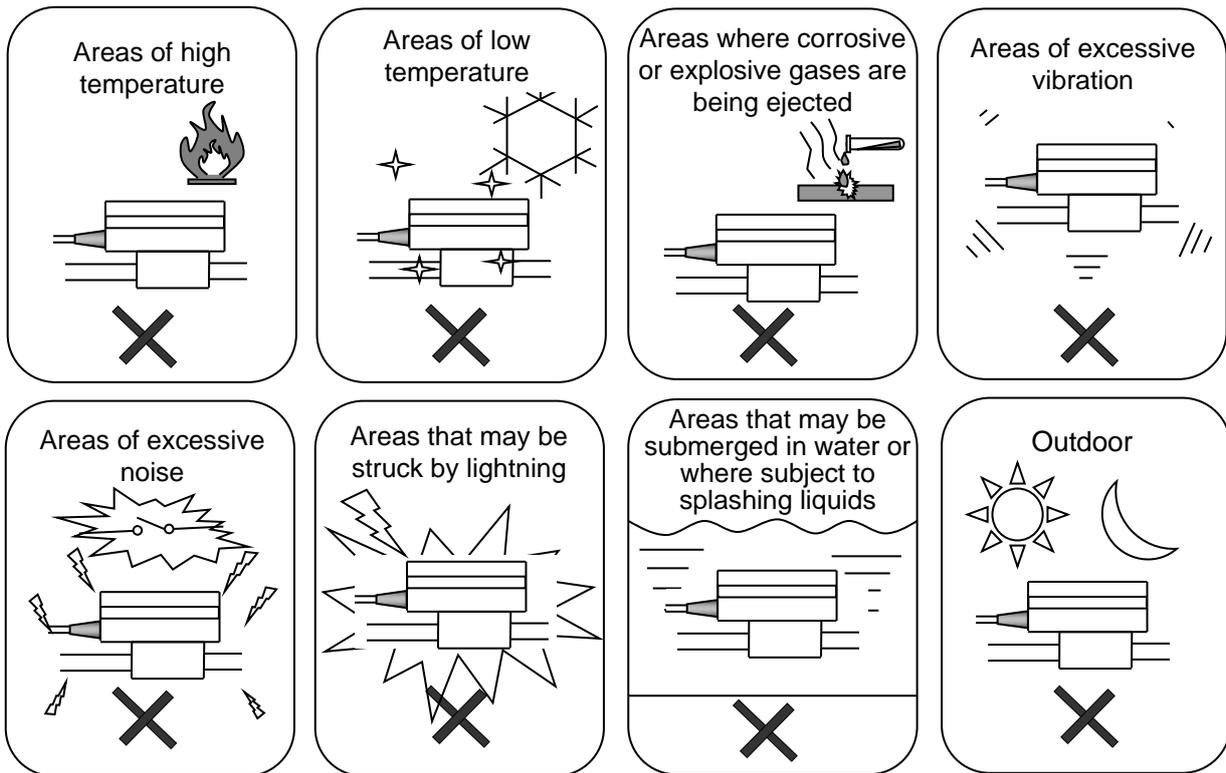


※₄ Cavitations

Phenomenon that the liquid evaporates, generating air bubbles, when the liquid pressure drops to the saturated vapor pressure or below.

Points to Observe When Installing

To prevent erroneous operation or premature wear, do not install in:



- Gas-liquid two-phase flows or flows containing bubbles may result in malfunction.
- Mount the flowmeter in the places where no bubble flows into or gets trapped inside the flowmeter.
- Do not use this product for slurry liquids or liquid containing foreign substances. Such usage may degrade the system performance.
- Do not mount heat exchangers or similar devices upstream, nearest to the flowmeter. Sharp changes in liquid temperature may result in malfunction. Keep the heat exchanger or similar devices away from the flowmeter to avoid sharp temperature changes.
- Do not mount the flowmeter in the places that may provide high temperature gradients or sharp temperature changes.
- Large ripples of bellows pumps or similar devices may result in errors in measurement. Minimize the ripples by using dampers or similar devices.
- Mount the flowmeter in the places where you can easily do inspection and tubing work.
- When wiring, do not connect the cables close to large-capacity motors or transformers, noise source such as power sources, and high-voltage/high-current sources. Neglecting this may result in malfunction due to induction.

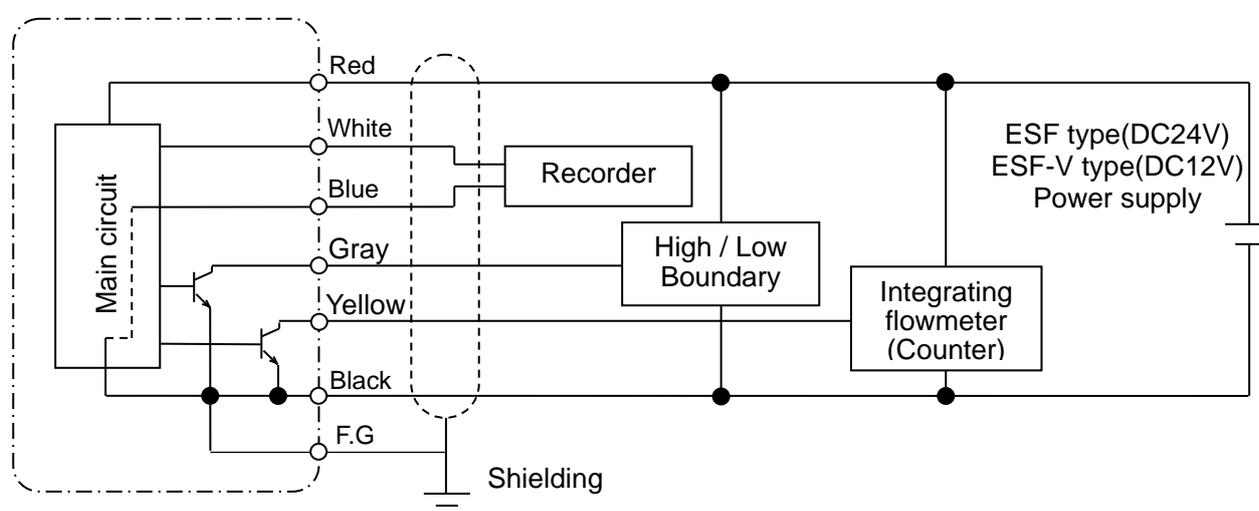
Wiring

Observe these precautions to connect the leads correctly.

⚠ CAUTION

- Never do wiring work when power supply is on. Doing so may cause electrical shock.
- Refrain from excessive pulling or bending of the cables. Doing so may cause disconnections which may cause electrical shock and fire hazards.
- Make sure to connect all leads correctly. Failure to do so may cause the product to fail.
- Apply the voltage in the specified range. Overvoltage may result in smoking or fire.
- Do not apply the voltage and current above the capacity to the pulse output (open collector output). Damages may occur.

Wiring diagram



※Black, Blue leads are connected each other within the circuit.

Name of Signal	Color
ESF type DC24V Power Supply ESF-V type DC12V Power supply	Red
0 V Power Supply	Black
4 ~ 20 mA Output (+)	White
4 ~ 20 mA Output (-)	Blue
Pulse Output (+)	Yellow
High / Low Boundary Output (+)	Gray

<Power Supply Connecting>

Connect to a DC24V power supply (ESF type) or a DC12V power supply (ESF-V type). To obtain the specified accuracy, warm up your flowmeter for at least 20 minutes.

<Analog Output>

Connect a load resistance between 4 ~ 20mA Output (+) and 4 ~ 20mA Output (-).
The value of load resistance of 500 Ω or less (ESF type) or 250 Ω or less (ESF-V type).

<High/Low Boundary Output>

The high/low boundary output is a NPN open collector output. Connect a load resistance between high/low boundary output (+) and power supply (+). Below are examples of load resistance.

e.g.) Load resistance	1k Ω	1W (Excitation Voltage 24V or less)
	1k Ω	1/2W (Excitation Voltage 12V or less)
	10k Ω	1/4W (Excitation Voltage 12V or less)

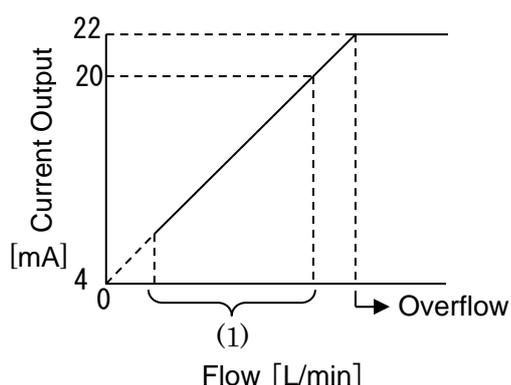
<Pulse Output>

The pulse output is a NPN open collector output. Connect a load resistance between pulse output (+) and power supply (+). Below are examples of load resistance.

e.g.) Load resistance	1k Ω	1W (Excitation Voltage 24V or less)
	1k Ω	1/2W (Excitation Voltage 12V or less)
	10k Ω	1/4W (Excitation Voltage 12V or less)

<Relationship of Flow and Analog Output>

The analog output increases proportional to flow in the range of (1) L/min.

**<Flow Range>**

ESF-10	0.5 ~ 3.5 L/min
ESF-15	1 ~ 16 L/min
ESF-20	2 ~ 40 L/min
ESF-25	5 ~ 130 L/min

At overflow ("OFLO" indicated), the analog output levels off at the maximum flow rate current.

<Overflow Range>

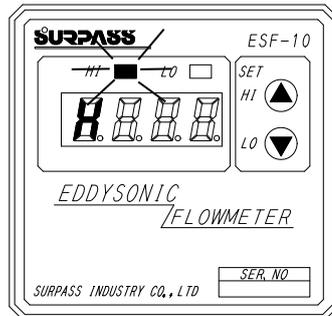
ESF-10	4 L/min or more
ESF-15	18 L/min or more
ESF-20	44 L/min or more
ESF-25	145 L/min or more

Setting the High/Low Boundary Value

<ESF-10·ESF-15·ESF-20>

◇Setting high boundary value

- Press and hold the SET HI (▲) button for at least one seconds.
-The high output alarm indicator lamp will light up, and an “H” will appear in the display.



- Adjust the high boundary value setting by pressing the ▲ ▼ button.
-The value on the display increases or decreases by 0.1.

-The numbers can be fast forward or reversed by holding down on the ▲ or ▼ button.

The setting range depends on the flowmeter model.

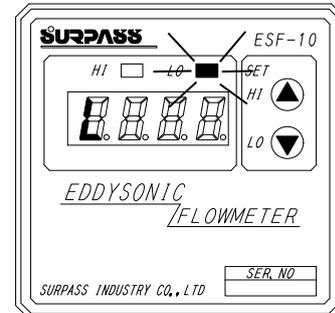
<Setting range for each model>

ESF-10	0.0 ~ 3.5
ESF-15	0.0 ~ 16.0
ESF-20	0.0 ~ 40.0

- After releasing the ▲ or ▼ button, the display will return to flow measuring mode in five seconds.

◇Setting low boundary value

- Press and hold the SET LO (▼) button for at least one seconds.
-The low output alarm indicator lamp will light up, and an “L” will appear in the display.



- Adjust the low boundary value setting by pressing the ▲ ▼ button.
-The value on the display increases or decreases by 0.1.

-The numbers can be fast forward or reversed by holding down on the ▲ or ▼ button.

⚠ CAUTION

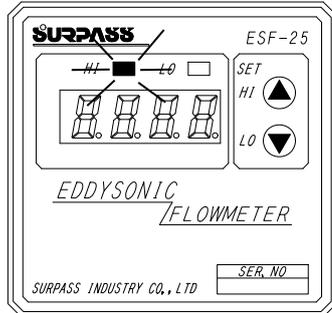
When setting the low boundary value, be sure to set the value less than the high boundary value.
The low boundary value exceeding the high boundary value may cause malfunction of the product.

- After releasing the ▲ or ▼ button, the display will return to flow measuring mode in five seconds.

<ESF-25>

◇Setting high boundary value

- (1) Press and hold the SET HI (▲) button for at least one seconds.
-The high output alarm indicator lamp will light up.



- (2) Adjust the high boundary value setting by pressing the ▲ ▼ button.
-The value on the display increases or decreases by 0.1.

-The numbers can be fast forward or reversed by holding down on the ▲ or ▼ button.

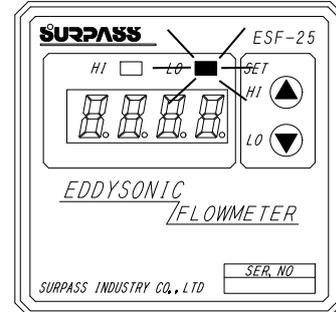
<Setting range>

ESF-25	0.0 ~ 130.0
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- (3) After releasing the ▲ or ▼ button, the display will return to flow measuring mode in five seconds.

◇Setting low boundary value

- (1) Press and hold the SET LO (▼) button for at least one seconds.
-The low output alarm indicator lamp will light up.



- (2) Adjust the low boundary value setting by pressing the ▲ ▼ button.
-The value on the display increases or decreases by 0.1.

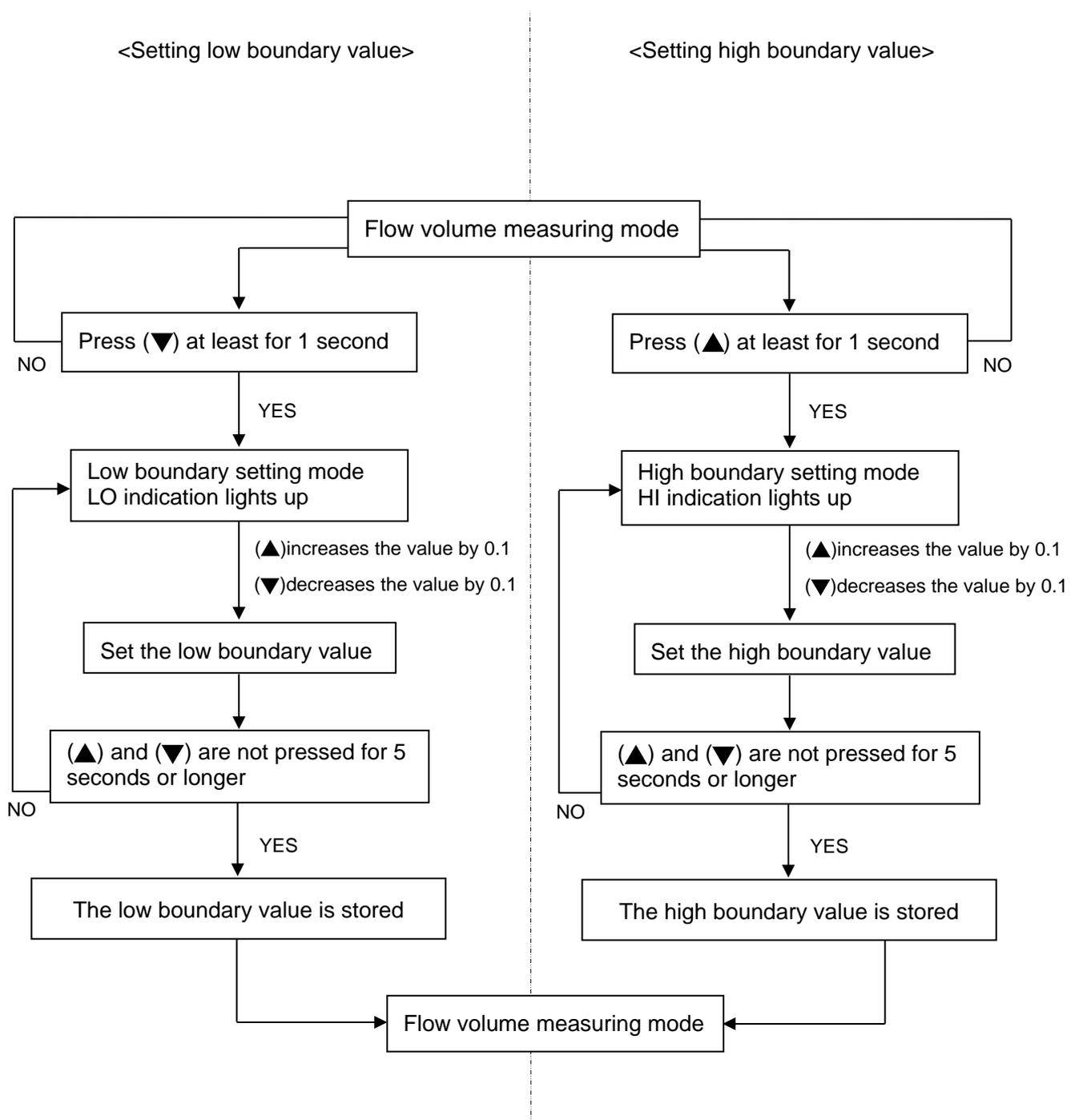
-The numbers can be fast forward or reversed by holding down on the ▲ or ▼ button.

⚠ CAUTION

When setting the low boundary value, be sure to set the value less than the high boundary value.
The low boundary value exceeding the high boundary value may cause malfunction of the product.

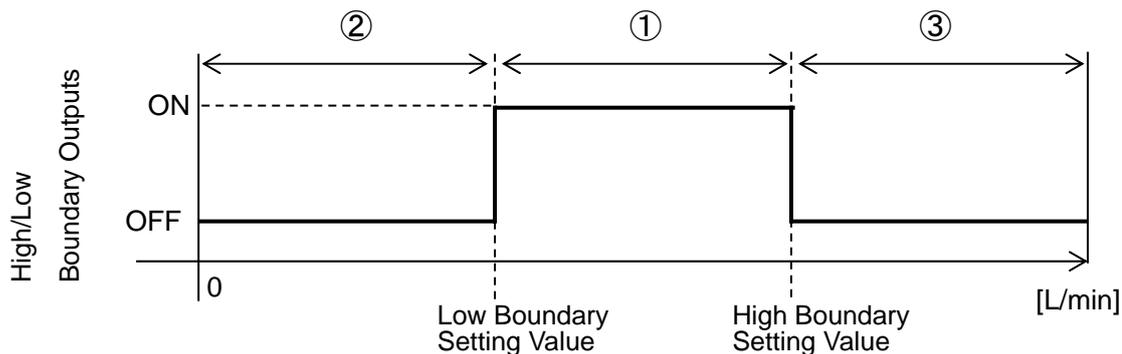
- (3) After releasing the ▲ or ▼ button, the display will return to flow measuring mode in five seconds.

Flow Diagram of High/Low Boundary Setting



High/Low Boundary Output and LED light-up state

<High/Low boundary output>



<LED light-up state>

Flow Range	②	①	③
	Lower than Low boundary value	Between High and Low boundary values	Higher than High boundary value
LED Light-up State	<p>LO turns off</p>	<p>HI & LO Light-Up</p>	<p>HI turns off</p>
Description of LED indication	LO indication turns off. (Only the HI indication lights up.)	Both of HI and LO indications light up.	HI indication turns off. (Only the LO indication lights up.)

Maintenance and Inspection

This product should be inspected regularly, about twice a year depending on the usage.

During the regular inspection, check the

- appearance
- corrosion, clogging, leakage, etc., from the connector parts.

<Safety Notes on Maintenance and Inspection>

DANGER unless these precautions are not obeyed!

- If using dangerous chemicals, solvents, gases, etc., make sure to wear protective, chemical resistant gear (protective gloves, mask, and clothing) to protect your entire body. Ejected liquids may result in physical impairment.
- Before disconnecting this product from the piping system, make sure the line is depressurized. Otherwise, the fluid inside will eject and may result in physical impairment.
- When replacing parts, or when performing maintenance or inspection, turn off the switch, and release the fluid inside the piping to depressurize the line. Otherwise, the fluid inside will eject and may result in physical impairment.

Storage

For potentially long term storage, store the product in the places where the following environmental conditions are satisfied.

- Being kept dry.
- Appropriate vibration or shock.
- Temperature of 5°C to 60°C and humidity of 5% to 80% RH (non-condensing).
- Places free from coarse particles.
- Places not exposed to direct sunshine.

In Case of Breakdown

Symptom	Cause	Countermeasure
No output value displayed with a flow.	Incorrect wiring.	Check the wiring diagram and correct the wiring.
	Incompatible power, voltage.	Check the power supply and voltage.
	The tubing system is not filled with the liquid.	Fill the liquid inside the tubing system.
	The flow rate is outside the measurable range.	Check the measurable range and choose the product.
Output value displayed without a flow.	The tubing system is not filled with the liquid.	Fill the liquid inside the tubing system.
	The liquid in tubes is fluctuating due to large ripple.	Minimize the ripples by using dampers or similar devices.
Large errors in measurement detected.	Incompatible power, voltage.	Check the power supply and voltage.
	Incompatible load resistance.	Use the load resistance of ESF type·····500Ω or less. ESF-V type·····250Ω or less.
	There is noise-generating equipment nearby.	Move the noise-generating equipment from the vicinity.
	There is flow-blocking equipment nearest to IN side of flowmeter.	Change the mounting position of flowmeter. (keep the rated straight-tube length as follows) IN side : 7 times longer than the bore diameter OUT side : 5 times longer than the bore diameter
	Cavitations are generated.	Keep the rated line pressure to prevent cavitations.
	There are bubbles contained in the liquid.	Do tubing not to have mixed bubbles.
	There are foreign substances caught by shedder body.	Remove the foreign substances.

Notify your nearest sales office for problems not listed above.

Notes on Warranty

The warranty runs for one year after the day when Surpass Industry products are delivered from Surpass factory in Japan. In case Surpass Industry should agree in writing that the defects in performance or material were caused by faulty design or workmanship of Surpass Industry, replacement products will be supplied free of charge. This warranty shall not be applied to any defects caused by misuse, alteration, neglectful treatment, and neglect of our recommendations or instructions.

In addition, we are not be liable to any direct or consequential loss, damage, and personal injury due to an unauthorized usage in combination with other products and an improper usage outside of the specifications. Our product warranty shall be limited to replacement of product.

Replacement with expense to the purchaser shall be applied to the followings:

- Any defective products caused by usage that is not described in the Instruction Manual.
- Any defective products caused by neglectful treatment.
- Any defective products caused by decomposition, alteration, and improper adjustment or repair.
- Any defects of products caused by acts of God including natural disaster or fires.
- Consumables and accessories.

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