Supersonic Flowmeter

Instruction Manual

for

SSL series

⚠ Caution

For your safety and proper use, please read this Instruction Manual with caution, prior to use.
Please always keep this Instruction Manual at hand for your quick reference when necessary.

TOFLO CORPORATION

157-R04

Contents

● Prior to use

⚠Warning

- Start operating after making sure that the kind of fluid to be used is fitted into the materials of the wetted part.
- Please be sure to read this Instruction Manual with caution and be familiar with the contents.
- Keep this Instruction manual at hand for your quick reference when necessary.
- Understand instructions about how to fulfill the original usage, and comply with their contents instructed in this Manual.
- Be sure to understand and comply with the contents of instructions stated in this Manual.

Strictly observe the Instructions stated above. Failure to do so may result in injury and accident.

＜Regarding this Instruction Manual ＞

- The contents of this Instruction Manual is subject to change due to improvement of performance and function without prior notice.
- It is prohibited from reprinting and making a copy of this Instruction either in its totality or partially.
- Please contact us, when you have lost the Instruction Manual.
- Every effort has been made in relating to the contents of this Instruction Manual, but if you found out any doubtful points and mistakes, or omission by any chance in this Instruction Manual, you are kindly requested to contact us at the nearest sales office

＜Where to contact ＞

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● Safety precaution

2-1 As to safety alert symbols

In order to use the products properly and also to prevent the persons in charge and other users from the harm or damages to the property, such as marks distinguished by **Danger**, **Warning** or **Caution** and so forth are used in this Instruction Manual.
The following safety alert symbols intend to signify the meaning as described below. Please read thoroughly those contents instructed with a good understanding.

⚠ **Danger**	This is the safety-alert symbol which indicates the overhanging dangers to the users which might be died or suffered from serious injury, if ignoring the symbol, and misusing the product.
⚠ **Warning**	This is the safety-alert symbol which indicates the potential for death or serious injury which might be caused, if ignoring the symbol, and misusing the product.
⚠ **Caution**	This is the safety-alert symbol which indicates that the potential for injury to the users might be caused, and also that only the material damage might be caused, if ignoring the symbols, and misusing the product.
!	This is the safety-alert symbol which indicates the most important points to notice and instructions in order to operate the products properly.

● Warning and instructions

Prior to using the product, please read the following warning instructions with caution, and comply with them.

<Installation location>

⚠ **Warning**
● The supersonic flowmeter is not constructed with an explosion-proof specification. Do not use this supersonic flowmeter in hazardous areas that produces inflammable gases. Ignoring this may result in fire and explosion. ● The supersonic Flowmeter has been designed for indoor-use only. Do not use this product for outdoor use. Outdoor use may cause short circuit or unexpected accidents.

<piping and installation>

⚠ **Danger** **Be sure to comply !!**
● **When using the dangerous chemicals and solvent, be sure to don the chemical resistant protective clothing such as the protective glove, mask and suit) which cover your entire body. If belching up a liquid, it may cause a physical disability.**

⚠ Warning

- Before making up pipe, confirm the correct direction of flow by checking the arrowhead direction marked with "IN → OUT" on the side of flowmeter body.
  Wrongly making up pipe may result in personal injury due to fluid leakage caused by damage to the flowmeter body.
- Make up pipe so as not to exert any excessive forces on and apply any bending moment to the flowmeter. Otherwise an excessive forces and bending moment may result in leakage by the damage of flowmeter body, and may result in suffering from physical disability.
- When tightening the tube fitting, tighten it so as not to give any additional forces to the flowmeter body. In no event may the fowmeter body be tightened with holding on to the flowmeter body. In no event shall such tightening be avoided. If not, it may cause damage to the flowmeter.

< wiring >

⚠ Warning

- Wiring should be made after turning off power. If not, it may cause an electrical shock and ignition.
- Do not apply more voltage than specified ranges. If not, it may cause smoke or ignition.
- Do not impress the current and voltage more than capacity to the pulse output (Open collector output). If not, it may cause damage to the Supersonic flowmeter.

< Inspection and maintenance >

⚠ Danger **Be sure to comply !!**

- **When using the dangerous chemicals and solvent, be sure to don the chemical resistant protective clothing such as the protective glove, mask and suit) which cover your entire body. If belching up a liquid, it may cause a physical disability.**

⚠ Warning

- The pressure applied to the inside of the pipe should be dropped to the atmospheric pressure, when removing the flowmeter from the pipe which has been connected. If not, it may cause liqu belching up and a physical disability.

!	In case that if the strongly permeating liquid is used for this flowmeter body(PFA), it may be resulted in corrosion (Failure). If there may be fears of such cases, we request you to replace the flowmeter periodically.

1. General description on the product

The Supersonic Flowmeter is composed of PFA in all the wetted parts, and most suitable for the flow measurement of chemicals because of having no sealed part which may lead to leakage.

1-1 How it works

Under the stream of the vortex shedding body in which has been put in the stream occurs the regular pattern of vortices called Karman vortex alternately. If f is the karman vortex shedding frequency, d is the width of the vortex shedding body and v is the value of the velocity, the following equation will be formed , that is,

$$f = S t \cdot v / d$$

S t is a dimensionless number called the Strouhal Number, and assuming that in a certain range of Reynolds Number it is a constant based on the shapes of vortex shedding body, V is therefore determined by measuring the shedding frequency f and the volumetric flowrate can be obtained from the V.

The ultrasonic sensor is installed aft the back wash side of the vortex shedding body, which is comprised of a pair of the transmitting and receiving devices as shown in Fig. below. An ultrasonic wave is always transmitted to the liquid from the transmitter, the transmitted ultrasonic wave passing through the liquid is transmitted to the receiver at a regular interval.
As shown in the figure below, if Karman vortex occurs, which flows in the reverse direction from the ultrasonic wave transmitting direction, it takes long time for the ultrasonic wave to transmit the receiver acting on this flow.
Adversely it takes short for the ultrasonic wave to transmit, when the flow direction of Karman vortex is agreed with that of the ultrasonic wave. Assuming from that the time to transmit the ultrasonic wave varies in proportion to the vortex shedding frequency, the flowrate can be measured by means of detecting the variation of the time in which ultrasonic wave will transmit. Since the ultrasonic sensor is provided outside the tube passage of the flowmeter body, the flow measurement can be made in no contact with the measuring liquid, resistant to the effect on vibration, and the sensor system featuring a high sensitivity, etc..

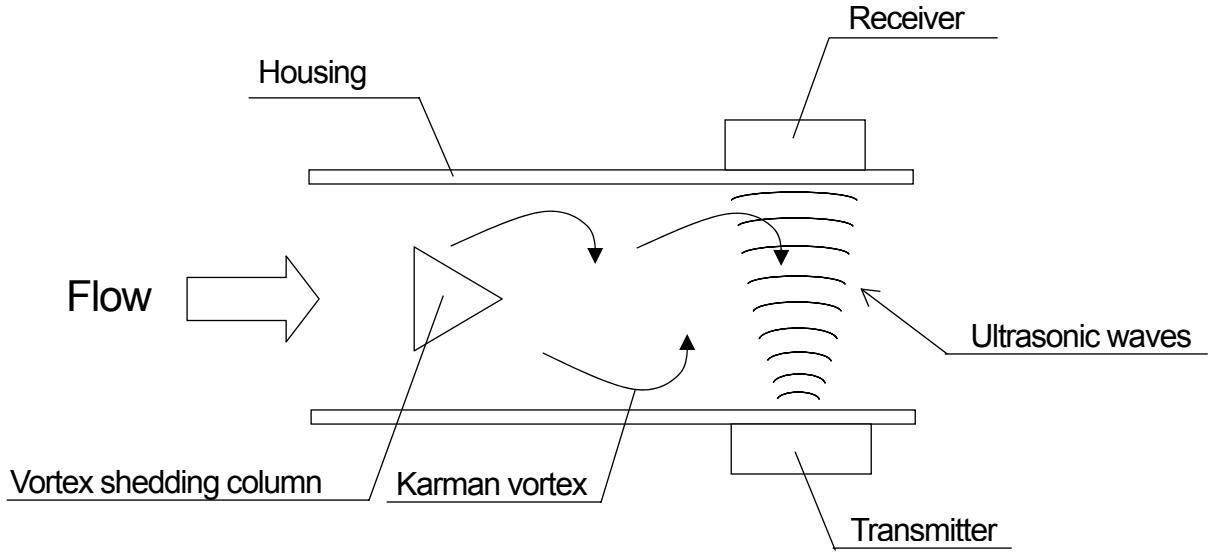


Diagram concerning what it works

1-2 Circuitry configuration

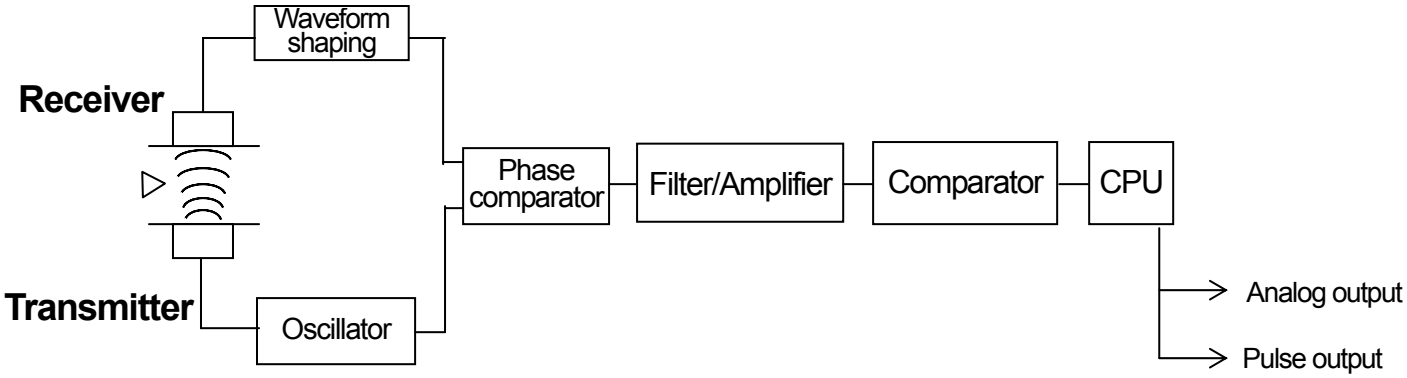


Fig. 2 Circuitry configuration

1-3 Specifications

⚠ Warning
● Be sure to use the Supersonic flowmeter within the flow ranges and the pressure ranges specified. If not, it may result in failure, damage or accident.

!	In case that if the strongly permeating liquid is used for this flowmeter body(PFA), it may be resulted in corrosion (Malfunction). If there is a fear of such cases, we recommend to replace the flowmeter periodically.

!	Do not use the Supersonic flowmeter for the slurry liquids or the liquids containing foreign matters. If not, it may result in performance decrement.

<A synoptical table of specifications>

	SSL-10	SSL-15
Applicable liquids	Liquids which will not corrode and permeate fluorocarbon resin	
Connecting tube diameter	Φ3/8" (Φ9.53xΦ6.35)	Φ1/2" (Φ12.7xΦ9.53)
Flow ranges (※①)	0.5 – 3.5 L/min (at 1x10^{-6}m^2/s)	2.5 – 16 L/min (at 1x10^{-6}m^2/s)
Operating liquid pressure (※②)	0.5MPa(G) at 25℃ at max.	
Operating liquid temperature	5 – 85℃	5 –85℃
Withstanding pressure	0.5MPa (at 25℃)	
Ambient operating humidity	5 – 80 % RH (Provided the condensation of humidity shall not be occurred.)	
Ambient operating humidity	5 – 80% RH (Non condensing)	
Ambient temperature	5 – 60℃	5 – 60℃
Flow accuracy (※③)	FS±2% (Fluid temperature 15℃ - 40℃) FS±5%	FS±2%
Power supply voltage	24VDC ±10%	
Power consumption	110mA and below	
Pulse output	NPN Open collector output	
Capacity	30VDC/80mA at max	
Pulse unit	10 mL/P	
Pulse width	Approx 5 m s	
Analog output	4 – 20 mADC	
Response time	Approx 2 s	
Load resistance	500Ωand below	
Installation direction	Horizontal, vertical and diagonal	
Material for wetted part	P F A	
Material for the case of main body	P P	

※① Regarding the flow ranges

Kinetic viscosity of liquids [x10^{-6}m^2/s]	1	2	3	4	5	6	7	Max flowrates [L/min]
Minimal flowrates on SSL – 15 [L/min]	2.5	5	7.5	10	12.5	15	–	16
Minimal flowrates on SSL – 10 [L/min]	0.5	1.0	1.5	2.0	2.5	3.0	–	3.5

Note) The minimal flowrate more than 2 [x10^{-6}m^2/s] of the kinetic viscosity indicates theoretical values, and yet may differ from the actual flowrate.

※ ② Regarding liquid pressure

Maximum possible operating pressure varies with liquid temperature. Calculate according to the following formula.

Maximum possible operating pressure = 0 . 5 x {1 − (T − 25) x 0 . 0 0 4 3) } (M P a)

T : Liquid temperature at the operating condition(°C)

※ ③ Regarding the flow accuracy

Due to the changes of the measuring liquid temperature some changes will appears in the inside diameter of the tube passage way because the measuring part of this flowmeter is made from PFA resin.
When the liquid temperature is used over 50°C and yet if the specified accuracy of flowrate is required, use it after compensating the flowmeter output in accordance with the following formula;

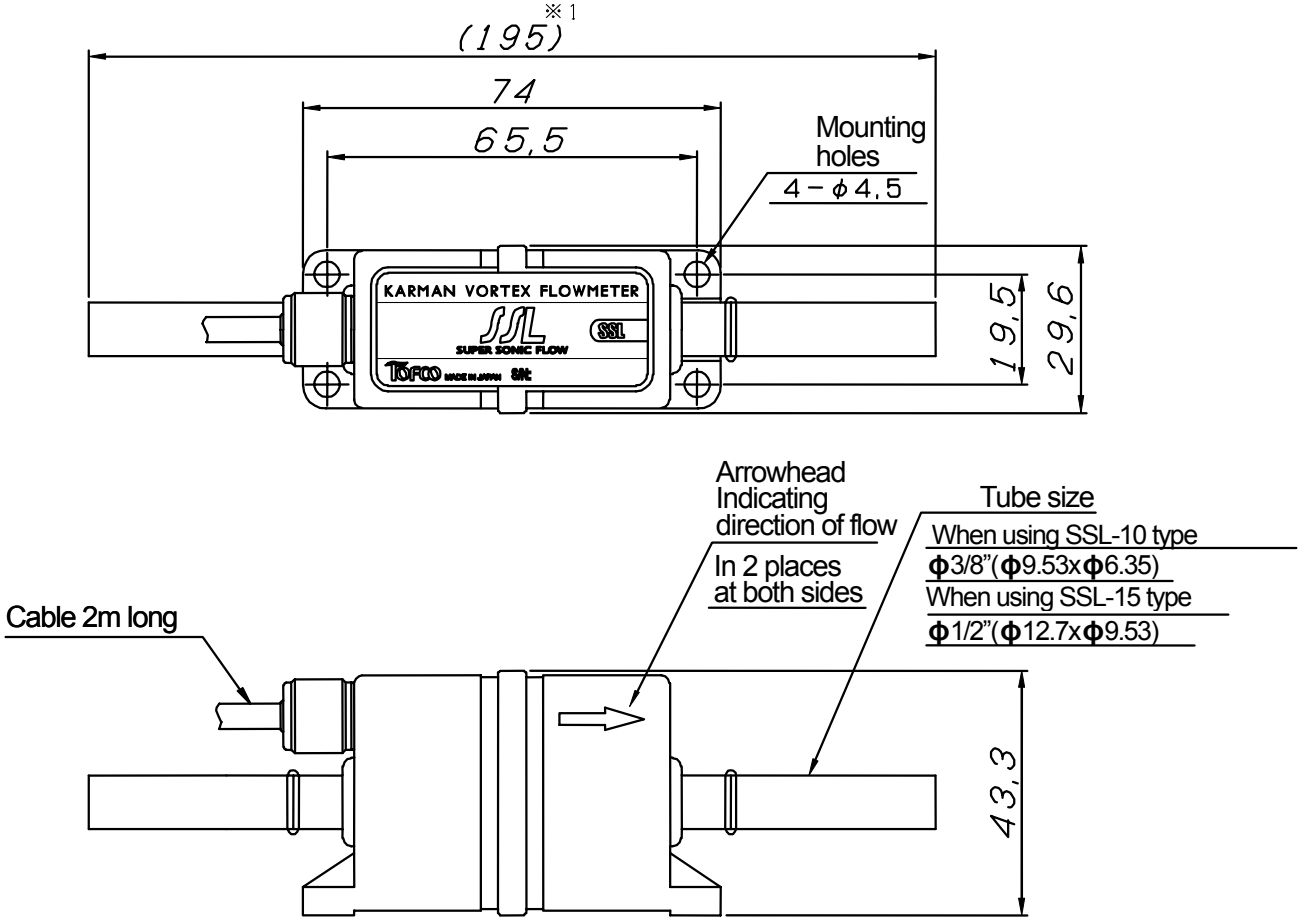
Actual flowrate at the operating conditions = a (1 – 4) x { 1 + (0 . 0 0 0 6 x (T – 2 5)) }

where are:

T : Liquid temperature at the operating conditions (°C)
I : Current output on the flowmeter (m A)
a : Coefficient
In case of SSL-15, • • • • • a = 1
In case of SSL-10, • • • • • a = 0 . 2 1 8 7 5

T: Liquid temperature in the operating condition(°C)

1 – 4 Outside dimensional drawing and each part names



※1 : The dimensional drawing indicates the dimensions for SSL-10, but it becomes (210) with respect to the SSL-15 type.

2. Handling

2-1 Delivery and unpacking

Carry the products preferably as it was in the same packed conditions as shipped from our factory to the installation location in order to prevent damaging during the transit.
Upon receipt of our product you ordered, unpack and check for any damage in appearance which may have occurred during the transit. Notify the dealer and us immediately of any damage to the product.

!	Do not give the impact shock to the products. If not, it may cause damage to the main body.

2-2 Storage

Store the Ultrasonic flowmeter in the location where is satisfied with the following condition, when storing them.

- In the locations where are rain and water will not splash.
- In the locations where vibration and shock will not occur.
- In the locations where the temperature is between 50℃ and 60 ℃ and the humidity is between 5 % and 80 % (Provided that condensation of humidity will not occur.)
- In the location where dust will not produce.
- In the location where is not subjected to direct sunlight.

3. Installation

3-1 Installation location

The installation location should be determined in considering with the following items in order to use the flowmeters over the years, to assure the flow accuracy and yet to facilitate the routine maintenance check and the easy operation.

⚠Warning

- Supersonic flowmeter is non-explosion proof. Do not use this Supersonic flowmeter in hazardous areas that produces inflammable gasses. Ignoring this may result in fire and explosion.
- Supersonic flowmeter is designed only for indoor use. Do not use this product for outdoor use. If not, it may cause short circuit or unexpected accidents.

① Install the Supersonic flowmeter to the location where is not to splash such as waters directly to the main body. If not, it may result in failure.
② The gas-liquid biphasic flow and the flow containing bubbles can cause it to disable the flow measurement.
③ Install the Supersonic flowmeter so as not to flow the bubbles into inside the flowmeter and not to remain them to be stopped flowing.
④ Do not install such as heat exchanger in the vicinity of the Supersonic flowmeter in the upstream. It may disable the flowmeter for the flow measurement due to the abrupt change of liquid temperature. Keep away from such heat exchanger and reduce the temperature change as smaller as possible.
⑤ Do not install the Supersonic flowmeter to the locations where are high in the temperature gradient and the temperature changes.
⑥ If pulsation such as bellows pump is so high, it may cause an error. Make it to reduce the pulsation as small as possible.
⑦ Install the Supersonic flowmeter to the location where is easily to check and make up pipe.
⑧ Wiring should be made avoiding the noise source such as high capacity motor, electrical transformer, noise source of the power supply for power line and the high voltage and current. If not, it may cause malfunction due to the induction.
⑨ Install the Supersonic flowmeter so as not to give the vibration and shock. If not, it can cause it to read inaccurately.

3-2 Piping and installation

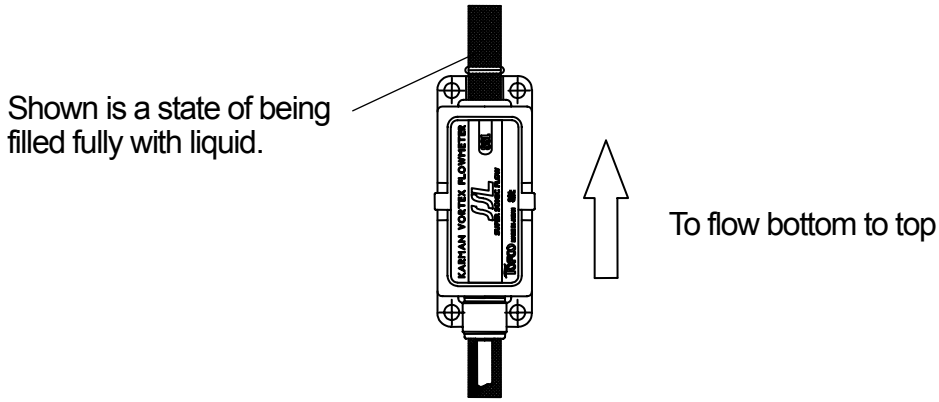
⚠ Warning

- Correctly make up pipe along the arrowhead direction of the flow indicated on the side of the flowmeter main body. Incorrect piping may result in personal injury due to fluid leakage caused by damage of the flowmeter body.
- Before installing, align the axes of tube on both sides so as not to exert any excessive forces on the flowmeter. Axial misalignment may result in personal injury due to fluid leakage caused by damage of flowmeter body.
- Use the designated sized tube to be connected. If using any tube in size other than the designated size, it may result in personal injury due to fluid leakage caused by the damage of the flowmeter body.

!	● If the inside diameter of the pipe made up to the both sides is smaller than that of Supersonic flowmeter, it may cause an error. ● When connecting tube fittings, do the work in accordance with the catalog and instruction manual attached by the manufacturer to be used. ● When using, be sure to air bleeding inside the pipe. If air exists, correct flow indication cannot be displayed. ● If air bubbles have been get mixed inside the fluid, they remain in the shedding part of the Karman vortex inside the main body, and it can cause it to read inaccurately.

① For installing posture it is possible to install in any posture such as vertically, horizontally and slantwise. Provided in any cases the pipe should always be filled fully with the liquid.

For installation postures we recommend to make up pipe vertically. Installing the Supersonic flowmeter so as to allow liquid to flow from bottom to the top enables to avoid flowing in the gas-liquid biphasic laminar flow.



② Provide the straight pipe to the back and front of flowmeter. The length of the straight pipe at the upstream should be more than seven times the inside diameter, and for the length of the straight pipe at the downstream should be more than five times the inside diameter.

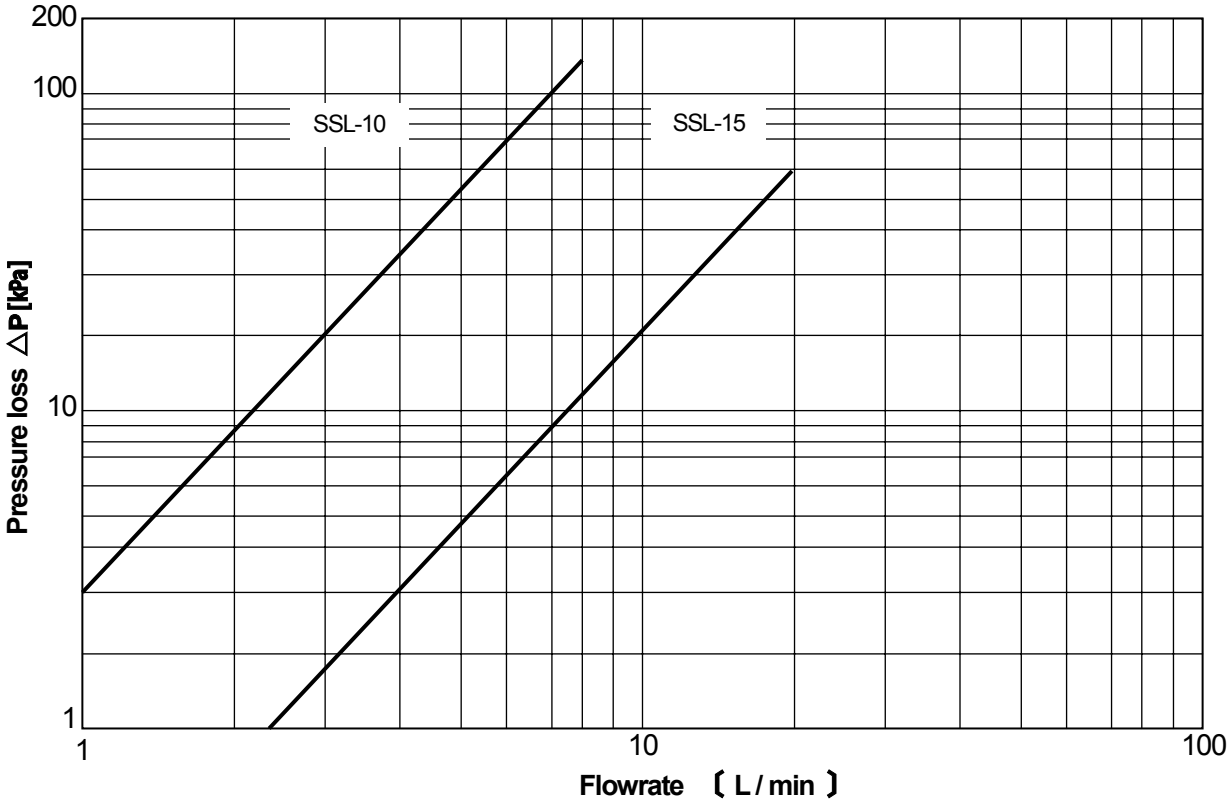
3 - 3 Regarding the pressure at downstream

In order to prevent the cavitation occurrence the pressure at the downstream should be more than that which has been obtained from the following formula.

$$Pd : 2.7 \quad \triangle P + 1.3 \quad P_0$$

Pd ： Pressure at downstream [kPa abs]
△ P： Pressure loss [kPa]
P_0 ： Vapor pressure of liquid [kPa abs]

＜ Pressure loss＞



※④ Regarding the cavitation

A phenomenon is one in which liquid evaporates and produces air bubbles, when the pressure of liquid decreases under the saturated vapor pressure.

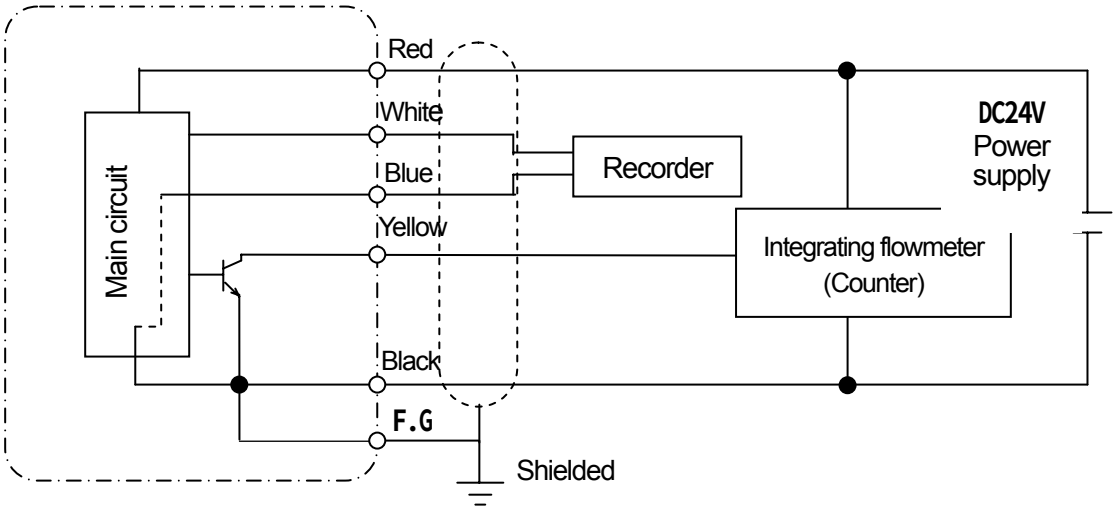
4. How to wire up

4 - 1 Output stage circuit and how to wire up

Wiring should be correctly done in reference to the output stage circuitry diagram, when wiring up.

⚠Warning

- Wiring should not be carried out, until after the power has been turned off.
- Do not apply any voltage more than specified ranges. If not, it may cause smoke or ignition.
- Do not impress any voltage and current more than the capacity to the pulse output (Open collector output). If not, it may cause damage.



※ Black and blue cables and F. G are connected within the circuit.

Signal names	Wire colors
Power supply at 24VDC	Red
Power supply at 0V	Black
Output at 4-20mA(+)	White
Output at 4-20mA(−)	Blue
Pulse output(+)	Yellow

Output staged circuit diagram

4 – 2 Connection to power supply

Connect to the power supply at 24VDC. In order to obtain the defined accuracy keep a preheating time for 20 minutes after turning on power.

4 – 3 Analog output

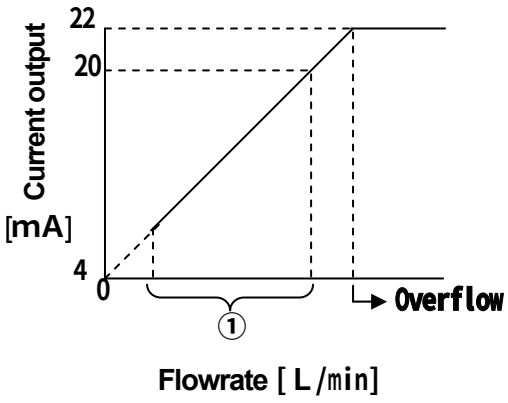
Connect a load resistance between (+) and (−) in the output of 4-20mA. The load resistance shall be 500Ω and under.

4 - 4 Pulse outpiut

The pulse output is a NPN open collector output.
Connect a load resistance between pulse output (+) and power supply (24VDC). The following is an example of the load resistance.

For example)	Load resistance	1 k Ω	1 W
		10K Ω	1/4 W

4 – 5 Analog output for the flowrate



- The graph showing the area occupied by ① is proportionate to the increase of flowrate.
  (Flow ranges vary according to the types.)

<Flow ranges>

SSL−10	0.5〜3.5 L／min
SSL−15	2.5 〜16 L／min

- It outputs the current at the time of max flowrate, when it is at the time of overflow(showing “O F L O”). (The ranges vary according to the types.)

<Overflow ranges>

SSL−10	4 L／min and over
SSL−15	18 L／min and over

5. Inspection and maintenance

5-1 Precaution for inspection and maintenance

⚠ Danger	Be sure to comply !!

- **When using the dangerous chemicals and solvent, be sure to don the chemical resistant protective clothing such as the protective glove, mask and suit) which cover your entire body. If belching up a liquid, it may cause a physical disability.**
- **When removing the flowmeter installed to the pipe, do it after making the pressure inside the pipe atmospheric pressure. Belching up of liquid may cause physical disability.**
- **When replacing parts or doing the maintenance work , make sure that power supply has been turned off, that liquid has been stopped running within the pipe and that the pressure inside the pipe has been reduced to atmospheric pressure. Failure to do so may be resulted in leakage and a physical disability.**

!	In case that if the Ultrasonic flowmeter (PFA) is used for the strongly permeating liquid, it may be sometimes resulted in corroding the product (Malfunction). If there is a fear of such cases, we recommend to replace the flowmeter periodically.

5-2 Trouble shooting

The Ultrasonic flowmeter has been carefully adjusted at the factory shipment and is warranted to be free from defects in workmanship and materials under the normal use. If a trouble happened by any chance, when setting up or during the operation. check the defective product in accordance with the table of trouble shooting as follows. Also feel free to contact us, if you have any difficulties to understand the trouble.

Phenomena	Points to check	Measures to be taken
Proper output not come out. (Output does not come out, regardless liquid is flowing.)	• Has a correct connection been made?	• To connect correctly(See p. 19)
	• Is power supply voltage used within specification ?	• To use power supply specified within specification(See p.8)
	• Is the value of the load resistance correct ?	• To make load resistance 500Ω and below.
	• Is the pipe line filled fully with liquid ?	• To improve the pipe line to fill fully with liquid.
	• Is flowrate within measurable range ?	• To confirm specification requirements.
Improper output comes out. (Output comes out, regardless liquid does not flow.)	• Is the pipe line filled fully with liquid ?	• To make load resistance 500Ω and below.
	• Is liquid within the pipe fluctuated greatly by pulse pressure(such as pumps) ?	• To let liquid within the pipe not fluctuate greatly.
A large amount of output error occurs.	• Is power supply voltage used within specification ?	• To use power supply specified within specification(See p.8)
	• Is the value of the load resistance correct ?	• To make load resistance 500Ω and below.
	• Does such noise sources exist outside as power line or electromagnetic generator ?	• To keep it away from noise sources.
	• Are such factors which disturb the flow as a valve located(upstream) right in front of flowmeter existed ?	• To change the installation location of flowmeter.(To ensure a specified length of straight pipe). At upstream: More than seven times the inside diameter. At downstream: More than five times the inside diameter.
	• Hasn't cavitation occurred ?	• To secure a specified line pressure in order not to cause cavitation. (See p.18)
	• Are air bubbles get mixed into liquid ?	• To make it not to get mixed air bubbles.
	• Are foreign matters entangled with vortex shedding body ?	• To get rid of foreign matters entangled.

6. Warranty

The products manufactured by TOFLO CORPORATION are warranted to replace the defective product with the same product for one year commencing from the date delivered to you, if TOFLO CORPORATION has approved in writing that the defect is caused by our designing and manufacturing with respect to the defects in performance and the material. It shall not be covered by the warranty that the product is used wrongly , modified, and has been used in no accordance with instructions for use specified in this Instruction Manual, and also used in no compliance with the advices and instructions done by TOFLO CORPORATION.
When using the product manufactured by TOFLO CORPORATION as a single unit or in conjunction with other product made by other manufacturer, we are not liable for any compensation for damage which arises as a result of direct or indirect loss and damage, personal injury and the damage including the others, caused by the use conditions where the product specifications are exceeded. The compensation is limited to the replacement of product based on the warranty by TOFLO CORPORATION.

The repair or replacement shall be done at your cost, if the defect arises from the following situation.

- Failure and damage caused by any applications other than the instructions as stated in the instruction manual.
- Failure and damage caused by carelessness for usage
- Failure and damage caused by overhaul, modification, inadequate adjustment and repair.
- Failure and damage caused by natural disaster, fire and any other for force majeure
- Replacement of consumable parts and accessories.

13. Where to contact

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