About Karman Vortex Flow Meter / Ultrasonic Flow Meter

Principle of the Karman vortex flow meter

Theodore Von Karman, a hydrodynamicist, revealed theoretically in 1911 that when an object was placed in a flow of fluid, a regular vortex was alternately generated on the downstream side. This vortex row is called a Karman vortex (row) in honor of his name. The Karman vortex flow meter is based on the measurement principle of the Karman vortex.

As shown in **Fig. 1**, if a vortex generator is placed in a flow, the Karman vortex row is generated on the downstream side. At this time, suppose the vortex row's frequency is f, its flow velocity is v, and the width of the vortex generator is d, there is a relationship of

$$f = St \cdot \frac{v}{d} \qquad (1)$$

The Karman vortex row is detected as a vortex frequency by a piezoelectric element disposed behind the vortex generator. Since this vortex frequency is proportional to the flow velocity in a certain range of Reynolds number, the flow velocity and flow rate can be measured by measuring the vortex frequency. The Strouhal number St is a dimensionless number decided by the shape and dimensions of the vortex generator. By selecting the shape and dimensions appropriately, it becomes a constant value over a wide range of Reynolds number.

Fig. 2 shows the relations between the Reynolds number and the Strouhal number. If the Strouhal number is understood beforehand by Expression (1), the flow rate can be measured by measuring the vortex frequency. Some of **KOFLOC's** Karman vortex flow meters have a temperature sensor incorporated to correct the temperature (Reynolds correction) to the non-linear region of the Reynolds number and Strouhal number.

Fig. 2. Reynolds number vs. Strouhal number

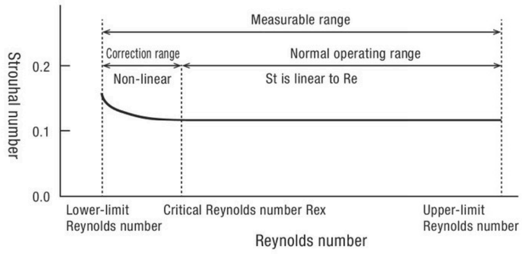
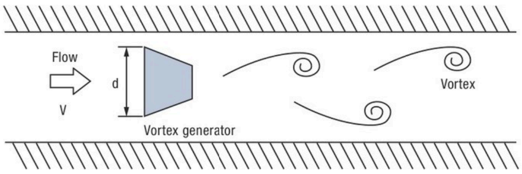


Fig. 1. Karman vortex row



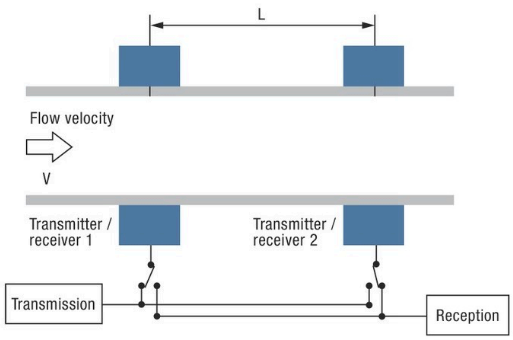
Principle of the ultrasonic flow meter

Ultrasonic waves are elastic vibration waves (sound waves) with high frequency unhearable to humans. They are generally defined as 20kHz or higher acoustic vibrations.

Since the ultrasonic waves are acoustic vibrations, a medium such as a gas or a liquid is required to convey them. The ultrasonic waves are suitable for the flow meters which do not require the signals to reach far away like communication devices, because their propagation velocity is slower and their wavelength is shorter than electric waves (electromagnetic waves) using similar media.

There are several measurement methods for ultrasonic flow meters such as ultrasonic propagation time difference method, ultrasonic reciprocal propagation time method (frequency difference method) and Doppler method. Our method, "ultrasonic propagation time difference method," has ultrasonic transmitters / receivers attached to the piping on the upstream and downstream sides as shown in **Fig. 3**, alternately transmitting and receiving ultrasonic waves from the transmitter / receiver 1 to transmitter / receiver 2 and vice versa. The flow velocity is calculated from the difference in the alternately received ultrasonic propagation time, and the flow rate can be obtained by multiplying the cross-sectional area of the flow path by a correction factor.

Fig. 3. Principle of ultrasonic propagation time difference method



Liquid Vortex Flow Meter with Temperature Correction

MODEL FML-300 SERIES NEW

Gas Liquid Controller Meter

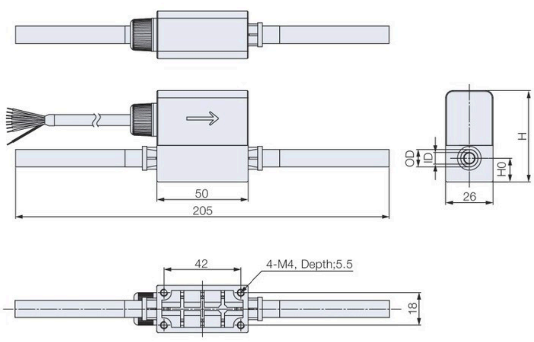
Applicable fluids	Liquid Water, pure water, chemical solution
Max. flow rate	Liquid 2.5 to 250L/min
Accuracy	±2 to 3%F.S.

CE

- Capable of measuring the fluid temperature by an on-board temperature sensor and correcting the flow rate to reduce the accuracy error caused by liquid temperature change
- New PFA for wetted parts (without O-ring)
- Compact design
- Available for wide range of flow rate (from 0.3 - 2.5L/min to 25 - 250L/min)
- Equivalent to IP65 protection rating

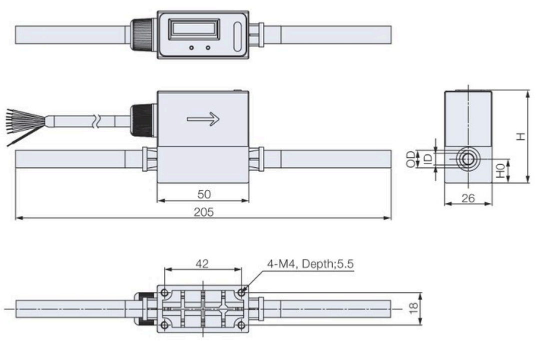
Dimensions

FML-301 to FML-305 without display



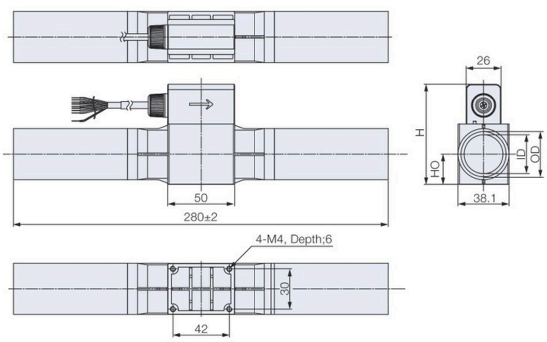
MODEL	Connection tube size	Dimensions (mm)			
		OD	ID	H	H0
FML-301-N	3/8 inch	9.52	6.35	50.0	13.0
FML-302-N	3/8 inch	9.52	6.35	50.0	13.0
FML-303-N	1/2 inch	12.70	9.52	50.0	13.0
FML-304-N	3/4 inch	19.05	15.87	52.0	12.0
FML-305-N	1 inch	25.40	20.20	60.7	15.7

FML-301 to FML-305 with display



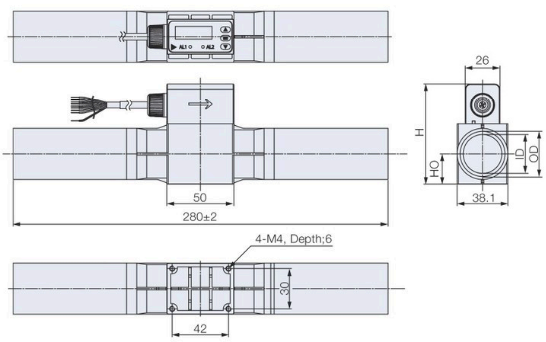
MODEL	Connection tube size	Dimensions (mm)			
		OD	ID	H	H0
FML-301-D	3/8 inch	9.52	6.35	50.5	13.0
FML-302-D	3/8 inch	9.52	6.35	50.5	13.0
FML-303-D	1/2 inch	12.70	9.52	50.5	13.0
FML-304-D	3/4 inch	19.05	15.87	52.5	12.0
FML-305-D	1 inch	25.40	20.20	61.2	15.7

FML-306 without display



MODEL	Connection tube size	Dimensions (mm)			
		OD	ID	H	H0
FML-306-N	1(1/2) inch	38.1	33.7	75.0	22.5

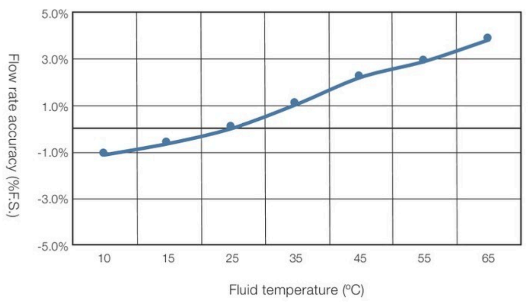
FML-306 with display



MODEL	Connection tube size	Dimensions (mm)			
		OD	ID	H	H0
FML-306-D	1(1/2) inch	38.1	33.7	75.5	22.5

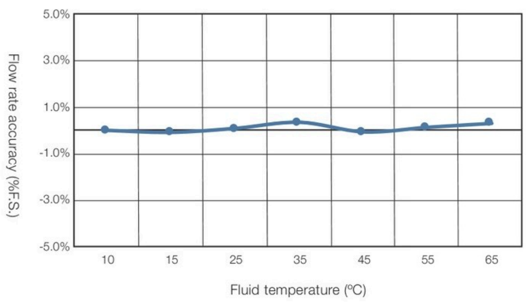
FML-300: Comparison of accuracy change between with and without temperature correction

Product used: FML-303, deviation from 25ºC data (%F.S.)



Accuracy change by the fluid temperature at 16L/min. (without temperature correction)

Product used: FML-303, deviation from 25ºC data (%F.S.)



Accuracy change by the fluid temperature at 16L/min. (with temperature correction)

Standard Specifications

MODEL			FML-301	FML-302	FML-303	FML-304	FML-305	FML-306
Connection			3/8" tube end		1/2" tube end	3/4" tube end	1" tube end	1 (1/2)" tube end
Flow range			0.3 to 2.5L/min	0.4 to 4.0L/min	2.0 to 16L/min	5.0 to 50L/min	10 to 100L/min	25 to 250L/min
Fluid			Water, pure water, chemical solution					
Accuracy			±2%F.S. (25ºC)				±3%F.S. (25ºC)	
Temperature accuracy			±2ºC ±0.15×ΔTºC (ΔT: Ambient temperature - Fluid temperature)					
Repeatability			±0.5%F.S.					
Fluid temperature			0ºC to 90ºC (no freezing and boiling)					
Accuracy guarantee temperature			Fluid temperature: 15ºC to 60ºC					
Max. working pressure			1MPa(G) @25ºC			0.75MPa(G) @25ºC	0.65MPa(G) @25ºC	
Allowable ambient temperature			0ºC to 50ºC (no freezing)					
Allowable ambient humidity			95%RH or less (no dew condensation)					
Storage temperature			-10ºC to 70ºC (no freezing)					
Protective structure			Equivalent to IP65 (drip-proof, dust-proof)					
Materials of parts in contact with liquid			New PFA					
Output	Flow rate output	Without display	Current: 4 to 20mA, Allowable load resistance: 250Ω to 500Ω at 24VDC input, 250Ω or less at 12VDC input or pulse output (1kHz at F.S. Duty: 50%, NPN open collector output: Max. 30VDC / 80mA)					
		With display	Current: 4 to 20mA, Allowable load resistance: 250Ω to 500Ω at 24VDC input, 250Ω or less at 12VDC input or pulse output (1kHz at F.S. Duty: 50%, NPN open collector output: Max. 30VDC / 80mA) Integrated flow output: Pulse output					
	Temperature output (only when water runs)	Without display	1-5VDC (0ºC to 100ºC), External load resistance: 250kΩ or more					
		With display	Current: 4 to 20mA (0ºC to 100 ºC), Allowable load resistance: 250Ω to 500Ω at 24VDC input, 250Ω or less at 12VDC input					
	Alarm output		Alarm contacts: 2points NPN open collector output, Max. 30VDC / 80mA (only with display)					
Digital communication			RS485 (MODBUS protocol, RTU mode) (only with display)					
Power supply			12 to 24VDC ±10%, Current consumption (80mA or less without display, 140mA or less with display)					
Cable length			3m terminated, preliminary soldering					
Weight		Without display	160g or less			175g or less	200g or less	360g or less
		With display	165g or less			180g or less	205g or less	365g or less

Ordering