Process Instrumentation

FLOW SWITCH 600 Series
Velocity Flow Sensor

Instruction Manual

Ultrasonic Velocity Sensor using Doppler Technology

Model: FS-600

Manual Release Date: November, 2009
ECHO Process Instrumentation, Inc.®

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Thank you for your purchase of the Flow Switch 600. We appreciate your business and wish to help you with your installation and start-up needs.

Please call us for any questions or needs.

ECHO TEAM

ECHO Process Instrumentation, Inc.

Mail to: PO Box 800

Ship to: 70 6th Ave.

Shalimar, FL 32579 USA

Phone: 850.609.1300 - Fax: 850.651.4777

Email: info@echopi.com - Website: www.echopi.com

Instruction Manual: FS-600

1.0 Introduction

The ECHO FS-600 is a clamp-on noninvasive Doppler flow sensor that measures liquid velocity in closed pipes or conduits.

1.1 Principle of operation

The Doppler flowmeter utilizes the well known Doppler Effect, this is named after Christian Doppler, who documented the effect in 1842. In general terms it is the change in frequency and wavelength of a wave as perceived by an observer moving relative to the source of the waves. The ECHO FS-600 flow meter has an array of piezoelectric crystals, part of the array transmits a beam of high frequency ultrasonic pressure waves so as to form a fixed cross angle with the pipe axis. As the beam travels into the non-homogeneous fluid, some energy is scattered back by solid particles or gas bubbles entrained in the flow. The relative motion of these discontinuities produces a frequency shift of the scattered wave, which is received and analysed by the ultrasonic flow meter. The different frequency is known as the Doppler shift which is linearly proportional to the fluid velocity. As the internal cross sectional area of the pipe is measured so the volumetric flow rate is easily calculated.

Doppler flow meters are used for slurries and liquids with bubbles and particulates. Transit time flow meters are used for clean fluids but can work with bubbles or particulates up to about 2-3 %. Then the Doppler transducer should be used. The exact percentage depends on the particular application.

1.2 Options

- Display unit battery DC or mains supply please contact ECHO to discuss your requirements.
- Portable small pipe support guide rail.
- Fixed small pipe support guide rail.
- Pipe mounting straps.
- Pipe mounting bands.
- Silicone ultrasonic coupling compound.

1.3 Instrument connections

Wire	**Connection**
Screen	Ground
Red	+15V or + 24V See Unit label or delivery note for details.
Green	Rate output (Pulse Output)
Black	0V (Common)
White	V m/s (Analog Voltage Output)

1.4 Selection of a measuring point

To perform a reliable and accurate measurement the point of measurement must be selected carefully. To ensure this, the application must have a pipe and fluid that is sonically conductive and a fully developed flow profile (most standard pipe materials and fluids with particulates or entrained gases). Ensure the point on the pipe where the sensors are positioned is always filled completely with no deposit material accumulate in the pipe at the measuring point.

The Doppler transducer is more sensitive to sensor position than the transit time sensor set and it may be necessary to make a number of measurements and choose the average result position for best accuracy.

Flow profile position guidelines:

Elbows, valves, pumps, T-sections, reducers, diffusers, and other pipefittings all cause flow profile distortion. As with all single beam ultrasonic flow meters it is important to have an axi – symmetrical shape flow profile.

The FS-600 will still give accurate results even under non-ideal measuring conditions. Follow the guidelines below to ensure best performance.

Horizontal pipe: avoid mounting the transducers on the top or the bottom of the pipe as solid particles are deposited on the bottom of the pipe and gas pockets can develop at the top About 45 degrees from the vertical is usually a good place see figure:

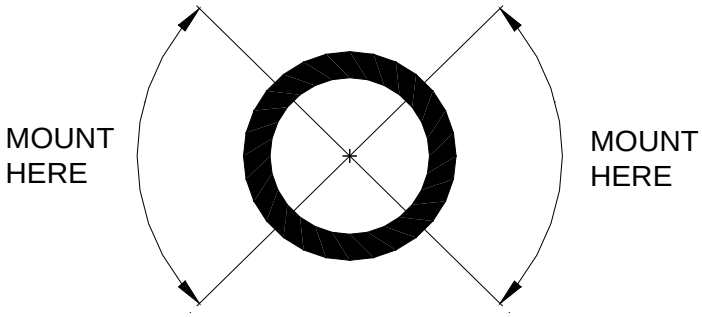

Figure 4

Vertical Pipe: Choose a site where the liquid flow is up this will help ensure the pipe is always completely filled.

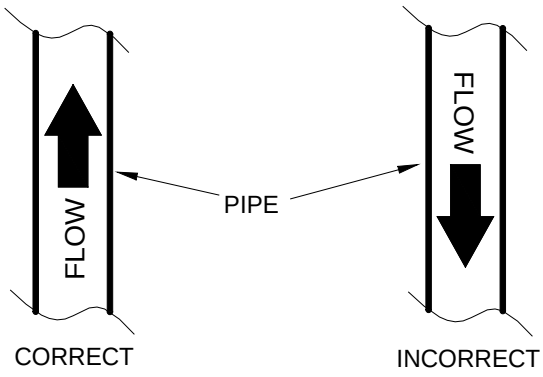

Figure 5

In the following table recommendations for straight inlet pipe lengths are given for common types of **up stream flow disturbance**, normally 10 diameters will give acceptable results.

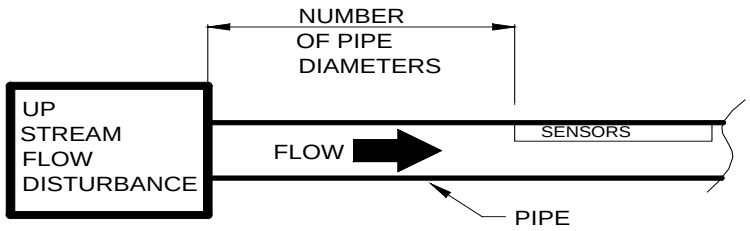

Figure 6

Disturbance source UP Stream to measurement	**Pipe diameters to sensor position (recommended, minimum is 10)**
Valve non full bore or butterfly type	40
Fully open Ball valve	10
90^{o} elbow	10
2 90^{o} elbows in one plane	30
2 90^{o} elbows in different planes	40
T connector	50
Expander	30
Reducer	10
Pump	50

In the following table recommendations for straight outlet pipe lengths are given for common types of **down stream flow disturbance**, normally 10 diameters will give acceptable results.

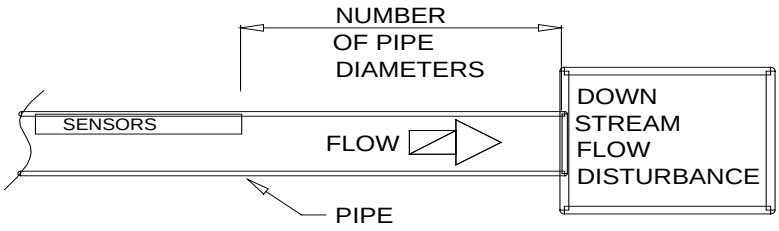

Figure 7

Disturbance source DOWN Stream to measurement	**Pipe diameters to sensor position (recommended, minimum is 5)**
Valve non full bore or butterfly type	10
Fully open Ball valve	10
90^{o} elbow	10
2 90^{o} elbows in one plane	10
2 90^{o} elbows in different planes	10
T connector	10
Expander	10
Reducer	10
Pump	50

A number of test readings should be made in non-ideal conditions to obtain an average flow velocity.

1.5 Application of ultrasonic gel – VERY IMPORTANT and REQUIRED

Ensure pipe walls are clean and free from loose paint and rust before attaching the sensor with the acoustical couplant gel.

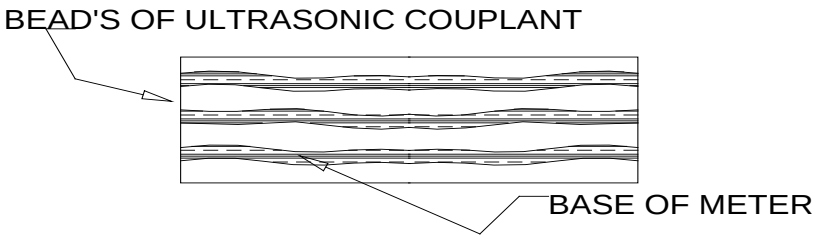

Figure 8a Doppler sensor

2.0 Outputs

2.1 Voltage Output (see delivery note for custom scaling)

If using a 0- 20ft/s output device. The voltage value is identical to the flow velocity.

1 Volt = 4 ft/s

If using a 0-10m/s output device the output must be scaled.

1 volt = 1.667 m/s

2.2 Rate Output

If using the pulse Rate output.

The Pulses should be averaged over 1 to 3 seconds and divided by the K factor supplied with the Flow meter.

Average Pulse count per second / Meters K Factor = flow rate in m/s

$$\frac{AveragePulseCount}{KFactor} = FlowRate$$

Where:

Average Pulse Count = Average pulse count per second
FlowRate = Flow rate in m/s
K Factor = K factor supplied with meter = 310

Example:

If in 2 seconds 760 pulse edges are counted and the meters K factor 310 has been supplied, then

$$\text{Average Pulse count} = \frac{760}{2} = 380$$

$$\frac{380}{310} = 1.23 m/s$$

2.3 Velocity to volumetric flow rate conversion

Having positioned the Sensor to give an average flow velocity, the volumetric flow rate can be calculated by scaling the Velocity reading using the following formula:

$$F = VxCxD^2$$

Where: F = Volumetric flow Rate
V = Velocity in m/s
D = Internal diameter pf pipe in cm
C = A constant
4.71 for l/min
1.04 for GPM
1.25 for US GPM
0.283 for M^3/hour
0.00471 for M^3/min

2.4 Signal strength (if fitted)

0 to 5 volts

No signal above 2 volts.
Ok signal 1.5 volts to 2 volts.
Good signal less than 1.5 volts.

3.0 Other information

3.1 Standard pipe dimension tables

PVC Pipe data Schedule 40 (Standard water pipe) A4.2.2-1

Nominal pipe size(mm)	Nominal Pipe Size(in)	Pipe OD (mm)	Pipe ID (mm)	Wall Thickness (mm)
19	0.75	26.67	20.57	3.1
25	1.0	33.4	26.24	3.6
32	1.3	42.16	34.65	3.8
38	1.5	48.26	40.44	3.9
51	2.0	60.33	52.04	4.1
64	2.5	73.03	62.1	5.5
76	3.0	88.9	77.27	5.8
102	4.0	114.3	101.55	6.4
152	6.0	168.28	153.19	7.5
203	8.0	219.08	201.75	8.7
254	10.0	273.05	253.39	9.8

MEDIUM WEIGHT (BLUE BAND) BS1387/1967

TUBE NOMINAL BORE		OUTSIDE DIAMETER MAX.		WALL THICKNESS MIN.			
in.	**mm**	**in.**	**mm**	**in.**	**mm**	**in.**	**mm**
1/8	6	0.411	10.4	0.386	9.8	0.080	2.00
1/4	8	0.547	13.9	0.522	13.3	0.092	2.35
3/8	10	0.685	17.4	0.660	16.8	0.092	2.35
1/2	15	0.856	21.7	0.831	21.1	0.104	2.65
3/4	20	1.072	27.2	1.047	26.6	0.104	2.65
1	25	1.346	34.2	1.316	33.4	0.128	3.25
1 1/4	32	1.687	42.9	1.657	42.1	0.128	3.25
1 1/2	40	1.919	48.8	1.889	48.0	0.124	3.25
2	50	2.394	60.8	2.354	59.8	0.144	3.65
2 1/2	65	3.014	76.6	2.969	75.4	0.144	3.65
3	80	3.524	89.5	3.469	88.1	0.160	4.05
4	100	4.524	114.9	4.459	113.3	0.176	4.50
5	125	5.534	140.6	5.459	138.7	0.192	4.85
6	150	6.539	166.1	6.459	164.1	0.192	4.85

HEAVY WEIGHT (RED BAND) BS1387/1967

TUBE NOMINAL BORE		OUTSIDE DIAMETER MAX.		WALL THICKNESS MIN.			
in.	**mm**	**in.**	**mm**	**in.**	**mm**	**in.**	**mm**
1/4	8	0.547	13.9	0.522	13.3	0.116	2.90
3/8	10	0.685	17.4	0.660	16.8	0.116	2.90
1/2	15	0.856	21.7	0.831	21.1	0.128	3.25
3/4	20	1.072	27.2	1.047	26.6	0.128	3.25
1	25	1.346	34.2	1.316	33.4	0.160	4.05
1 1/4	32	1.687	42.9	1.657	42.1	0.160	4.05
1 1/2	40	1.919	48.8	1.889	48.0	0.160	4.05
2	50	2.394	60.8	2.354	59.8	0.176	4.50
2 1/2	65	3.014	76.6	2.969	75.4	0.176	4.50
3	80	3.524	89.5	3.469	88.1	0.192	4.85
4	100	4.524	114.9	4.459	113.3	0.212	5.40
5	125	5.534	140.6	5.459	138.7	0.212	5.40
6	150	6.539	166.1	6.459	164.1	0.212	5.40

3.2 Conversion factors

To use this chart:
From X Multiplier = Into
Into X Reciprocal = From

From	Into	Multiplier	Reciprocal
Inches	Millimetres	25.4	0.0394
Inches	Meters	0.0254	39.37
Square inches	Square centimeters	6.4516	0.155
Square feet	Square meters	0.0929	10.764
Cubic inches	Cubic centimetres	16.387	0.061
Cubic inches	Litres	0.016	62.5
Cubic feet	Cubic meters	0.028	35.315
Cubic yards	Cubic meters	0.765	1.308
Imperial gallons	Litres	4.546	0.22

USA gallons	Litres	3.785	0.264
Imperial gallons	USA gallons	1.205	0.83
Feet per second	Meters per second	0.305	3.281

3.3 Specification

Protection Class : NEMA 4X (IP66)
Material : Stainless Steel and Plastic
Weight : 0.44 lb (200 g)
Dimensions : 4.4 x 1.4 x 1.3 inch (112 x 35 x 32 mm) without cable and cable connector
Display : none (Display Meter sold separately)
Temperature range (Operating): 21ºF to +167ºF (-6ºC to +75ºC)
Temperature range (Storage) : 14ºF to +122ºF (-10ºC to +50ºC)
Power supply :24V DC (40mA) V min 18V V max 34V
15V DC (40mA) V min 14.5V V max 15.5V (optional)
Outputs: Any 2 of the following
Voltage output 0 – 5 Volts indicating 0 to 20 ft/s (US Standard)
0 – 6 Volts indicating 0 to 6m/s (European Standard)
0 – 6 Volts indicating 0 to 10 m/s
TTL Pulse rate out put up to 5000 Hz calibrated value supplied with flowmeter*
Signal indicator output
Cable length: (termination bare ends)
2m (Standard length)
5m
Flow velocity range (output dependent): 0.05 m/sec to 10 m/sec
Pipe size range: ¾ inch to 300 inch (large pipes >12 inches should have more sensors to average velocities at different locations of the pipe circumference)
Linearity : ±0.2% of F.S.
Repeatability ±0.2% of F.S.
Accuracy: Typically better than ± 1% to ± 3% of F.S or ± 0.02 m/sec .
whichever is the greater, depending on application.

Notes: The linearity, repeatability and accuracy of the display system should be considered. The specification assumes turbulent fully developed flow profile and correct installation. Various pipe mounting hardware, display heads and power supplies are available please contact ECHO for details.
* Calibrated K factor value supplied. Pulses should be averaged over 1 to 3 seconds depending on application. If in doubt please contact us or use the voltage output.
ECHO Process Instrumentation, Inc. reserves the right to alter any specification without notification. Special application transducer design service is available please contact ECHO.

Limited Warranty and Disclaimer

ECHO Process Instrumentation, Inc. (aka ECHO) warrants to the end purchaser, for a period of one year from the date of shipment from our factory, that all new transmitters and transducers manufactured by it are free from defects in materials and workmanship. This warranty does not cover products that have been damaged due to normal use, misapplication, abuse, lack of maintenance, or improper installation. ECHO's obligation under this warranty is limited to the repair or replacement of a defective product, if the product is inspected by ECHO and found to be defective. Repair or replacement is at the discretion of ECHO. If the product is outside of the warranty period a purchase order must be received from the end purchaser before repair work will start. The product must be thoroughly cleaned and any process chemicals / contamination removed before it will be accepted for return. The purchaser must determine the applicability of the product for its desired use and assumes all risks in connection therewith. ECHO assumes no responsibility or liability for any omissions or errors in connection with the use of its products. ECHO will under no circumstances be liable for any incidental, consequential, contingent or special damages or loss to any person or property arising out of the failure of any product, component or accessory. All expressed or implied warranties, including the implied warranty of merchantability and the implied warranty of fitness for a particular purpose or application are expressly disclaimed and shall not apply to any products sold or services rendered by ECHO. The above warranty supersedes and is in lieu of all other warranties, either expressed or implied and all other obligations or liabilities. No agent or representative has any authority to alter the terms of this warranty in any way.

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