Precision Sterile Tubing Flowsensors

ME-PXL-Series for TS410 Modules

3PXL

9PXL

11PXL

20PXL

New Generation Extracorporeal Flowsensor for All Tubing Applications

Unique ultrasonic transit time technology measures volume flow with sensors specifically designed for accuracy on tubing.

- ✔ **Artificial Heart & VAD Performance**
- ✔ **Flow Phantoms & Circulatory Models**
- ✔ **Medical Device & Pump Engineering**
- ✔ **Manufacturing & Compliance Flow Testing**

Transonic PXL-Sterile Tubing Flowsensors clip on the outside of flexible laboratory tubing to measure most non-aerated liquids including saline and buffer solutions, blood, water and even diesel fuel. No physical contact is made with the fluid media. ME-PXL-Series flowsensors can be calibrated and programmed for up to 4 different fluid / temperature / tubing combinations. Sensor size is determined by outside diameter of the tubing.

TUBING SENSOR	TUBING SPECIFICATIONS						ACCURACY SPECIFICATIONS							
	TUBING ID		WALL THICKNESS		TUBING OD		BIDIRECTIONAL FLOW OUPUTS				ACCURACY[1]			ULTRA-SOUND Frequency MHz
Catalog #	inches	mm	inches	mm	inches	mm	Resolution[2] ml/min	1/4 Flow Scale 1 volt = ml/min	Normal Scale 1 volt = ml/min	Maximum Range 5 volt = L/min	Maximum Zero Offset ml/min	Absolute Accuracy %	Relative Accuracy %	
ME 2PXL	In sizes 2XL - 5XL ratio of tubing wall thickness to OD must not exceed 1:5 for PVC; 1:3 for silicone				1/8 - 5/32	3.1 - 4.0	0.5	50	200	1	± 3.4	± 10	± 4	3.6
3PXL					3/16 - 7/32	4.7 - 5.5	1	100	400	2	± 6.6	± 10	± 4	3.6
4PXL					1/4 - 9/32	6.3 - 7.7	1	100	400	2	± 6.6	± 10	± 4	2.4 - 3.6
5PXL					5/16 - 11/32	7.8 - 8.7	1	100	400	2	± 6.6	± 10	± 4	2.4 - 3.6
6PXL	1/4	6.4	1/16	1.6	3/8	9.5	2.5	250	1 L	5	± 20	± 10	± 4	2.4
7PXL	1/4	6.4	3/32	2.4	7/16	11.1	5	500	2 L	10	± 40	± 10	± 4	1.8
8PXL	3/8	9.5	1/16	1.6	1/2	12.7	5	500	2 L	10	± 40	± 10	± 4	1.8
9PXL	3/8	9.5	3/32	2.4	9/16	14.3	5	500	2 L	10	± 40	± 10	± 4	1.8
10PXL	1/2	12.7	1/16	1.6	5/8	15.9	10	1 L	4 L	20	± 80	± 10	± 4	1.2
11PXL	1/2	12.7	3/32	2.4	11/16	17.5	10	1 L	4 L	20	± 80	± 10	± 4	1.2
12PXL	1/2	12.7	1/8	3.2	3/4	19.0	10	1 L	4 L	20	± 80	± 10	± 4	1.2
14PXL	5/8	15.9	1/8	3.2	7/8	22.2	25	2.5 L	10 L	50	± 200	± 10	± 4	1.2
16PXL	3/4	19.0	1/8	3.2	1	25.4	25	2.5 L	10 L	50	± 200	± 10	± 4	1.2
20PXL	1	25.4	1/8	3.2	1 1/4	31.8	50	5 L	20 L	100	± 400	± 10	± 4	0.9

Calibration is dependent on tubing material, wall thickness, ultrasound velocity of liquid flowing through the tube, and temperature.

1a Absolute Accuracy is composed of zero stability, sensitivity and linearity errors. Stated values apply when flow rate is greater than 5% of maximum range and zero offset is nulled.

1b If the sensor is calibrated on-site for the tubing and liquid in use, absolute accuracy is further improved to the value listed as “Relative Accuracy.”

1c On-site calibration is recommended if the sensor is routinely used to measure flows less than 5% of the maximum range to account for non-linearities associated with flow profile.

2 Resolution represents the smallest detectable flow change at 0.1Hz filter (average flow output).

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PXL specs RL-21, Rev. B 11-03

Key to ··············· **Accurate Flow Measurements with Transit Time Ultrasound**

Tubing Flowsensor Acoustics

Uniform Conditions

The acoustic principles used to determine the most accurate coupling agent for Transonic perivascular flowprobes are identical to those which govern the design, tubing-specific manufacture and proper use of our Sterile Tubing Flowsensors. Just as the acoustic properties of the coupling agent can affect ultrasonic transit time measurement accuracy on blood vessels, the acoustic properties of tubing will also affect accuracy. This is why we request a sample of tubing for flowsensor calibration and shudder when our perivascular flowprobes are "jury-rigged" for flow measurements on tubing. (Only glove-thin latex and custom-thin polyurethane can be used predictably with perivascular probes).

■ "Squaring Off"

Tubing can attenuate, reflect, focus or delay ultrasound timing dependent upon tubing material, density, wall thickness and temperature. Since the most accurate transit time measurements are achieved under uniform acoustic conditions, the challenge in flowsensor design is to ensure conditions where the tubing affects ultrasound transmission in a uniform predictable way. Thus, Transonic sterile tubing flowsensors "square off" the tubing circumference to minimize focusing of the ultrasound and variable path lengths of the acoustic beam. The ultrasound transmit level and received signal timing window, and calibration factor are determined and set specifically for the tubing to be used. Even so, there are conditions of acoustic mismatch which affect accuracy. If anticipated, these can be minimized.

♦ Temperature

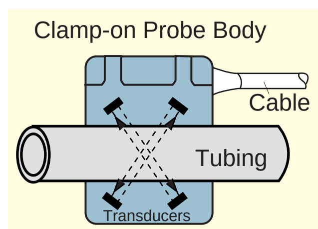
The most significant changes in uniformity of the acoustic beam occur at the sensor/tube border and the tube/liquid border. Fluctuations in temperature can affect the acoustic properties of these interfaces. To minimize these effects, we recommend that the sensor be allowed to equilibrate on the tube before measurement. Zero stability can be improved for measurement of circulating cold liquids by cooling the flowsensor as well. This can be as simple as insulating around the sensor and tube with foam or maintaining the tubing circuit and flowsensor in a controlled environmental chamber.

♦ Vaseline Seal

We recommend a thin smear of Vaseline to acoustically couple sterile tubing flowsensors with tubing. Water-based gels will dry out and can build up on the sensor to contribute their own layer of offset and error.

♦ Calibration

A discussion of accuracy in tubing flow measurement would not be complete without consideration of the acoustic properties of the liquid to be measured. Transonic Systems will custom calibrate the sensor for the specific liquid if a sample is provided. Changing the liquid (or temperature) will affect the calibration. Transonic Systems TS410, T110R Flowmeters allow the user to adjust the calibration gain on site; users of the T106/T206 should apply a correction factor to collected data. Adjustments to flow data should be made only after a comparison of flowmeter reading with timed collection.



Sterile Tubing Flowsensor
Ultrasonic transducer shell clamps onto tubing.

Ultrasound That Measures Volume Flow, Not Velocity

Using wide-beam illumination, transducers pass ultrasonic signals back and forth, alternately intersecting flowing blood in upstream and downstream directions. The transit time of the ultrasonic beam is decreased when traveling downstream with the blood flow and increased when traveling upstream against the flow. The difference between the integrated transit times is a measure of volume flow.

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Syringe Calibration

Tubing Flowsensors

Fluid

PXL, PXN and XL-Series sensor calibrations should be performed using the actual fluid. A fluid separator diaphragm (latex works well) may be used to keep the syringe clean.

Temperature

Sensors should be calibrated within ± 2C° of the specified fluid temperature since the acoustic velocity of the fluid and tubing properties change with temperature. Constant temperature is maintained through a heat exchanger.

Tubing for PXL-Series & XL-Series Sterile Tubing Flowsensors

Calibration should be performed on the specific tubing to be used since tubing material and type can change the probe calibration.

Method

Tubing flow can be calibrated using a syringe with two switch points, with a known volume between the points. This volume is calibrated by weight, by drawing water from a reservoir sitting on a calibrated scale. The reservoir is gravity fed with an overflow hole to maintain constant reservoir height and constant pressure. The switch outputs are then fed to a computer or voltmeter, which calculates the time between the switches. The average volume flow of the syringe (volume flow = volume/time) is then known. At the same time the flowmeter's pulsatile flow output voltage is fed to the computer (or monitor the flow reading) to average the flow over the above time. The slope of that point is then calculated using the following equation:

$$\text{Slope} = \frac{\text{Measured Flow (of flowsensor)}}{\text{Real Flow (of Syringe)}}$$

Calibration Routine

A standard calibration routine consists of the following. First a zero flow point is taken. The zero flow reading is subtracted from each Measured Flow point. Data is taken at intervals near the typical flow range and the corresponding slopes are averaged together. The gain adjustment is calculated by the following:

$$\text{Calibrated Adjustment} = \frac{100\%}{\text{Average Slope}}$$

Since the PXL, PXN and XL sensor designs have two transducer pairs, each pair of transducers must be separately calibrated at the factory. This corrects for any slight angle changes between piezoelectric crystals and effects of slight differences in the glue layers. Since the percent difference between the trnasducer pairs is linear, a new calibration (different tube or fluid) can be made using the calibration adjustment of the flow program. Consult your manual for details on using the menus.

Please contact Transonic Systems Inc. for more information.

Note:
The "average of slopes" line fit is used rather than "linear regression" because the line fit needs to be forced through the zero flow point.

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