
# Precision Inline Flowsensors

## ME-PXN-Series for TS410 Modules

1PXN

5PXN

10PXN

19PXN

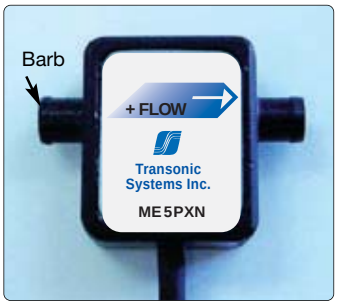
25PXN

### A Completely New Extracorporeal Inline Flowsensor for Enhanced Accuracy over a Wide Dynamic Range

**PXN Inline Flowsensors** splice into laboratory tubing and measure absolute volume flow of blood and other fluids. The new four-transducer sensor design offers precision accuracy for steady state and pulsatile flows from less than 1 ml/min to 100 liters/min. Flow range sensitivity is scaled to sensor size and flow is measured equally well across the full dynamic range of the sensor with little sensitivity to turbulence. The smooth round flow channel is easy to clean and and does not trap air bubbles that can degrade ultrasonic performance. Sizes 4PXN - 25PXN have barbed ultem tubing ends to mate easily with flexible laboratory tubing. Miniature sizes 1PXN - 3PXN sensors are fabricated around flexible Pebax tubing. The Pebax tubing may be cut to length for insertion into small tubing circuits or perfusion apparati. PXN-inline sensors can be calibrated and preprogrammed for up to four fluid/temperature combinations for highest accuracy performance in:

- ✔ **Isolated organ studies**
- ✔ **Flow phantoms**
- ✔ **All applications requiring maximum volume flow sensitivity**

ME 1PXN




ME 5PXN

| INLINE SENSOR | Physical Specifications | | | | | | Accuracy Specifications | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tubing ID | | Barb OD[1] | | Dimensions[2] | | Bidirectional Flow | | | | Accuracy | | | Ultra-sound |
| Catalog # | inches | mm | inches | mm | Total Length w/ tube ends mm | Case Length w/out ends mm | Resolution at 10 Hz ml/min | Low Flow 1 Volt = ml/min | Full Range 1 Volt = ml/min | Max Flow 5 Volt = ml/min | Maximum Zero Offset[3] ml/min | Absolute Accuracy % | Non-Linearity[4] % | Frequency MHz |
| ME1PXN | 3/64 | 1.2 | Pebax | | 100 | 6 | ± 0.02 | 5 | 20 | 100 | ± 0.4 | ± 8 | ± 2 | 9.6 |
| ME2PXN | 1/16 | 1.8 | Pebax | | 100 | 9 | ± 0.02 | 10 | 40 | 200 | ± 0.6 | ± 4 | ± 2 | 9.6 |
| ME3PXN | 3/32 | 2.4 | Pebax | | 100 | 12 | ± 0.05 | 25 | 100 | 500 | ± 1 | ± 4 | ± 2 | 7.2 |
| ME4PXN | 1/8 | 3.2 | 0.16 | 4.0 | 22 | 15 | ± 0.1 | 50 | 200 | 1 L | ± 2 | ± 4 | ± 2 | 4.8 |
| ME5PXN | 3/16 | 4.8 | 0.23 | 5.8 | 31 | 20 | ± 0.2 | 100 | 400 | 2 L | ± 4 | ± 4 | ± 2 | 3.6 |
| ME6PXN | 1/4 | 6.4 | 0.3 | 7.6 | 40 | 27 | ± 0.5 | 250 | 1 L | 5 L | ± 10 | ± 4 | ± 2 | 2.4 |
| ME10PXN | 3/8 | 9.5 | 0.44 | 11.1 | 57 | 39 | ± 1 | 500 | 2 L | 10 L | ± 20 | ± 4 | ± 2 | 1.8 |
| ME13PXN | 1/2 | 12.7 | 0.58 | 14.7 | 75 | 52 | ± 2 | 1 L | 4 L | 20 L | ± 40 | ± 4 | ± 2 | 1.2 |
| ME16PXN | 5/8 | 15.9 | 0.72 | 18.2 | 91 | 63 | ± 5 | 2.5 L | 10 L | 50 L | ± 70 | ± 4 | ± 2 | 1.2 |
| ME19PXN | 3/4 | 19.1 | 0.86 | 21.9 | 109 | 71 | ± 5 | 2.5 L | 10 L | 50 L | ± 100 | ± 4 | ± 2 | 0.9 |
| ME25PXN | 1 | 25.4 | 1.14 | 29.0 | 146 | 100 | ± 10 | 5 L | 20 L | 100L | ± 200 | ± 4 | ± 2 | 0.6 |

[1] Subject to minor modification
[2] Standard cable length: 1.8 meters.
[3] Zero offset can be eliminated by Zero Adjustment prior to measurement.
[4] Over 5% to 100% of Maximum Flow

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# Care Guidelines

# ME-PXN Inline Sensors

Transonic Systems' PXN Inline Flowsensors are designed for laboratory use. The smooth cylindrical flow channel will not trap air bubbles or particulate material and can be easily flushed to keep it clean and free from a build up of material deposits on the interior surfaces.

Sizes 4PXN and larger are made with a rigid Ultem plastic tube with barbed ends to mate with flexible laboratory tubing. A variety of clamps are commercially available for high pressure applications.

Sizes 1PXN – 3PXN are manufactured with a flexible Pebax tubing channel that optimizes the ultrasound signal transmission for the highest accuracy and sensitivity for low flow applications. Pebax is a polyether block amide plastic with strong physical and mechanical properties. The tubing ends are supplied approximately 45 mm long, but may be cut to a preferred length without compromising the integrity of the sensor. Plastic connectors are available for, or the Pebax tubing ends may be expanded to fit over tubing in the experimental apparatus. Instructions for expanding the tubing ends follow.

## Cleaning and Sterilization

The outside surface and internal channel of PXN inlines may be cleaned with mild soap and warm water (< 55 degrees C; 130 degrees F). Use a soft bristled brush to remove any foreign material. Avoid scratching the inner channel surface. A syringe with a plastic luer lock adapter, a pipe cleaner or small gauge covered wire may be used to mechanically clean the internal channel of the smaller inline sensors. The surfaces may be wiped or flushed with ethyl alcohol to promote drying. The electronic connector should be washed only when necessary; rinse briefly with 90% ethanol.

The PXN inline sensors may be sterilized by cold ethylene oxide gas (< 60 degrees C; 140 degrees F). **Avoid subjecting sensor housing to temperatures higher than 60ºC.** The PXN inline sensor should not be boiled, autoclaved or sterilized by cold liquid sterilization.

## Mounting and Use

Transonic PXN inline sensors should be mounted into the tubing circuit so that they are supported on both ends. They should not be hung or supported by the flowsensor cable. The arrow indicates direction of positive flow. Use the invert feature of the TS410 if the sensor cannot be mounted in the positive position.

Larger sizes (4PXN and larger) have barbed ends to grip flexible laboratory tubing. The Ultem tubing edge is thin to provide a streamlined transition with circuit tubing. Protect these from sharp impact damage or dropping. Hard High durometer or thick walled tubes may slide onto the barbed ends more easily if the flexible tubing end is warmed prior to insertion. Nylon hose clamps are available to secure the junction for high pressure applications.

Smaller 1PXN - 3PXN probes are spliced into the flow circuit with short lengths of rigid plastic or metal tubing. Do not pull the flexible Pebax tubing from the sensor housing: damage may result. The Pebax tubing may be cut to a shorter desired length using a sharp blade. The ends may also be widened to mate with larger diameter tubing, if desired (such as glass perfusion apparatus).



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# Care Guidelines

# ME-PXN Inline Sensors

## PeBax Tubing

Pebax tubing becomes pliable at higher temperatures. To achieve a larger diameter tubing ends to fit tightly over custom apparati, the ends may be expanded by heating them over either a single gradually tapered rod or successively larger diameter rods. Transonic Systems recommends experimenting with this process on a sample of the Pebax tube cut from one of the tubing ends or a sample obtained from Transonic Systems **BEFORE** altering the sensor ends. Transonic Systems cannot be responsible for damage made to the inline sensor resulting from modification of the Pebax tubing.

## Instructions for Expanding PeBax Tubing Ends

1) Mount the end of the tubing approximately 5 mm onto a metal rod that is slightly larger than the inner diameter of the Pebax tube (or a rod that tapers down to the tubing ID). The rod should not have sharp edges or come to a point. Dip the end of the rod in soapy water, and grip the Pebax tubing with a paper towel or cloth to make insertion easier. Expanding the Pebax tubing within 2 cm of the sensor housing is not recommended.
2) Vertically submerge the rod, but **not** the Pebax tubing in near-boiling water (about 95ºC) for 30 seconds. The metal rod will transfer the heat to the tubing end.
3) Keeping the assembly vertical, submerge the rod and Pebax tubing (but not the sensor housing) into cold water for 30 seconds. Grip the Pebax tubing with a paper towel and carefully remove the rod.
4) Repeat the process with successively larger diameter rods until the desired diameter is achieved. It is possible to expand the 1.2 mm diameter 1PXN tubing to 2.0 mm.

## Sensor Storage

PXN inline sensors should be stored dry in their plastic shipping cases.

## Calibration Guidelines

ME-PXN Flowsensors are precalibrated at the factory for use with customer specified fluid and temperature. This calibration is performed with equipment that has been calibrated traceable to the standards of National Institute of Standards and Technology and to Transonic Systems Inc. equipment performance standards. A Calibration Certificate, valid for 1 year, will be supplied with each flowsensor at the time of purchase. Up to 4 fluid/temperature combinations may be preprogrammed into the connector eprom. ME-PXN flowsensors may be recalibrated by the user for other fluid/temperature conditions using the gain adjustment program in the TS410 flowmeter.

Please note, the ultrasound signal amplitude is also normalized for the fluid/temperature use specified. Using the sensor at a different temperature or with fluid other than specified may show a significant reduction in the normalized received signal of the sensor. (Ultrasonic transmission is affected by the density of the fluid). Accurate measurements can be made even with a low received signal indication if a careful calibration is performed to correct the flow gain of the flowsensor.



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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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