



Precalibration

Transonic Systems' perivascular flowprobes are precalibrated in the factory using a calibration set up and procedure similar to the one described on the reverse side. Each probe is calibrated individually prior to shipping to the customer to determine the proper calibration gain for true flow reading. The gain is then programmed into the probe connector or, for flowprobes with chronic connectors, into the serialized calibration EPROM key. Calibration is performed under controlled procedures traceable to National Institute of Standards and Technology.

The volume flow measurement by Transonic Systems' ultrasonic transit-time probes is a function of the angles of the piezoelectric crystals and the reflective pathway. Theoretically, this dimension is fixed in the flowprobe and does not change over time. Therefore, flowprobes that meet operational tests and specification do not require recalibration.

Recommended Tests

Transonic Systems recommends testing of its flowprobes on a routine use basis to determine if any changes have occurred in the probe to warrant recalibration or repair. These tests are simple and can be performed by the end user in minutes.

1. **Received signal:** This is a test of the flowprobe's ultrasound signal utilizing the flowmeter's TEST mode. Probes are normalized in production to read 1 volt in TEST using a 1 meter extension cable, unless they are specified by the customer to be used with a 2 or 3 meter cable. Lowered signal may be indication

of probe degradation over time or misalignment of the reflector. See the flowmeter manual for more specific instruction.

2. **Zero offset:** This is also a test of the integrity of the probe and ultrasonic pathway. Transonic flowprobes meet a maximum offset specification; an increase in offset may be indicative of reflector misalignment or changes to the piezoelectric transducer/epoxy interface which may affect the flowprobe's function. Offset testing can be performed in a non-reflective plastic vessel that is lined with sponge or other sound absorbing material. Test the zero offset with the flowmeter in "MEA" (measure) mode. Submerge the flowprobe and allow sufficient time for the water to quiet and the probe to equilibrate. When the reading on the digital display has stabilized, it should be \leq the maximum offset specification for the flowprobe size/series. (See the flowprobe data sheet or table of specifications in the flowmeter manual.)

Certification

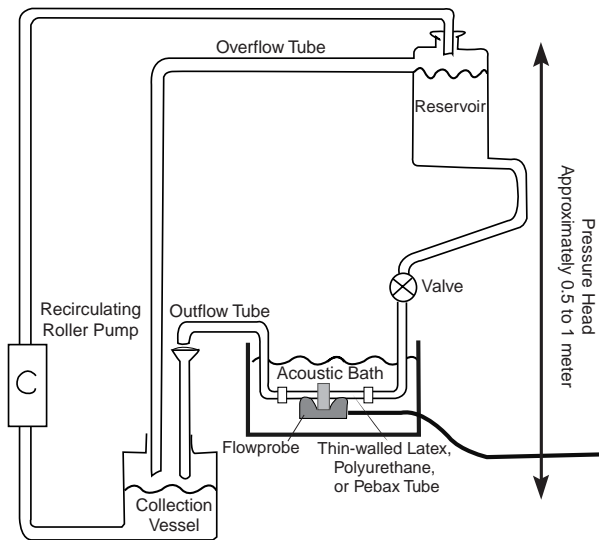
For quality assurance and to meet GLP (Good Laboratory Practices) guidelines as outlined by the FDA, Transonic Systems' provides Certificates of Calibration for customers who require these. Calibration certification is valid for one year and encompasses factory recalibration of Transonic flowprobes.



Flowprobe Bench Calibration

Bench Calibration Procedure

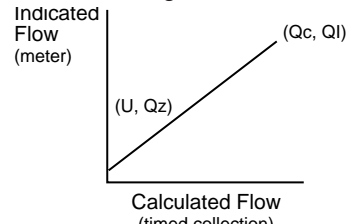
The calibration of Transonic perivascular probes can be confirmed using a gravity-fed constant flow set-up. Mount a thin-walled Penrose drainage tubing or Pebax polyurethane tubing within a water bath and position the probe around it. Observe the received signal amplitude on the front panel analog meter with the flowmeter in "TEST" mode. If the signal amplitude drops less than 10% when the tube is introduced into the probe's acoustic window, the walls of the tubing are sufficiently transparent to ultrasound to be used in the test set-up. Calibrate the constant flow set-up by collecting the outflow into a graduated cylinder over a measured period of time, and by calculating the volume rate of flow. (Make sure that the pressure head is not altered when the outflow tube is moved from the collection vessel to the graduated cylinder.)



Gravity-fed Constant Flow Set-up

- The temperature of circulating water and water within the bath should be approximately the same.
- A roller pump is preferred over a centrifugal pump, as the latter heats up the circulating liquid.
- Tap water that has been standing long enough so it does not form air bubbles on the surfaces of probe and containers should be used in both the water bath and the circulating system.
- Sponge or other sound absorbing material should be used to line the basin. Extraneous sound reflections from the basin walls may cause drift or signal noise.
- Positioning the flowprobe so that the reflector is facing up will also help avoid reflections.
- Use a straight length of tube 10 x the diameter on either side of the probe to avoid turbulence in the flow stream from tubing junctions or bends.

Record the calculated flow and the indicated flow and graph the data as shown in the figure below.



Once graphed, correct the flow for the zero offset and compute the slope of the curve by taking the difference between the indicated zero and the indicated flow and dividing it by the calculated flow.

$$\text{SLOPE} = \frac{(Q_I - Q_Z)}{Q_C}$$

This slope of the calibration graph should be approximately one. There will be small deviations because the ideal of a constant ultrasonic field within the flowsensing area is not fully achieved.

Correction for Blood: Bench calibration may be performed using water at room temperature (23°C) for most probes. An adjustment to the calibration is applied to correct for the acoustical velocity of blood vs. water and measurement conditions.

Acute vs. Chronic: Transonic R and S-Series flowprobes precalibrated for acute use will read 10% higher (using water at 23°C) than probes calibrated for chronic use to compensate for lowered sensitivity in acute conditions. See TN # 11.

Micro-probe Calibration: Transonic high frequency probes (0.5, 0.7, 1, 1.5 mm) are calibrated using water at 40° C to optimize signal transmission through tubing. Confirm probe calibration *in vivo* or on isolated vessel segments using blood at 37°C.

Tubes Used in Flow Calibration of Perivascular Probes

| Probe Size | Calibration Tubing | Supply #, Type |
|--------------------|--------------------|------------------|
| 0.5S, 0.5V | .020"/0.5 mm od | Pebax (3) |
| 0.7S, 0.7V | .028"/0.7 mm od | Pebax (3) |
| 1R, IV | .039"/1 mm od | Pebax (3) |
| 1.5S, 1.5R | .059" /1.5 mm od | Pebax (3) |
| 2S, 2.5S | 0.080" od. | polyurethane (1) |
| 2R, 3R, 3S | 0.120" od | polyurethane (1) |
| 4R, 4S | 0.188" od. | polyurethane (1) |
| 6R, 6S | 1/4" od. | 9787 (2) |
| 8R, 8S, 8A | 5/16" od | 9788 (2) |
| 10S, 10A | 3/8" od | 9789 (2) |
| 12A, 14S, 14A | 1/2" od | 9790 (2) |
| 16S, 16A | 5/8" od | 9791 (2) |
| 20S, 20A | 3/4" od | 9792 (2) |
| 24A, 28A, 32A, 36A | 1" od | 9794 (2) |

- (1) POLYURETHANE TUBING:* custom made by Thermedics Inc., Woburn, MA
- (2) LATEX TUBING:* .006" wall* Penrose draining tubing from: Mohawk Hospital Supply P.O. Box 27 335 Columbia St. Utica, NY 13503
- (3) PEBAX TUBING* (custom): samples available from Transonic Systems Inc.