

1. Introduction

Thermal mass flow sensors can measure mass flow independently of pressure and temperature. But how good is their performance in practice? In this application note we will discuss this issue in detail.

2. Total measurement uncertainty (a.k.a. “accuracy”)

The total measurement uncertainty is the official definition of accuracy. It consists of the sum of all possible errors in your measurement. In case of flow meters, these errors are:

- The stated calibration error, which you can find in the calibration report. This error can vary depending on brand and type of flow meter.
- Installation errors, due to flow profile effects. The flow is measured at one point, but you can never know the exact shape of the flow profile in the pipe. This applies to all single point insertion flow meters regardless of type and brand.
- Installation errors due to mechanical effects (alignment, insertion depth of your probe). This typically depends on the skills of the installation engineer.
- Pressure and temperature effects: some flow meters, especially non-mass flow meters, are sensitive to pressure and temperature effects. VPIstruments’ flow meters are mass flow meters, meaning they compensate automatically for pressure and temperature changes.

Accuracy and precision are often used the wrong way. The figure below explains the difference between the two.



Not accurate, not precise



Not accurate, but precise



Accurate, but not precise



Accurate, and precise

3. Pressurized calibration process

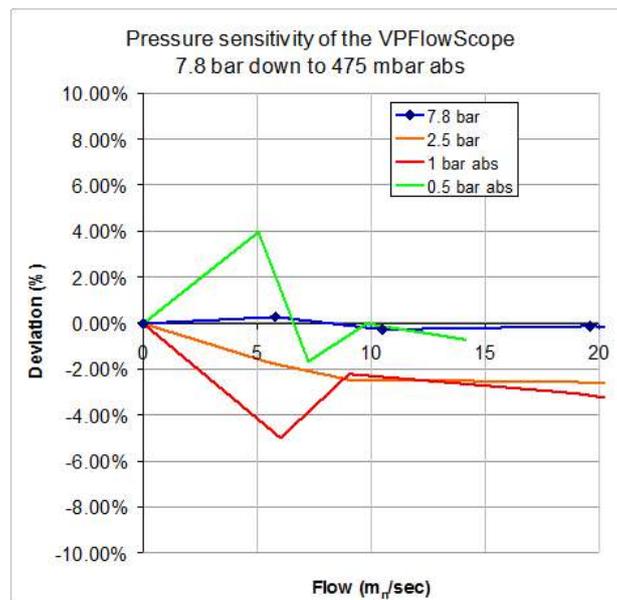
VPInstruments' insertion probes are calibrated by our proprietary pressurized calibration system, which is unique in the world. Pressurized flow meter calibration has many advantages:

- It is best practice to calibrate flow meters as close as possible to the actual process conditions to obtain the highest possible accuracy.
- The flow profile in a tube is linked to a Reynolds number. It is good practice to calibrate a flow meter near the Reynolds number at actual operating conditions as the flow profile will be close to the real profile in the field.

As a result, our proprietary pressurized calibration process leads to the lowest possible measurement uncertainty.

4. Pressure tests from 475 mbar abs up to 7.8 bar abs

We have performed air flow tests under four different pressures in the Zephyrus wind tunnel. The device that was tested was a VPFlowScope. The results are shown in the graph below.



5. Conclusions

- Pressure errors are within +/- 2 % over a test range of 475 mbar up to 7.8 bar, resulting in an error of less than 0.25% per bar.
- In vacuum systems, one should be aware of temperature effects. The thermal conductivity is longer than under pressurized conditions, so a longer response time of the flow meter can be expected.
- The normal VPFlowScope has a built-in 0 ... 16 bar sensor. The pressure sensor will not break under light vacuum conditions and will indicate a value on the LCD display. However, we cannot make any statement on the accuracy of the pressure sensor under these conditions.