

Four steps to more effective gas flow calibration

Application Note

The calibration of a flow sensor requires making a leak free plumbing connection between the unit under test (UUT) and a flow reference, passing the calibration media through both devices, and comparing their output.

Historically, flow calibration devices such as piston provers, bell provers and other variable volume devices have been used to calibrate process flow sensors. Unfortunately, these devices have a number of limitations:

- They give the operator only a limited amount of time to make a flow rate measurement before the device needs to be “reset”. This causes pressure and temperature fluctuations that often adversely affect the calibration.
- These devices typically must operate at atmospheric pressure, putting limits on operating conditions for the UUT.
- Many moving parts make them more complicated to use and more prone to error and instability.



Four steps to improve calibration results – using the molbox/molbloc gas flow system from Fluke’s DH Instruments division

- 1. Make leak free connections.**
- 2. Produce and maintain steady-state flow.**
- 3. Compare the reference and UUT over the same time period.**
- 4. Improve calibration results through automation.**

1. Make leak free connections.

You probably won’t be able to establish a 100 % leak-free connection between the flow reference and the UUT. However, you can minimize leakage so that it doesn’t significantly affect the overall uncertainty of the calibration.

The molbloc/molbox system helps you do this in two ways. Internal reference pressure transducers look for pressure decay in a pressurized, sealed test setup. Use this feature to quantify and correct leaks that might exist in your test.

The molbox embedded software features a system leak check that gives you a pass/fail indication of leakage in your test setup. This pass/fail criterion is based upon the flow range of the molbloc element.

Tech tip

Use the molbox System Leak Check function in order to ensure your plumbing system is leak free and ready to perform calibration.

2. Produce and maintain steady-state flow.

Since the flow rate of the reference and the UUT are compared in real time during the calibration process, it is important that the system flow rate does not vary with time. Flow rate changes at one location in the plumbing system may not be reflected in other parts of the system.

Minimize the amount of volume between the reference and UUT, particularly for low flow rate calibration work (less than 1 slm). This volume, often referred to as inventory volume, should be less than the flow rate volume. For example, when calibrating a 10 scfm UUT, the inventory volume should be kept below 10 cubic centimeters.

Because gases are highly compressible, changes in temperature within the system will cause changes in gas density within this volume, which in turn affect the rate at which gas is flowing between the two devices. The molbox/molbloc system measures and accounts for these changes.

Temperature and pressure measurements of the UUT must reflect actual conditions of the UUT, and can be adversely affected by restrictions in the system when these measurements are taken remotely from the UUT. The larger this volume is, the greater error it will cause. Also, the more stable the ambient conditions are, the less error will result.

In addition, if the pressure changes across a restriction, flow rate through the system also changes. This adversely affects the calibration process. You can avoid this problem by using high quality regulators to set pressure on the flow system. Isolating the test setup from external influences can also help. Using a flow calibration system such as molbloc/molbox, which does not change the pressure and temperature operating conditions of the test system during calibration, is the best insurance for achieving proper results.

Tech tip

The operator can enter a stability setting (typically 0.05 % FS) in the molbox system to indicate when the flow rate is stable and ready to take data.

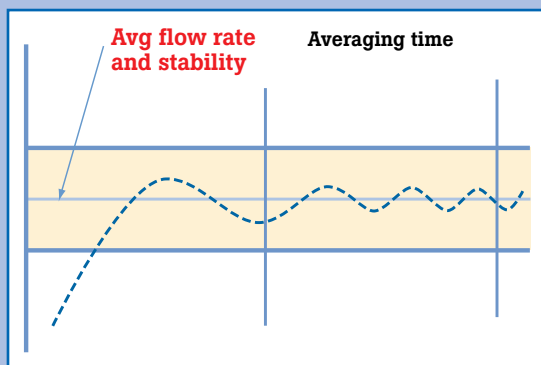
3. Compare the reference and UUT over the same time period.

Most process flow sensors have real time and continuous output indications. Examples of these are variable area flowmeters (rotameters), turbine flow meters, thermal mass flow meters/controllers, venturis, laminar flow elements, among others.

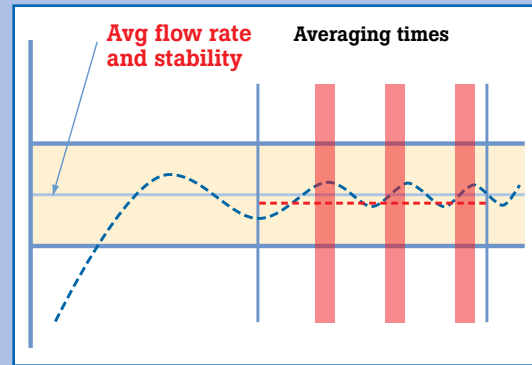
It is very important to acquire the output of your UUT and the reference at the same time.

A piston-prover manufacturer recommends setting the desired flow rate and measuring it with their reference, then changing the plumbing connection and diverting the gas flow into the UUT, to determine the UUT output. But if you use this method to calibrate a flow device, you cannot ensure that the flow rate and operating conditions remain constant, or that the UUT output did not change.

Another drawback to piston provers and similar devices is that the stroke time is so short that the manufacturer recommends taking averages across multiple strokes. This is not ideal, because the piston oscillations cause fluctuations of the gas flow stream that can affect the UUT. The figures below show that averaging multiple proving strokes with this device can cause an error due to even small amounts of flow instability.



Averaging the UUT flow and continuous reference flow.



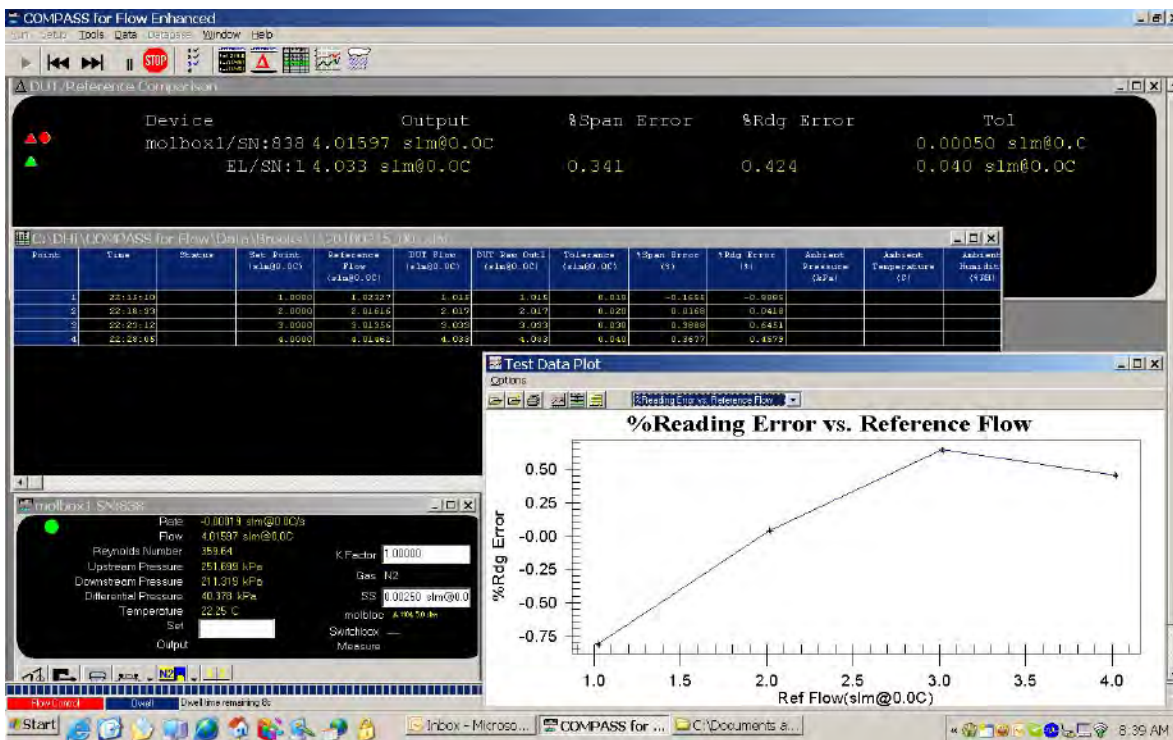
Averaging a non-continuous reference flow with resultant erroneous average flow.

Like most of the flow sensors it calibrates, molbloc/molbox gas flow calibration system has real time and continuous output indicators, making it an ideal solution for verifying and calibrating process flow sensors. molbloc/molbox enables the operator to make a direct comparison of the UUT with the reference, for as long a period as is necessary to obtain valid results. Once the desired flow rate is set, operating conditions within the calibration system such as line pressure, differential pressure, and temperature do not change.

4. Improve calibration results through automation.

COMPASS for molbox® and COMPASS for Flow® are PC software applications that enable you to automate the flow calibration process. They provide data acquisition capability, allowing you to take multiple readings from your UUT and reference at the same time. It is recommended to acquire and average the readings from the molbox system for at least 10 seconds. This will result in approximately 6-8 flow reference samples. If your UUT has a slower output update rate, more time might be desirable.

In some cases, complete automation might not be possible. When any of the components involved do not have electronic output, partial automation should still be considered. The benefit of following a structured procedure still exists even when the operator must interact with the software to provide a portion of the "automation."



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