

Unlike an actual gas calibration, this inferred equivalency method does not accurately replicate the true thermal heat dissipation of the actual gas. Corrections required for process conditions, such as variations of pressure and temperature extremes, create an even greater uncertainty. As stated and confirmed by ISO Standard 14511, Section 8:

"... the best practice for calibrating thermal mass flow meters is to perform an actual gas calibration, and at actual process conditions, when feasible."

Any critical application where stoichiometric calculations are critical or when measured gas flow rate are essential for safety or efficiency, no simulated calibration method should be considered for thermal flow meters when an actual, "true" fluid calibration is available.

Furthermore, an air equivalency, simulated calibration is not recommended where process conditions are moderately unstable; where flow velocity profiles are potentially in the transitional range, or where there is a potential non-linear relationship between the calibration fluid and the actual service fluid. Therefore, theoretical or equivalency calibrations represent a very limited range of applications. Many flow ranges with turndowns greater than 10:1 extend well beyond a simple linear correction range and a single factor correction as applied by many manufacturers is ineffective due to the non-linear relationships between the fluids. This is particularly true with thermal mass flow meters that rely on thermal conductivity and cooling effects as the essential measurement.

The Problem With Simulated Calibrations

To illustrate graphically the measurement uncertainty of simulated calibrations, consider the accuracy performance curves shown in *Figure 1*. These curves were obtained from a thermal flow meter produced by a leading global, multi-technology flow meter manufacturer, whose meter embedded a user selectable menu of gases. It is alarming to see the extent of the errors. Clearly, this instrument is not calibrated directly in each of these basic gas compositions but instead applies an inaccurate equivalency algorithm correction factor.

The large errors seem to indicate a simple, single order correction, and the manufacturer does not even attempt to use a polynomial correction for purposes of correcting non-linearities. It is visible through most of the flow range that these corrections, while extremely large in scale, have a certain linearity. As expected, the air and nitrogen curves are relatively close to zero offset because the base calibration is performed in air as the calibration fluid. However, when the instrument has one of the other gases selected, then the additional measurement error after the theoretical correction factor is applied can be as high as $\pm 100\%$!

Also detectable is the inability of the algorithm to correct non-linearity for some gases flowing at slightly elevated temperatures. This non-linearity range can vary as much as 30%, which means a correction factor approach, even if accurate, would not apply across the full fluid flow range.

Figure 1



