Application Note 76

The Effect of Temperature and Pressure on GC Flow Measurements

Chromatographers must routinely measure gas flow as part of their GC setup. Because changes in atmospheric temperature and pressure affect gas volume, and not mass, correction factors must be used when comparing readings obtained from bubble meters with those obtained using electronic mass flow meters.

Key Words:
- gas chromatography • flow rate • carrier gas
- bubble meter • flowmeter

The pressure, temperature, and volume of any gas are interrelated. As the temperature increases, the mass occupies a larger volume. Inversely, as the pressure increases, the volume that the mass occupies decreases. In both cases the mass remains the same, even though the volume changes.

The following equation, known as the ideal gas law, illustrates this relationship:

$$PV = nRT$$

where

P = pressure of the gas
V = volume of the gas
n = number of moles of the gas (the number of molecules with respect to the molecular weight)
R = universal gas constant
T = temperature (°K)

The pressure at the inlet of a column in a GC system is higher than that at the exit. Thus, the volume of gas entering the column is less that that exiting the column. These differences are observed when flow is measured with a bubble meter. Although the volumetric gas flow rates may be different at the column inlet and exit, the amount of gas (mass) entering and leaving the column must be the same (1).

Currently, several types of flowmeters are used in laboratories. Comparison of values obtained using different flowmeter types can result in unexpected inconsistencies if correction factors are not implemented. Some devices measure flow as volume and express these measurements in volumetric units (mL/min). Others measure mass (e.g., grams/hr) and convert to a volumetric value using a conversion factor. This converted value usually is expressed as standard cubic centimeters per minute (SCCM), or the volume that 1 cm^3 of a gas occupies at standard temperature and pressure (STP).

Since volume changes with variation in atmospheric conditions, volumetric measurements must be corrected to STP values. STP generally is defined as 1 atm (760mm Hg) and 21°C (0°C by some standards). Values that do not conform to STP (e.g. 30°C) must be recorded with the flow measurements; otherwise, comparison with other measurements would be misleading.

Of the different volumetric measuring devices presently used in flow measurements, bubble meters are the most common. Bubble meter readings, however, are affected by changes in atmospheric conditions. Correction factors must be incorporated to compensate for variations.

Electronic bubble meters are more accurate than simple bubble meters. Optical sensors respond more accurately to the passage of a bubble. Still, these meters generally do not compensate for fluctuations in ambient pressure or temperature. Again, correction factors must be incorporated. Additionally, for bubble meters that use soap solutions to generate bubbles, water vapor error should be considered. Other types of volumetric measuring devices include electromechanical flowmeters and thermal flowmeters. These require no compensation for the effects of water vapor because no water is present.

Electronic mass flowmeters provide a more consistent measure of gas flow rate, because they are not affected by pressure or temperature changes over the specified range of the unit. Electronic mass flowmeters measure mass, and convert mass to volume using a constant value for temperature and pressure. These flowmeters should be recalibrated periodically to comply with laboratory and other requirements, such as ISO 9000 standards. A recalibration service usually is available.

Bubble meters and electronic mass flowmeters are both available from Supelco. Our technical service chemists can help you select the type of flowmeter best suited for your analyses.

Ordering Information:

Mass Flowmeters

Humonics Veri-Flow 500 Electronic Flowmeter

The Veri-Flow 500 is multiple-point calibrated to NIST-certified volumetric standards for nitrogen, helium, hydrogen, air, and 5% argon/methane (certificate supplied), for superior accuracy and to help you comply with ISO 9000, GLP, and other stringent quality control protocols. A recalibration service is available.

- Compatible with electronic pressure control
- Range of 5.0-500mL/min; accurate to within ±2% of reading or 0.25mL/min, whichever value is larger
- Continuous readings in volume, linear velocity, or split ratio
- 9-pin RS 232 communication port for recording data
- Internal rechargeable NiCad battery
- AC power adapter jack and recharger
- Only 4 x 5 x 3" (10 x 12.5 x 7.5cm)

110VAC	**23143**
International Version*	**23142**

Humonics Laminar Micro-Flo 20 Flowmeter

The Micro-Flo 20 is calibrated to NIST-certified volumetric standards for helium and hydrogen. When the unit is turned on, the display defaults to linear velocity readings – display mL/minute readings simply by pushing a button. A recalibration service is available.

- Calibrated for helium and hydrogen
- Range of 0.10-20mL/min (read linear velocity to 999cm/sec)
- Accuracy: ±2% of volumetric reading, averaging ±1cm/sec in linear velocity mode
- Continuous readings in volume or linear velocity
- Highly visible display
- Capillary column adapter and 1/8 inch ID tubing provided

23144

*International version supplied with:
standard 110VAC USA power cord

European 220VAC power cord

universal AC to DC power adapter/charger, tested and approved by Humonics, CE approved and labeled

The AC to DC adapter/charger has the following rating:
Input: 100-240VAC, 50-60 Hz; Output: 5VDC, regulated.

The adapter/charger will work everywhere, including the USA and Japan.

Electronic Bubble Meters

The Humonics Digital Flowmeter provides you with a reliable means of measuring gas flow. Accurate to within ±2% of any reading, it is a high-precision instrument that combines the simplicity and versatility of a bubble meter with the speed and accuracy of a microprocessor.

This unit is versatile — it can be used with *all* gases. And it features an easy-to-read, accurate digital display, eliminating the need for tedious bubble watching, timing, and flow rate/time conversions. The bubble is visible for your observation.

- Accurate for all gases
- Portable — includes standard 9-volt battery
- Fault condition display
- Automatic power-off for extended battery life
- Low battery indicator
- Field replaceable tubes
- Compatible with electronic pressure control
- Computer interface capability on some models
- Recalibration service for ISO 9000 requirements

Optiflow 420 Digital Flowmeter

Displays in mL/min or linear velocity
Flow Range: 0.5-50mL/min
Accuracy: ±3% of any reading **22806**

Optiflow 520 Digital Flowmeter

Displays in mL/min or split ratio
Flow Range: 0.5-500mL/min
Accuracy: ±3% of any reading **22910**

Optiflow 650 Digital Flowmeter

Displays in mL/min or split ratio
Flow Range: 5-5000mL/min
Accuracy: ±2% of any reading **22912**

Replacement Flow Tube

For Optiflow 520 Meter	**22776**
For Optiflow 650 Meter	**22778**

References

1. Hinshaw, J. V., *GC Connections — Measuring Flow*, LC-GC, Vol. 13, No. 2, Feb. 1995.

Reference not available from Supelco.

Contact our Technical Service Department (phone 800-359-3041 or 814-359-3041, Fax 800-359-3044 or 814-359-5468) for expert answers to your questions.