AN07 Application Note –
Gas corrections & Mass flow

Introduction

The VPFlowScope thermal insertion probe and in-line flow meters use a thermal mass flow principle. This is great, because you don't need an external pressure or temperature sensor to compensate the output signal. But it also means that the output depends on the density, the thermal conductivity of the gas, the heat capacity and the viscosity. For common technical gases, we have verified the conversion factors experimentally. In this application note, we provide more background information on how conversion factors can be used.

1. Gas calibration

Real gas calibration vs theoretical factor

We offer real gas calibration for a selected group of safe, non-corrosive, non-oxidizing, non-combustible and non-toxic gases. Due to safety regulations of our calibration lab, we cannot test with toxic gases, nor can we calibrate with strong oxidizing gases. Real gas calibration results in a higher accuracy of the instrument compared to conversion factors, as this eliminates any on-linear effects.

Oxygen

As oxygen is a strong oxidizing gas, which can cause fire under some circumstances, we cannot calibrate with pure oxygen in our lab. Therefore, the conversion factor is a calculated value. Oxygen, Nitrogen and air have quite similar thermal properties, resulting in a conversion factor of 1.0.

Helium

When the gas properties differ significantly, the conversion factor will also differ significantly. The most dramatic effect is seen with helium gas. This gas has a very low density and a high thermal conductivity. This results in a non-linear conversion factor, so we always offer a real gas calibration for this gas.

Conversion factors table

The conversion factor table is shown below. The factor applies to most **in-line flow meters**. Note that the factor may vary when applied to insertion probes due to viscosity effects. Our standard gas is compressed air, which has a reference factor of 1,0. When subjected to another gas, the flow meter output needs to be multiplied with a conversion show the correct measurement value. The factor is applied over the full range of the instrument, and does not cancel out any non-linear effect.

<table>
<tr><th>Gas</th><th>Factor</th><th>Real gas</th><th>Theoretical factor</th><th>Calibration range (probes)</th><th colspan="3">Calibration range (in line meters) [m^3_n/hr]</th></tr>
<tr><td>Argon</td><td>1,08</td><td>✓</td><td></td><td rowspan="5">150 m_n/sec</td><td rowspan="5">0,32..80</td><td rowspan="5">0,88..250</td><td rowspan="5">2,86..1000</td></tr>
<tr><td>N2</td><td>1,00</td><td>✓</td><td></td></tr>
<tr><td>O2</td><td>1,00</td><td></td><td>✓</td></tr>
<tr><td>Air</td><td>1,00</td><td>✓</td><td></td></tr>
<tr><td>Corgon 18</td><td>1,48</td><td>✓</td><td></td></tr>
<tr><td>CO2</td><td>1,00</td><td>✓</td><td></td><td>105 m_n/sec</td><td>0,32..42</td><td>0,88..140</td><td>3,53..700</td></tr>
</table>

VPFlowScope DeltaP

For differential pressure based instruments, the conversion factor cannot be applied in the same way. In general, a differential pressure meter signal depends mainly on the density of the gas. Please consult us when you intend to apply the VPflowScope DeltaP for gases other than Compressed Air, Nitrogen or Oxygen.

Mass flow in kg per time unit

The VPFlowScope measures mass flow. Mass flow can be expressed in normal cubic meters per time, or in mass per time unit, for example kg/sec or kg/hr.

To calculate from “volumetric” mass flow units to “mass” mass flow units, you need to know the density of the gas at reference conditions. The gas density can be found in many physics books, or on the internet. Be careful to make sure the reference conditions are equal, and when browsing the internet, make sure to use a trusted reference source. Most technical gas companies, for example Linde Gas, Praxair, Air Products have excellent on-line libraries with gas properties.

The density can be defined at 20°C (293.15 K, 68°F) and 1 atm (101.325 kN/m^2, 101.325 kPa, 14.7 psia, 0 psig, 30 in Hg, 760 torr). It can also be defined at 0°C (273.15 K, 32°F) and 1 atm (101.325 kN/m2, 101.325 kPa, 14.7 psia, 0 psig, 30 in Hg, 760 torr).

Since our flow meters refer to 0°C, we need the second reference condition. Make sure when consulting gas property tables on-line to use a table with identical reference conditions. This results in the following table. The density values in this table can be used to calculate the mass flow in kg/hr or kg/s when desired.

Gas	Density [kg/m3]
Argon	1,784
C02	1,977
N2	1,251
O2	1,429
Helium	0,179
Air	1,293
Nitrogen	1,251

Example: Carbon Dioxide (C02)

C02 is used for packaging, and generated in beer breweries. In some breweries, C02 is re-cycled, cleaned and used for carbonized soda drinks. C02 has a density of 1,98 kg/m^3

In this example, the flow is 340 m^3_n/hr. The mass flow can be calculated by multiplying this with the density: This results in a mass flow of 1,98 · 340 = 673,2 kg/hr