Mass Flow Tutorial

Volumetric versus Mass Flow

Mass flow measures just what it says, the mass or weight of the gas flowing through the instrument. Mass flow (or weight per unit time) units are given in *pounds* per hour (lb/hour), *kilograms* per sec (kg/sec) etc. When your specifications state units of flow to be in mass units, there is no reason to reference a temperature or pressure. Mass does not change based on temperature or pressure.

However, if you need to see your results of gas flow in volumetric units, like *liters* per minute, *cubic feet* per hour, etc. you must consider the fact that volume DOES change with temperature and pressure.

A mass flow meter measures mass (grams) and then converts mass to volume. To do this the density (grams/liter) of the gas must be known. This value changes with temperature and pressure.

Volume changes with temperature. When you heat a gas, the molecules have more energy and they move around faster, so when they bounce off each other, they become more spread out, therefore the volume is different for the same number of molecules.

Think about this:
The density of Air at 0° C is 1.29 grams/liter
The density of Air at 25° C is 1.19 grams/liter
The difference is 0.1 grams/liter. If you are measuring flows of 100 liters per minute, and you don't use the correct density factor then you will have an error of 10 g/minute!

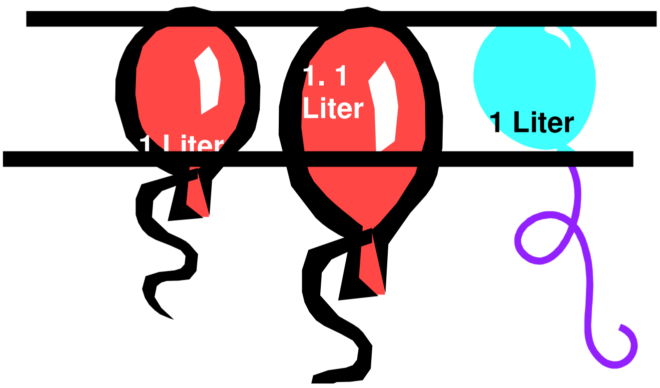
Volume also changes with pressure. Think about a helium balloon with a volume of 1 liter. If you could scuba dive with this balloon the pressure on it will increase. What do you think happens to the weight of the helium? It stays the same. What would happen to the volume (1 liter)? It would shrink.

The designation of standard
Why is the word **standard** included with the volume terms like *liters* and *cubic feet* in mass flow applications?
A mass flow meter measures mass …and we know we can convert mass to volume using a known density. But to use density, we must pick one value (or **standard temperature and pressure**- STP) to use in our calculation. When this calculation is done, the units are called **standard** liters per minute (SLM) or **standard** cubic feet per minute (SCFM), etc.

With STP values, you can convert from mass flow to volumetric flow:
Flow1 x P1/P2 x T2/T1 = Flow2
Watch out for the 7% error (for 0ºC vs. 20ºC)
Note: Temperature and Pressure are absolute
– T (Kelvin) = ºC + 273.15
– PSIA = PSIG + 14.696

Example:

0° C	25 C	25° C
0.179 grams/1 liter	0.179 g/1.1 liters	0.164 grams / 1.liter



Using the example to the left, we can see a standard liter can be defined differently. The first balloon contains 0.179 grams of Helium at 0 ° C and 760 Torr (0.179 grams/liter is the density at that STP). Heat up that balloon to room temperature and the volume increases, but the mass has not changed because no gas has escaped the ballon – but the volume is not 1 liter anymore, it is 1.1 liters.

So to define a standard liter of Helium at 25 C, we must extract only one liter from the second balloon and that liter weighs only 0.175 grams.

If a mass flow meter is set up for STP at 0 ° C and 760 Torr, when it measures 0.179 grams of He, it will give you results of 1 SLM.
If a second meter is set up for STP at 25 C and 760 Torr, when it measures 0.164 grams, it will give results of 1 SLM.

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