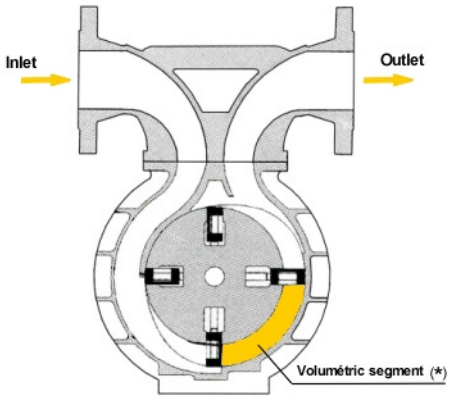
TANGENT LABS
Calibration, Sales & Repair from every angle.

Volumetric Flow vs. Mass Flow

By John Ulrich
Director of Metrology

2845 Tobey Drive | Indianapolis, IN 46219
TE 317.487.2378 | FAX 317.487.2375 | FREE 888.701.2378
www.tangentlabs.com

Contents



Measure that "Stuff"

Flow rates are not created equal. Some people often confuse mass flow rate and volumetric flow rate with velocity or air speed. It's like comparing apples to oranges. Depending on the application you are using them for, they have much different uses. As discussed in a previous white paper, velocity is nothing more than speed. It's a measure of how fast something moves from one place to another, or distance divided by time (eg, m/s, mph, fpm, etc.) Flow rates have to do with the actual amount of "stuff" that passes through a known surface.

There are all kinds of different substances that can be measured with a flow rate. They can be liquids, gases, or even plasmatic substances like blood. No matter what is measured, the formula for the rate is the same. However, you have to know some characteristics of what you're measuring to make sure your flow meter is giving you good measurements. One of the biggest problems clients have with their flow meters is having the confidence that they are making a good measurement. They get lost in conversions and coefficients and densities. Some flow meters are rated for certain gases and fluids, while others are rated for all kinds of different substances.

Mass Appeal

One flow rate to consider is mass flow rate. By definition, it is the mass of a substance passing through a given area of a surface for a given amount of time. One can see units of mass flow in kg/s, g/m, lb_m/hr, etc. The actual formula for mass flow rate is

$$\dot{m} = \rho \times v \times A$$

Where ρ is the density of the material, v is the velocity of the material, and A is the cross-sectional area which the mass is passing through. NASA is one organization that uses mass flow rate constantly and it is crucial to the success of the space program.

When a rocket blasts off from Earth into space, they are very interested in the mass flow rate of the gas through the propulsion system to ensure there is enough thrust to get the rocket up to speed. The change in momentum of gas is what creates the thrust so the mass flow rate has to be at a certain rate.

In most operations however, mass flow rate is measured in facility processes where gases are being distributed. Unlike the aforementioned propulsion system which expels the gas out of the system, the mass flow rate through a tube or pipe is relatively constant since the size of the tube is the same diameter throughout the process. So taking into account the fact that the density of the gas doesn't change and the cross-sectional area of the tube doesn't change, the velocity is the only varying factor and typically processes like to see constant velocity. You wouldn't want a lot of variation in your velocity if the gases you're distributing through your facility are used to run machines. A good example is wind tunnel testing.

Other popular areas where this is used is testing for leak rates out of nozzles and orifices. Properly calibrated leak orifices can act like flow meters as well. Since you know the exact size of the openings, you can be assured that the proper amount of substance is flowing through the holes at a certain rate. This kind of testing is done to ensure production pieces don't have leaks that could affect performance for the consumer.

Pump up the Volume

The other flow rate that gets used in many processes is volumetric flow rate. Instead of measuring the mass of a substance through a given area over a given time, now we measure the volume of a substance through a surface over a given time. One can see units of m^3/sec, ft^3/sec, etc. The actual formula can thought of in terms of mass flow divided by the density of the substance $Q = \dot{m}/\rho$. This way, it doesn't matter what the mass or weight of the substance is, only what its flow rate is. This becomes clear when thinking of terms of measuring the flow rate through duct work. You can certainly put a velocity probe in the duct work to measure the speed of the air flowing through it, but doesn't it matter how much air is flowing? What if you had a lot of turbulent air that was creating drag? If the facility uses a lot of dryers in its processes, it will want to know that their drying gases are escaping through their pipes at a fast enough rate to ensure all contaminants and pollutants leave the facility. Otherwise those contaminants can cling to the piping and bacteria and fungus can grow which in turn creates even more headaches by possibly making employees sick. If you knew what volume of air was flowing out of the ducts, you can be relatively certain that even though their might be some minor turbulence that a sufficient enough volume of air is leaving the building.

Summary

There are all kind of shapes and sizes and styles of flow meters that Tangent Labs calibrates every day. They are not all created equal and proper sizing and range is important depending on the type of application they're used for.