

The Problem

Products frequently need to be evaluated for correct flow rate to ensure the passage of air through devices being tested.

Less sophisticated test machines are unable to measure a true gas flow rate. Some testers use pressure differential to calculate an apparent flow rate. Pressure is measured before and after the flow restriction and the difference in pressure is *calculated* as flow.

Calculated flow rate can be misleading because pressure differential does not always reflect the actual flow dynamics of devices being tested. At low flow, the pressure differences are extremely small and subject to measurement errors.

The Solution

Uson mass flow testers use a micro-machined solid-state mass flow transducer to measure the actual flow through the test product.

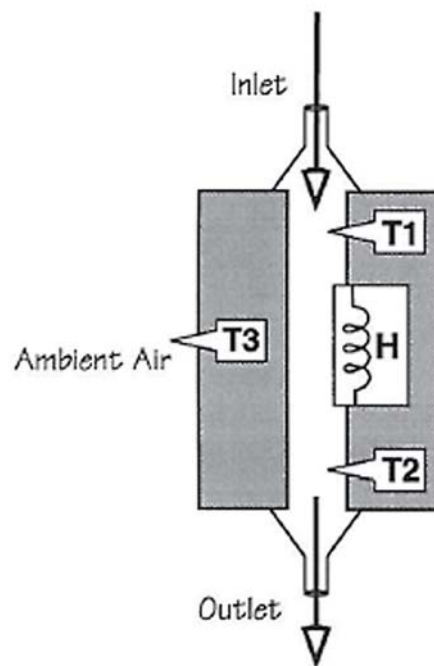
Because mass flow is, in essence, counting molecules, flow measurement is extremely fast, accurate, and repeatable.

Another major advantage: mass flow eliminates the need to enter the volume of the product into the tester. Flow measurement is automatic. Users simply select a test pressure, attach the product to the test port, and then press the start switch.

How It Works

Uson's Mass Flow sensor works like this:

- Test pressure is entered into one of the tester's programs. Product is attached and the test is started manually or automatically.
- Air moves into the inlet port and the precision micro-thermistors shown as [T1] measures the temperature of the inlet air. (See the figure at right.)
- The flow sensor's heater [H] increases the temperature of the moving air far above room temperature as measured with the sensor [T3].
- Temperature of the outgoing air is measured at the next precision micro-thermistors [T2].
- The temperature difference of T2 minus T1 is proportional to the ability of the air mass to transfer heat. The tester reads out in mass flow units such as standardized cubic centimeters per minute.



Mass Flow Sensor

Sensor Operation

Uson uses a microbridge flow sensor, which operates on the principle that heat is transferred in proportion to the amount (mass) of moving air. Output voltage of the sensor varies in proportion to the mass of air flowing through the transducer.

Built around a thin-film, thermally isolated bridge structure containing heater and sensing elements; the sensor provides a sensitive and fast response to air flow over the chip.

Heater Control and Temperature Compensation

The sensor's heater control circuit keeps the heater temperature at a constant differential above ambient air temperature under varying temperature and flow conditions. Ambient temperature is sensed by a resistor/heatsink combination on the chip. This mode of heater and ambient temperature sensing reduces the effects of changes in air supply and ambient temperature.

Changes Due to Air Composition

If the quality of the gas (typically air) is kept constant, there will be no measurable measurement effects due to gas composition.

Changes Due to Air Density

The tester measures true air flow in units standardized to 29.92 inHg (14.68 psi) at 20 degrees C.

Although measurements are accurate and traceable to NIST standards, flow readings could be different if the tester is used at drastically different altitudes. This is not a tester fault; rather, conditions have changed and the tester measures this difference. At a high altitude, air is less dense than air at a lower elevation. When compressed to the same relative pressure, the air will exhibit a density shift when compared with air compressed to the same relative pressure at a lower elevation.

Difference in air density is the primary reason user's can observe slightly different results when temperature and gauge pressures are identical. For this reason, it is important to establish all test parameters at the same altitude and under the same conditions at which the tester will be used.

Compensation may be necessary to reconcile air density variations between the two locations if measurements are made at different altitudes.

How Can Density be Different if Pressure Stays the Same?

The absolute pressure (measured against vacuum) at different altitudes are not the same when using a gauge pressure measurement. Gauge pressure is measured with respect to surrounding air pressure. Thus, gauge pressure is a relative pressure number and may only appear to be the same from place to place and from day to day.

Let's say we compress air at sea level (approximately 15 psig ambient) to a pressure of 10 psig. We'll call this Air Down.

Let's now compress air at a 5,000 foot higher altitude (app. 12 psig ambient) to a pressure of 10 psig. We'll call this Air Up.

Which compressed air has greater density?

The answer is Air Down. Because we started with already dense air and then had to raise that air above a surrounding ambient pressure that was 3 psig higher than our more elevated (lower pressure) location.

Although both Air Down and Air Up have the same relative pressure when compared to respective surroundings (back pressure), Air Down has a molecular count greater than Air Up. Higher molecular count means more mass, which means increased air flow.

Because air flow is based on heat transfer, Air Down can transfer more heat due to its greater density. All other parameters being equal, flow readings made at a high altitude will create smaller numbers than readings made at a lower altitude.

We call this variation the Compression Ratio.

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