Rosemount DP Flow Gas Flow Measurement

Errors Due to Pressure and Temperature Variation

In gas flow measurement, the density of the gas changes as pressure and temperature change. This change in density can affect the accuracy of the measured flow rate if it is uncompensated.

There are two cases when an uncompensated density change will *not* affect the flow measurement. First, a mass flow measurement made with a direct mass meter (i.e. coriolis or thermal mass). Second, an actual volumetric measurement made by a velocity type meter (i.e. Vortex, Turbine, Ultrasonic, PD, etc.). The accuracy of all other types of flow measurements are affected by changes in gas density. Since most gas measurements are made in mass units and are not measured with a direct mass flowmeter, the majority of gas measurements will be affected by changes in density.

The Impact of Uncompensated Density Variation

There's a fairly simple rule of thumb that can be used to calculate how much the density of a gas will change due to changes in pressure and temperature. Gas density can be calculated using the real gas law.

$$\rho = \frac{MW_{gas}P}{ZR_0T}$$

Since gas density is a function of absolute pressure and absolute temperature, the change in density is proportional to the change in pressure or temperature. So a 1% change in absolute pressure causes a 1% change in density.

$$\Delta\rho_{temp} = \frac{\Delta T}{T_{abs}} \qquad \Delta\rho_{press} = \frac{\Delta p}{P_{abs}}$$

Example:

1. Gas flow measurement at 75 psig line pressure that varies by ± 3 psi.

$$\Delta P_{press} = \frac{\pm 3psia}{(75 + 14.7)_{psia}} = \pm 3.34\%$$

2. The same Gas flow measurement is at 20 °C and varies by ± 5 °C

$$\Delta P_{temp} = \frac{\pm 5K}{(20 + 273.15)} = \pm 1.71\%$$

The total change in density due to changes in pressure and temperature is ±5.05%; the sum of the two. The maximum density is at maximum pressure and minimum temperature, and vice versa.

How much this affects the flow measurement depends on the type of meter. Velocity type measurements have a 1:1 relationship between flow error and density change. DP flowmeters have a $^1/_2$:1 relationship between flow error and density change.

In the example above, for velocity meters, the flow error due to density variation is ±5.05%. For a DP flowmeter, the error due to density is only ±2.525%. A DP Flowmeter is ***half*** as sensitive to density variation as a velocity flowmeter.

To eliminate these errors, line pressure and temperature should be measured to compensate the flow rate. The 3051S MultiVariable™ Transmitter measures pressure and temperature to dynamically compensate for density changes.

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