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ESTIMATING ERRORS IN GAS MEASUREMENT SYSTEMS WHICH DO NOT USE TEMPERATURE AND PRESSURE COMPENSATION

INTRODUCTION

Turbine flowmeters offer an accurate means to measure the flow of gases over wide flow ranges at low cost. This has resulted in the broad use of the device.

The turbine flowmeter is a volumetric measuring device. In most applications, however, the desired units of measurement will be in equivalent gas volume at normal atmospheric temperatures and pressure (typically 14.696 PSIA and 70°F).

To accomplish this, the flowing temperature and pressure are normally measured and the Ideal Gas Law is computed in a Gas Flow Computer or in a Digital Flow Totalizer equipped with gas temperature and pressure compensation.

When temperature and/or pressure variations are small, as can occur in indoor pressure regulated lines, the added expense and complexity of gas temperature and pressure compensation may not be justifiable. For these applications the systematic errors resulting from the failure to gas compensate should be carefully evaluated.

ESTIMATING THE ERRORS IN UNCOMPENSATED GAS MEASUREMENT SYSTEMS

The errors resulting from failure using uncompensated measurement systems which are set up for average conditions may be estimated by examining the ideal gas law normally computed by Gas Flow Computers.

$$\text{SCF} = \text{ACF} \times \frac{\text{Flowing Pressure in PSIA}}{14.7} \times \frac{530}{{}^\circ\text{F} + 460}$$

The above expression may be seen to have three terms which determine the accuracy of the resulting measurement in SCF or SCFM. The first term is the ACF determined by the flowmeter and has a linearity error or +/-1%. The errors resulting from failure to temperature and pressure compensate are analyzed as separate terms in the following discussion.

ERRORS FROM LACK OF TEMPERATUE COMPENSATION

In gas measurement systems where the gas source is either a pipeline or a gas cylinder, temperature compensation may sometimes be omitted without greatly increasing the measurement error.

This is a result of the fact that the temperature of the gas is reasonably constant. In applications where outside gas storage tanks are used or where the output of an ambient vaporizer is used as the gas source, temperature compensation should be applied since the source temperature varies widely as a function of seasonal temperature and gas discharge rates.

To estimate the errors related to temperature variations, begin by obtaining the expected temperature variation for the gas source. Designate the two extremes Tmax and Tmin. If the gas source is an underground gas line the temperature variations will in general be small. Perhaps 30°F in most of the United States. Next, compute the average temperature, Tave, to be used in setup of any electronics systems.

$$\text{Tave} = \frac{\text{Tmax} + \text{Tmin}}{2}$$

The error in the SCF computation from failure to temperature compensate will be:

$$\%\ \text{Error} = +/- \frac{\frac{\text{Tmax} - \text{Tmin}}{2}}{\text{Tave}} \times 100\%$$

Where temperature is in degrees rankine (°R = 460 +°F).

For our example, if we assume a ground temperature of 60° +/-15°, the resulting error in the SCF computation would be +/-2.89%. This error will be unsatisfactory to most users.

ERROR ESTIMATES FOR NOT PRESSURE COMPENSATING

On any pressure regulator there exists a curve which shows how well the pressure is regulated as a function of the flow rate thru the regulator. This curve should be referenced to estimate the minimum and maximum pressure likely to occur with the anticipated flowrates the user requires. Note the maximum and minimum pressures, in PSIA, estimated as well as the nominal setting, Pave, which will be adjusted upon installation, is PSIA. Use the following expression to calculate the error resulting from failure to pressure compensate.

$$\%\ \text{Error} = +/- \frac{\frac{\text{Pmax} - \text{Pmin}}{2}}{\text{Pave}} \times 100\%$$

Where pressure is in PSIA (PSIA = PSIG + 14.7).

In general, the lower the average line pressure, the more important pressure compensation becomes since the line losses are a greater percentage of the total pressure.

For example, if the line pressure setting is 50 PSIG, 64.7 PSIA, and has a 5 PSI variation, the resulting error from failing to pressure compensate would be +/-7.7%. This again would be unsuitable for many individuals.

The illustrative examples are typical of what many users considered to be “regulated” temperature and pressure. It is important to carefully examine these error components when deciding whether or not to use gas temperature and pressure compensation.