Technical Library

As A Service to the HydroCarbon Measurement Industry, CRT-SERVICES Curates this collection of Digital resources.

Effects of Atmospheric Pressure on Gas Measurement
Class # 1390.1

Denis Rutherford
Regional Sales Manager Central US
Schneider Electric Telemetry & Remote SCADA solutions
6650 W Sam Houston Pky. S. Suite 420
Houston, TX USA

This white paper discusses the differences between gauge and absolute pressure sensors, methods of determining the atmospheric pressure at a location, and effects on measurement accuracy.

Abstract
One of the often overlooked or misunderstood parameters in upstream gas measurement is the atmospheric pressure input. To correctly configure any Electronic Flow Measurement (EFM) device to calculate a corrected volume, the static pressure at the meter run must be input to the calculations as an "absolute" pressure value. Since the absolute pressure is defined as the sum of the gauge pressure and the atmospheric pressure at the site, proper EFM setup requires that the atmospheric pressure be accurately determined for each metering location. This paper discusses the differences between gauge and absolute pressure sensors, methods of determining the atmospheric pressure at a location, and effects on measurement accuracy.

Pressure Defined

We need to first understand the concept of **atmospheric** pressure. Simply put, atmospheric pressure is the force exerted by the weight of the atmosphere on a given point of the earth's surface. A standard atmosphere at mean sea level is generally accepted to be 101.325 kPa or 14.696 PSI or 1 ATM.

 This brings up two points to consider:

1. The weight of the atmosphere at any given moment, at any given point on the earth's surface changes with the density of the air, which is dependent on the temperature and moisture content, or put simply, it changes with the weather. In reviewing some Environment Canada data for atmospheric pressure changes over the course of a year for any given location, the maximum change due to weather is limited to approximately +/- 2 kPa or +/- .3 psi. So we can see that the impact of weather on determining the atmospheric pressure at a location is, for most production applications, quite small.

2. The weight of the atmosphere at any given point is a function of the elevation above sea level. For example there is more atmosphere above a lower elevation on earth, such as sea level, and hence a higher atmospheric pressure, than at any point of higher elevation. As you climb a mountain and your elevation above sea level increases the amount of atmosphere above you decreases, and subsequently the atmospheric pressure on you decreases. The following formula is often used to approximate the atmospheric pressure at an elevation:

Atmospheric Pressure (kPa) = 101.56 – (0.0113 * Elevation (m))

From the above formula you can see that as a rule of thumb, the atmospheric pressure decreases by approximately 1 kPa for each 100 meters or 328.8 feet of elevation rise above sea level.

To illustrate the above point, the Calgary International Airport website lists the elevation there as 1139 m above sea level. Using the above formula the approximate atmospheric pressure at the airport will be 88.7 kPa, a considerable change from the mean sea level value of 101.325 kPa.

So we now a have a good understanding of atmospheric pressure, the next step in defining absolute pressure is to understand gauge pressure. The term "gauge pressure" comes from the original gauges that are still routinely used to measure the pressure contained in a tank or vessel. A typical pressure gauge utilizes an invention called the Bourdon tube to translate pressure in the tube to a linear movement of a needle on a gauge face. A Bourdon tube is typically a thin stainless steel tube with an oval cross-section that is bent into a semi–circular or coiled

shape. The tube is sealed at one end and open to the pressure source at the other. As the pressure increases inside the Bourdon tube, it causes the tube to expand and straighten, thereby causing its shape to change. A mechanism is then used to translate this increased radius to a linear deflection of the dial.

Because the outside of a Bourdon tube is subject to atmospheric pressure at the site, the atmospheric pressure becomes the reference and the measured value shows only how much higher the process pressure is in comparison to the atmosphere. Therefore, if we are located at sea level where our atmospheric pressure is highest, our gauge reading will be lower than if we are at 1000 meters above sea level where there is less atmospheric pressure, and subsequently less counter force exerted on the Bourdon tube. Hence a Bourdon tube gauge will need to be calibrated to read correctly at the installed atmospheric pressure.

The term absolute pressure is defined as:

Absolute Pressure = Gauge Pressure + Atmospheric Pressure

Where absolute zero pressure is defined as the pressure inside a perfect vacuum.

Electronic Sensors

With increased use of electronic sensors (Multivariable Transmitters MVT's) coupled with Electronic Flow Measurement (EFM) devices to calculate corrected flow at the well head or sales points, it is important that users understand the type of pressure transmitter technology being used so that the pressure input is applied to the flow computer correctly.

There are basically two types of electronic pressure sensors available on the market today:

1. Gauge pressure sensor
2. Absolute pressure sensor

Gauge pressure sensors are constructed in two configurations: vented gauge, and sealed gauge.

A vented gauge sensor has its reference connected to the local atmospheric pressure and is designed to compensate for changes in atmospheric pressure, and always report the true gauge pressure in the line or vessel.

A sealed gauge sensor has the reference side of the pressure sensor sealed at atmospheric pressure. Typically a sealed gauge sensor will show a zero offset when initially installed and opened to atmosphere, due to the difference in the atmospheric pressure at the local site from the atmospheric reference pressure in the cell. This zero offset is typically "calibrated out" at the time of installation.

The third sensor type is a true absolute pressure transmitter. The absolute pressure sensor is constructed with its reference to a near perfect vacuum or absolute zero pressure. This type of sensor when properly calibrated and opened to atmosphere will read the actual atmospheric pressure at the location based on local elevation and weather conditions. In lab conditions an absolute pressure sensor zero calibration is often done by applying a vacuum to the sensor. Since applying a vacuum to a sensor is not practical for field calibrations, and since many field service companies are not equipped with accurate electronic barometers, it is common practice to set the vented absolute pressure to be equal to the atmospheric pressure obtained from the site and the estimation formula on page 1.

Flow Computer Configuration

When configuring the static pressure input for an EFM device there is typically a selection box to select whether the pressure will be input as a gauge or absolute pressure value. A second input box is typically provided to enter the Atmospheric Pressure reference for the location. If using a gauge sensor the atmospheric pressure must be either measured or calculated using the estimation formula and entered as part of the configuration. If using an absolute pressure sensor there is no further need to enter a fixed atmospheric pressure, as a properly calibrated sensor will automatically provide this reference.

Flow Error Example

What are the effects of an incorrectly set atmospheric pressure reference on measurement? This largely depends on the actual static pressure that is being measured by the well. As the static pressure decreases, the effect of any error in the atmospheric pressure reference has an increased effect on the calculated flow rate.

One of the most common mistakes in well head EFM is to enter the atmospheric pressure reference as 101.325 kPa (the standard for sea level). Let's assume that the meter is installed at the Calgary Airport where the reference atmospheric pressure should be 88.7 kPa. Utilizing an industry standard calculation-check program with sample inputs, a comparison of the calculated flow rate with an incorrect atmospheric pressure input of 101.325

kPa versus the correct input of 88.7 kPa shows a 5% error for 50 kPa gauge readings. The effects at higher pressures are shown in the table and graph below:

Flow Calculation Inputs
Orifice Diameter: 50 mm
Pipe Diameter: 100 mm
Temperature: 20 C
Differential Pressure: 25 kPa

P gauge kPa	Flow Rate (E3M3)		Flow Rate Difference	Flow Rate % Error
	Patm = 101.325 kPa	Patm = 88.7 kPa		
50	31.40	29.91	1.50	5.01%
100	36.75	35.48	1.28	3.60%
200	45.64	44.61	1.03	2.30%
500	65.55	64.83	0.72	1.11%
1000	89.71	89.18	0.53	0.60%
5000	202.57	202.29	0.28	0.14%
10000	299.19	298.99	0.20	0.07%

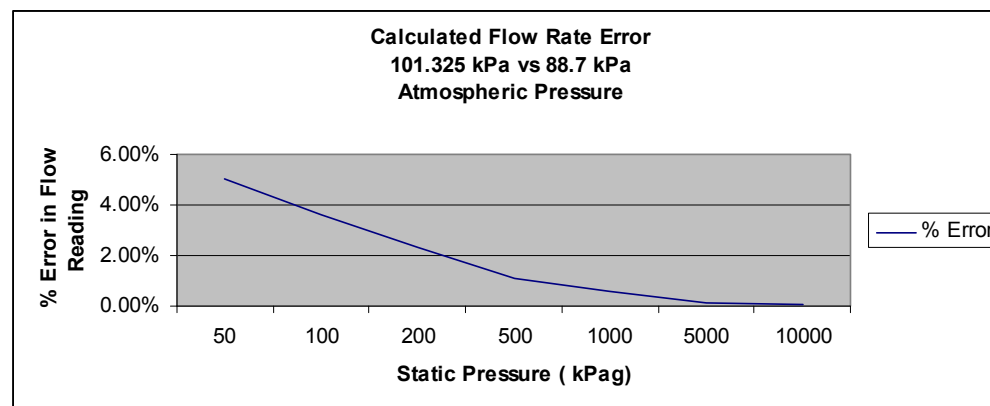Table 1: Flow Error due to Incorrectly Entered Atmospheric Pressure Reference

Fig. 1

From the above data you can see that a significant overstatement of the corrected volume is shown for pressures below 2000 kPa. As expected, the significance of the error diminishes as the static pressures climb. In practice, the effect of using an incorrect atmospheric pressure reference will have more effect at the well head especially in low pressure fields, than at a higher pressure sales or distribution point.

Conclusion
As the reservoir pressures decline in our traditional gas fields and with growing interest in the production of lower pressure coal bed methane wells, the error incurred by incorrect specification of the atmospheric pressure reference can begin to have a large effect on the overall accuracy of the measurement. Utilizing proper calibration equipment, or as a minimum, applying the estimation formulas to calculate the atmospheric pressure based on the elevation of the site, will help to minimize measurement errors.

Glossary of common pressure terms:

Absolute Pressure -   The sum of gauge pressure and atmospheric pressure.

Atmospheric Pressure - Pressure exerted on the earth by the weight of the atmosphere above it.

Barometric Pressure or
Station Pressure -   Local atmospheric pressure as measured using a barometer. This pressure is often reported by weather stations and is typically referenced to zero elevation (sea level) with the effects of elevation removed.

Contract Pressure -   This is the reference contract pressure condition that the gas volume being measured is to be corrected to. This value is 101.325 kPa in Canada.

Gauge Pressure -   Pressure exerted in the piping or vessel by the volume of gas being contained.

Standard Atmosphere -   101.325 kPa is generally considered a standard atmosphere at 0 m elevation above sea level.