WHITEPAPER

SIERRA

Sub-Metering of Natural Gas

Flexible Flow Measurement Delivers Improved Accuracy and Substantial Savings

by: Scott Rouse, VP Product Management, Sierra Instruments, Inc

After a decade of remarkable growth, the United States has become the world's number one producer of natural gas, and its largest consumer, with consumption in 2019 at 31 trillion cubic feet. This high growth rate is expected to continue. For example, electricity generation using natural gas has increased from 17% to 35% of total electrical consumption, and is likely to increase to 50% by mid-century.

This natural gas boom highlights the importance for utility companies to provide homes, businesses, and mid-to-large size facilities with accurate natural gas billing. Traditionally, utility companies have used diaphragm meters to measure natural gas usage, which is then charged to customers on their monthly energy bill. Although diaphragm meters are a trusted billing mechanism by utility companies, they may not provide customers with the most accurate natural gas bill. Diaphragm meters have limitations in natural gas measurement. If the diaphragm meter does not accurately measure the natural gas, this can result in utility companies overcharging customers.

To avoid this problem, many mid-to-large-size facilities use flow meters to sub-meter their natural gas usage to validate the diaphragm meters' readings and more efficiently allocate energy. Thermal flow meters have traditionally been an accurate device for sub-metering natural gas. But these meters are unable to compensate for the composition and pressure changes inherent in natural gas measurement. Recent advancements in thermal dispersion technology offer facility operators more advanced flow metering options to drive their energy management programs. By taking control of their energy management instead of relying on utility companies, facilities can save thousands of dollars in natural gas usage charges and improve energy allocation.

WHAT IS NATURAL GAS?

Natural gas is the cleanest burning fossil fuel, producing by-products of mostly carbon dioxide and water vapor. It is used extensively in power generation, industrial and commercial applications, and for home utility and heating. Natural gas is primarily a mixture of methane, ethane and propane, but those components can vary greatly. Table 1 shows the typical composition of gas delivered by Pacific Gas and Electric (PG and E).

Natural Gas Composition Analysis	
CONSTITUENT	PERCENT BY VOLUME
Methane	95.60
Ethane	2.27
Propane	0.10
n-Butane	0.01
i-Butane	0.01
Nitrogen	1.30
Carbon dioxide	0.71
Total	100.00

Table 1. Pacific Gas and Electric Natural Gas Analysis

> "If the diaphragm meter does not accurately measure the natural gas, this can result in utility companies overcharging customers."

One British thermal unit (BTU) is equal to the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit at atmospheric pressure. One standard cubic foot of natural gas has an average heating capacity of approximately 1000 BTUs. This value varies with gas composition, and since utilities use gases from different sources at different times of the day, the heating value changes as well. The heating value for PG and E natural gas is required to range between 990 and 1,050 BTU/ft3 and will normally range from 1,000 to 1,030 BTUs per standard cubic feet.

> "Temperature, pressure and heating value compensation must be made to measure the actual amount and value of gas moving through a meter."

DEALING WITH CHANGING COMPOSITIONS AND DELIVERY PRESSURE

The most common type of gas meter, seen in almost all residential and small commercial installations, is a diaphragm meter. Utility companies use diaphragm meters to measure the flow rate of natural gas and monetize the usage for billing (See Figure 1).

Within the meter there are two or more chambers formed by movable diaphragms. With the gas flow directed by internal valves, the chambers alternately fill and expel gas, producing a near continuous flow through the meter. As the diaphragms expand and contract, levers connected to cranks convert the linear motion of the diaphragms into the rotary motion of a crank shaft, which serves as the primary flow element. This shaft can drive an odometer-like counter mechanism or it can produce electrical pulses for a flow computer (a smart meter).

Diaphragm gas meters are positive displacement meters. These gas meters measure a defined volume, regardless of the pressurized quantity or composition of the gas flowing through the meter. Temperature, pressure and heating value compensation must be made to measure the actual amount and value of gas moving through a meter. These fixed compensation variables used by utility companies can yield inaccuracies and overcharging of utility bills. For example, the diaphragm meter typically measures the natural gas volume in hundreds of cubic feet (CCF); however, the consumer is billed in therms, where one therm is equal to 100,000 BTUs. Customers are billed by taking the gas meter reading in cubic feet, converting this value to therms, then applying a multiplier that is the product of the heat value of the gas (composition dependent) times the gas density (pressure dependent).

Figure 1. Diaphragm Meters

A typical home or business may receive natural gas at .7 psig with a heating value of around 1030 BTU/ft3. Applying a correction factor for the heating value of 1030/1000 equals 1.025 and a correction factor for the density of (0.7 + 14.7)/14.7 equals 1.048. The overall correction factor is 1.025 x 1.048 = 1.074. This multiplier is applied to therms consumed and the consumer is billed according to the result.

Ideally this multiplier will be 1.000. The energy value of the gas in BTUs is normally 1000 BTU/ft3 when averaged over time, but this assumes the utility company is tracking this value throughout the year and making the necessary adjustments in the multiplier. The density portion of the multiplier is where more variability is seen, as pressure in delivery lines can vary with the demand placed on them or may be controlled with poor pressure regulation. As an example, if the pressure in the gas delivery line drops from 0.7 psig to 0.25 psig the correction factor changes from 1.048 to (0.25 + 14.7) / 14.7 = 1.17. That is a 12% increase in the consumer's bill, potentially putting the customer in a higher usage tier. As mentioned, the diaphragm meter is a volumetric meter, while natural gas is sold on the basis of mass. Volumetric meters cannot account for changes in gas composition nor deal with changes in pressure and temperature (and hence density). Such changes must be corrected for, and the consumer is at the mercy of the utility company to make those corrections.

SUB-METERING VERIFIES CUSTODY TRANSFER OF NATURAL GAS

While such overcharging may not hurt the average homeowner, it can add significantly to the energy bill for mid-to-large-sized factories, campuses, or universities. These facilities traditionally use large quantities of natural gas, so inaccurate natural gas measurement can move them above their baseline usage tier. This has led many facilities to sub-meter the natural gas entering the facility. Using a flow meter for sub-metering, facilities can compare the utility's gas usage totals to the natural gas measurement totals that the sub-meters provide (See Figure 2).

Sub-metering verifies the accuracy of the monthly utility bill and monitors which buildings or processes use the most natural gas. This valuable information on energy usage improves energy management efficiency and decreases natural gas costs. Traditional thermal flow meters have been successfully used in sub-metering applications. But the flaw in these devices is they cannot automatically adjust for changing gas composition and pressure changes. When these variables change, the meter must be returned to the factory for recalibration to remain accurate.

NEW TECHNOLOGY SOLVES OLD PROBLEMS

Four-sensor technology by Sierra Instruments has provided a new method for dealing with changing natural gas compositions and density changes caused by pressure variations with high accuracy. This flow meter corrects for density variations using the AGA Report No. 8 *(American Gas Association, "Compressibility Factor for Natural Gas and Related Hydrocarbon Gases") approved density equation for natural gas.

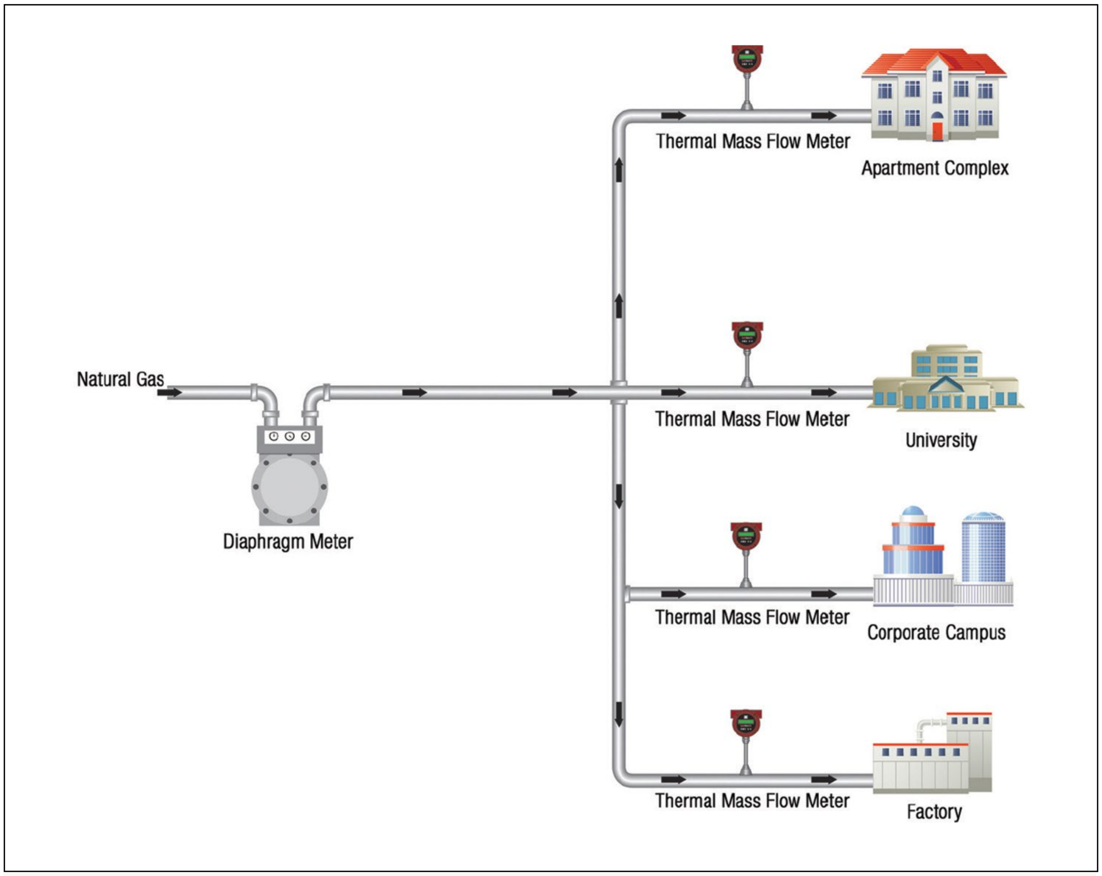

Figure 2. Sub-Metering Natural Gas to Mid-Size Facilities

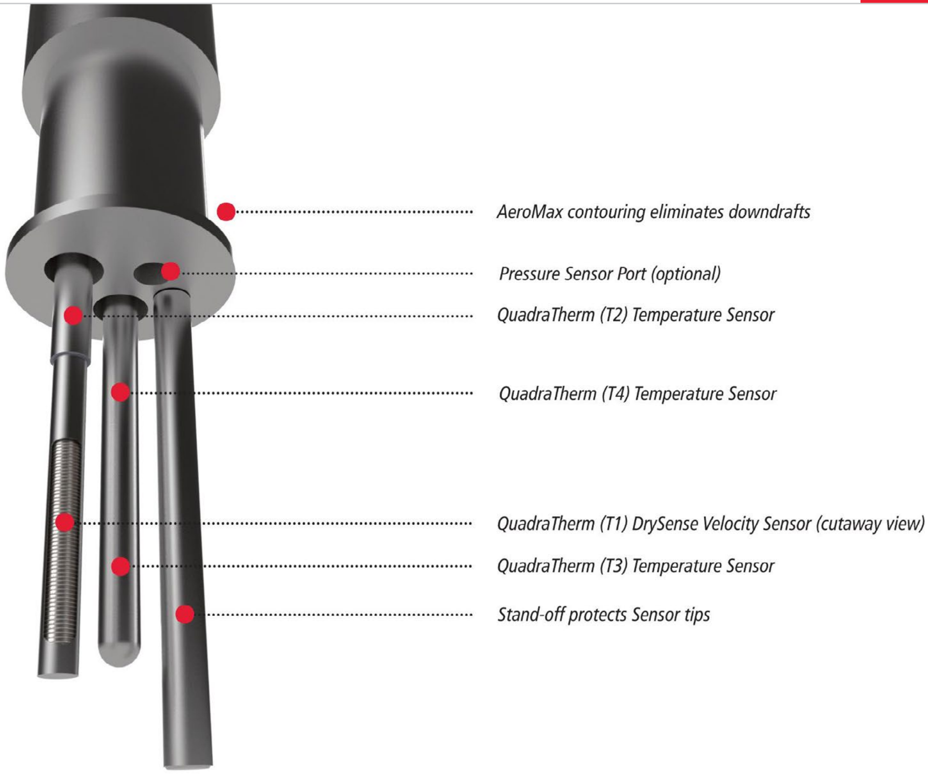

Figure 3. QuadraTherm® Four-Sensor Thermal Dispersion Sensor by Sierra Instruments

Instead of having two temperature sensors, one a temperature sensor in the temperature probe and the other a self-heated sensor in the velocity probe, there is an additional sensor in each, giving a total of four temperature sensors. The extra temperature sensor in the stem of each probe measures the stem conduction, which is a function of the total heat transfer budget and must be accounted for. Stem conduction depends on the ambient temperature outside of the pipe. (See Figure 3).

Measuring flow is challenging in field applications. A fully developed flow profile in which the velocity is zero at the wall of the pipe and maximum velocity at the center is ideal, but will not occur if there are elbows, other valves or bends in the pipe. An accurate measurement requires the gas to pass through a flow conditioner. The QuadraTherm employs a double screen setup for that purpose.

* *AGA, the American Gas Association, is a nonprofit organization that develops and publishes standards for the natural gas industry. AGA standards are used by more than 200 energy companies that collectively provide natural gas to 91% of the United States market. AGA Report No. 8, "Compressibility Factor of Natural Gas and Re-lated Hydrocarbon Gases", presents the information needed to compute gas densities and compressibility factors for natural gas and other related hydrocarbon gases. The density and compressibility of natural gas are critical parameters in determining the mass flow rates and heating values associated with the sale (custody transfer of natural gas.*

ACCURACY MUCH BETTER THAN DIAPHRAGM METER

The traditional analog measurement circuit is now a fast microprocessor that runs a comprehensive flow-measurement algorithm. This algorithm solves the first law of thermodynamics and calculates the various heat transfer properties of the gas and even the mass flow rate even when the outside temperature changes plus or minus 50 degrees centigrade. Accuracy for these thermal meters is +/- 0. 5% of reading for in-line meters, better than the 1.0% reading usual for a diaphragm meter (See figure 4).

Figure 4: QuadraTherm 640i / 780i Mass Flow Meters by Sierra

CHANGING GAS COMPOSITION USING QMIX TECHNOLOGY

Four-sensor technology has the capability to address changes natural gas compositions with “dial-a-gas”. The meter can hold four gas mixtures on-board, allowing facilities managers to select the appropriate heating value through qMix software. As pointed out above, two-sensor thermal flow meters need to be sent back to the factory for recalibration each time the gas composition changes or the application specification changes. Quadratherm also has the capacity to totalize four different tiers, allowing consumers to enter different dollar rates for baseline usage and every tier exceeded.

ENERGY MANAGEMENT IN THE FUTURE

In the next decade, efficient energy management will be a cornerstone to the profitability of mid-to-large-size facilities. Through managing energy costs, including natural gas, facilities can save thousands of dollars a year in reduced utility bills. Facilities managers will continue to need the most accurate and flexible sub-metering flow meters on the market to drive down energy costs and keep utility companies in check. They will no longer be at the mercy of utility company correction factors.

> "Through managing energy costs, including natural gas, facilities can save thousands of dollars a year in reduced utility bills."

Scott A. Rouse

currently serves as Vice President of Product Management at Sierra Instruments, where he has been employed for over a decade. Rouse obtained his bachelor's degree in Chemical Engineering from the University of Texas at Austin. He can be reached at s_rouse@sierrainstruments.com.

Contact Sierra

Sierra Instruments
5 Harris Court, Building L
Monterey, CA 93940 / USA
USA: 831.373.0200
Europe: +31 71 5071400
China: +8621 5879 8521 (8522)
Email: info@sierrainstruments.com
Contact us: sierrainstruments.com/contactus
www.sierrainstruments.com

DISCOVER MORE

sierrainstruments.com/library/infographics/natural-gas-infographic
sierrainstruments.com/products/upgrades/qmix.html
sierrainstruments.com/library/tags/natural-gas-measurement-control
See other Flow Energy Management solutions

PN 99-2203 REV D