

ULTRASONIC METERS FOR RESIDENTIAL AND COMMERCIAL APPLICATIONS



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INTRODUCTION

An ultrasonic meter falls into the classification of inferential meters. Unlike positive displacement meters that capture volume to totalize volume, inferential meters measure flowing gas velocity to totalize volume. Ultrasonic meters use sound waves to measure flowing gas velocity to infer volume, and have been around for many years, primarily in liquid measurement. However, we are seeing more and more applications in the natural gas industry.

ULTRASONIC THEORY

An ultrasonic flow meter normally operates based upon the time-of-flight or the Doppler principle. A meter utilizing the Doppler principle requires “particles” in the flow stream to reflect waves. When people think of the Doppler principle, they think of weather and police radar. The rain and your car are the “particles” used to reflect the waves. This sort of meter is common in liquid measurement because bubbles can be introduced into the liquid to reflect the waves.

Ultrasonic meters used for gas measurement typically utilize the time-of-flight principle due to a lack of “particles” to reflect the sound waves. Meters that utilize the time-of-flight principle are basically a very accurate clock. The meters measure the very small difference in the time that it takes an ultrasonic pulse to travel a known distance with and against the gas stream. Transducers typically are capable of both generating and receiving ultrasonic pulses. An ultrasonic meter for distribution applications will typically use one pair of transducers to measure the speed of gas. Higher capacity meters used in transmission applications tend to use multiple pairs of transducers to measure the velocity of the gas. An ultrasonic meter that has at least two independent pairs of measuring transducers is called a multipath meter. While differences in the flow profile are generally insignificant for distribution customers due to the small flow area, they can dramatically affect measurement in transmission pipeline applications. Larger pipeline ultrasonic meters use multiple pairs of transducers to obtain a better sampling of the flow profile - the more pairs, the better definition of the flow profile, the better estimate of the true velocity measurement. On the other hand, small distribution piping single path ultrasonic meters can accurately estimate the flow velocity from a single pair of transducers.

A simple explanation of the theory of a single path meter starts with the gas flowing through the meter with a speed of v . Multipath meters operate the same way, except that they use multiple pairs of transducers to sample the velocity profile. The transducers take turns producing and receiving ultrasonic pulses that travel with and against the flow of the gas. While one transducer is sending a pulse the other transducer is acting as a receiver. The difference in time it takes for the pulse to reach the transducers is used to calculate the speed of the gas. The simplified derivation of the formula is as follows:

t_1 = time it takes pulse to reach the transducer in the direction of flow

t_2 = time it takes pulse to reach the transducer against flow

L = length of measuring chamber

c = speed of sound in the gas (approx. 1400 ft/sec)

v = velocity of the gas

$$t_1 = \frac{L}{(c + v)} \quad (1)$$

$$t_2 = \frac{L}{(c - v)} \quad (2)$$

By rearranging the terms, and then subtracting equation (2) from equation (1), one can determine the velocity of the gas from:

$$v = \left[\frac{\Delta t}{t_1 \times t_2} \right] \times \frac{L}{2}$$

Once the velocity of the gas is calculated, v , the volume of flow is calculated by multiplying the velocity times the cross-sectional area of the flow tube.

The speed of sound of the velocity of the gas can be calculated by rearranges the terms and then adding equations (1) and (2). The speed of sound in the gas is then determined from:

$$c = \frac{L}{2} \times \left[\frac{t_2 + t_1}{t_2 \times t_1} \right]$$

By periodically checking the speed of sound, the meter can verify that the gas has not changed dramatically, or that the measurement has not drifted. It can also be used for tamper detection if a meter is exposed to air.

Composition, temperature, and pressure can all affect the speed of sound in the gas.

TRANSDUCERS

Transducers are composed of several parts (Figure 1.). Piezoelectric elements are the heart of any ultrasonic meter transducer. They are typically made from PZT (lead zirconate titanate). They exhibit the property of becoming electrically charged when subjected to mechanical stress. That is, they generate a small electric charge when they are compressed due to a force acting on them. Conversely, they will expand when they are excited with a small electric charge. The electrical leads are used to transmit the electrical charges to the meter's electronics. Since a piezoelectric element is a poor conductor of motion, a low-density material is put on the face of the piezoelectric element to amplify the waves of energy. This material is called the quarter wave plate. Behind and around the sides of the piezoelectric element is a dense backing material. This material is used to minimize the flow of energy towards the back and sides of the transducer. A cap is put on the face of the quarter wave plate to protect the material from anything in the gas stream, such as (contaminants, moisture, sand, and debris).

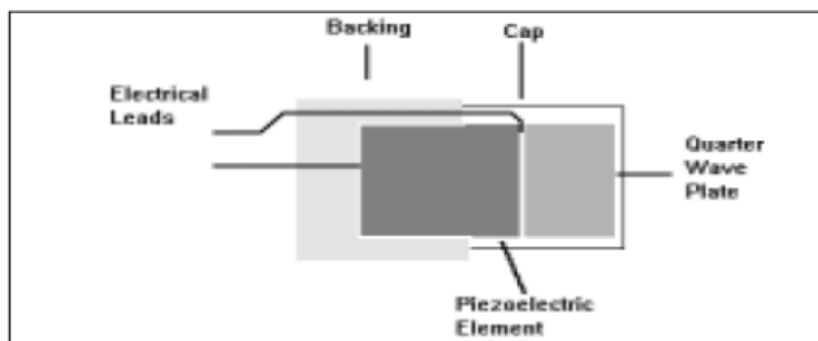


FIGURE 1

Putting it all together, Figure 2 shows one of the basic single-path ultrasonic meter schematics

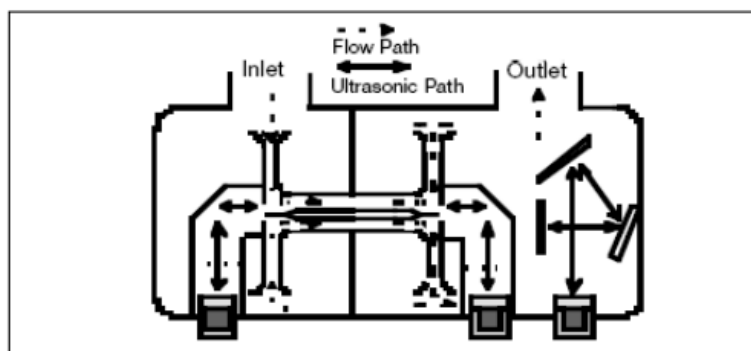


FIGURE 2

Figure 3 shows a variation of a single-path ultrasonic meter schematic using a signal bounce pattern

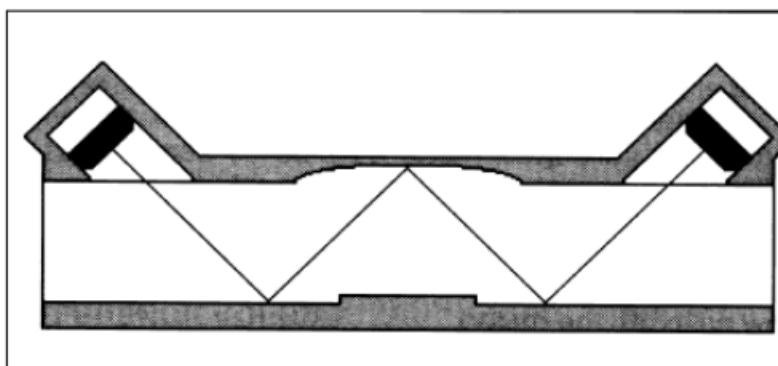


FIGURE 3

RESIDENTIAL ULTRASONIC METERS

Gas meters are important for gas supply companies because they are the basis for billing. Therefore, it is critical that a gas meter continuously and accurately measures how much gas is delivered to the customer. Since the basics of how these measurements are conducted have been nearly unchanged for decades, the industry is ripe for disruption. The commercial viability of ultrasonic gas meters is poised to deliver stiff competition to the traditional mechanical diaphragm equivalent, and the switch to “smart gas” will accelerate this.

While ultrasonic metering technology is not new, it has only recently become cost competitive with mechanical alternatives. Ultrasonic meters also deliver many advantages, including precision dramatically reduced wear and tear, and compatibility with advanced, smart gas metering infrastructure. The ultrasonic gas meter is now poised to be a game changer in residential gas metering. Forward thinking gas utilities that adopt this technology can leverage its advantages to increase process efficiencies and hone a competitive advantage in the smart gas landscape.

History of ultrasonic gas metering

After several decades of use, ultrasonic flow technology got an unexpected boost in the late 1980's when British Gas set up a competition to develop a more compact gas flow meter. Two of the winning entries used ultrasonic technology as the driver and showed promise at this early stage, ultimately leading to a single-path ultrasonic meter. Originally developed for the European market, this new and improved design was more compact and accurate than traditional diaphragm meters. Over 1.3 million residential single-path ultrasonic meters of this design were produced between 1993 and 2000.

On the heels of this success in Europe, ultrasonic gas meters were ready for a test drive in North America. While residential ultrasonic gas meters have made steady inroads since their introduction in 2000, the higher cost – almost three times that of a residential mechanical meter – prevented wider adoption.

That no longer remains true today, especially with the additional features and benefits available in the ultrasonic meter's electronic platforms. Modern ultrasonic meters, which are now priced competitively against traditional diaphragm meters, are positioned for rapid growth in North America. Below are some of the residential single-path ultrasonic meters immersing in the North American Market.

Residential

- Today, there are several single path ultrasonic meters being offered in the North American market



INDUSTRIAL AND COMMERCIAL APPLICATIONS

The single path ultrasonic technology has even expanded into larger industrial and commercial size measurement applications. The Sensus Sonix2000 meter actually uses two single path flow tubes to achieve a capacity of 3000 CFH at 1.3" W.C. differential. The volumes measured in each of the flow tubes is summed to obtain the total volume passing thru the meter. In theory, it is conceivable to continue adding single flow tubes to achieve greater capacities. However, there is an economy of scale that would be reached. The single path technology is scalable up to a certain point, then multiple paths are needed to obtain a better estimate of the true velocity for accurate measurement in larger single flow tubes (pipes).

The electronic platform of industrial and commercial ultrasonic meters affords all the features and benefits of residential ultrasonic meters. They have significant - size and weight advantages over equivalent capacity mechanical meters yet cost roughly the same as their mechanical counterpart. While most residential ultrasonic meters have pressure measuring for monitoring, the cost of a pressure transducer accurate enough for pressure compensation in residential meters is cost prohibitive. Additionally, with most residential applications operating under 2 psig, pressure compensation is not used, or fixed factored pressure compensation is applied. However, in industrial and commercial applications operating at higher pressures, an accurate pressure transducer can be included to provide accurate pressure correction. This, in combination with live temperature measurement results in a built-in electronic volume corrector.

Below are some examples of industrial and commercial single path ultrasonic meters.

Commercial and Industrial Applications

- In 2002, commercial and industrial single path ultrasonic meters started to take their places in North American markets



MULTIPATH ULTRASONIC METERS

Multipath meters appear to be more applicable to larger pipe sizes where flow profiles may vary, and more velocity samples are required to provide accurate results. This makes Multipath meters more expensive, but they are measuring greater volumes at higher pressures. The single-path ultrasonic meters appear to be settling into residential and light commercial distribution applications where the volumes and pressures are considerably less than their Multipath counterparts. This permits single path measurement of the smaller flow areas to be very applicable.

ADVANTAGES OF ULTRASONIC OVER MECHANICAL METERS

Ultrasonic flow meters boast several advantages compared to the traditional mechanical diaphragm meters. First, they are far more precise and measure a larger range of gas flows and usage swings. Second, ultrasonic flow meters have no mechanical components to wear out and can go for a much longer period without maintenance. By contrast, diaphragm meters are made of elastomers that stiffen, shrink or change shape with changing temperatures, accelerating wear and tear. Third, the solid-state construction of ultrasonic gas meters means greater resistance to freezing and contamination of parts, which prolongs life and enables them to operate under a wide variety of environmental conditions. Finally, the ultrasonic gas meters are smaller and lighter, facilitating installation in tight spaces. Most residential single path ultrasonic gas meters weigh about 6 pounds or less, while mechanical equivalents can weigh four times that amount. It typically takes just one worker to install a residential single path ultrasonic gas meter.

Until recently, the only obstacle to the adoption of ultrasonic residential gas flow meters was cost. With mass production, automated assembly and testing, the key technologies used in ultrasonic flow meters — long-life batteries, transducers, sensors and inexpensive microcontrollers powerful enough to perform the analysis in real time — are decreasing in cost.

The single path ultrasonic flow meter is connected to the utility and provides continuous usage logs, leading to more accurate billing statements. In addition, the residential ultrasonic meters are theft and tamper resistant, which also reduces lost revenue.

A FOUNDATION FOR SMART GAS

In addition to being cost competitive while offering more benefits, modern ultrasonic meters are also capable of adapting to future technologies like smart gas and advanced metering infrastructure (AMI).

As ultrasonic flow meters containing microcontrollers become more common in residential gas pipes, additional use cases will likely follow. Intelligent meters can now send the gas readings directly to the utility's remote billing computer over a wireless network, replacing the traditional method of inspecting the indicators on each meter and recording the gas readings manually.

With ultrasonic gas flow meters, utilities get more than just a remote meter read. They can access comprehensive data logs that include corrected volume, uncorrected volume, pressure, temperature and alarm information. Applications residing in the back-end system monitor this steady stream of information, including pressure. Since automatic thresholds can be used to trigger the remote shut-off feature, it does not require additional prompting from the utility company. A proactive approach to gas management leads to greater efficiencies in terms of time, labor and safety for all parties.

It is also possible to remotely send commands the opposite way - from the central utility to the microcontroller, allowing the utility to control the meter without a truck roll. The microcontroller can actuate a valve inside the meter and shut off the gas. Ultrasonic gas meters provide the foundation for a smart grid that monitors and reacts to situations like over-pressurization, temperature extremes, excess flow, theft attempts, and other natural disasters.

Additional features and functionalities are also wirelessly delivered to the microcontroller as software updates. In this way, the entire utility network can be made more intelligent over time as features and functions are made available.

Today's ultrasonic meters combine 30-year track record of success and the cost competitiveness of modern manufacturing. Residential ultrasonic gas meters are the best choice when it comes to efficiency and lasting value. They are smaller, lighter, tamper- and theft-proof and operate accurately under a variety of environmental conditions and usage situations. The shovel-ready interface to the smart gas technologies of tomorrow means companies making the switch to ultrasonic meters can now get ahead of the competition and stay there.

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[AMI Trends and Developments in Gas and Water Utilities Ultrasonic Domestic Gas Meters — A Review](#)
[Ultrasonic Flowmeters: A Sound Technology Ultrasonic Meters for Commercial Applications](#)