by Curtis Gulaga

Where flare measurement matters

Meters vary in ability to read flowing velocities

There are two primary concerns industry has when it comes to measuring flare gas and complying with provincial regulations; Overall range ability with an emphasis on low-flow repeatability, as well as the ability to adapt to changing process conditions that include flow rates and per cent of carbon dioxide, hydrogen sulfide and methane, to name a few.

Currently, transit time ultrasonic meters are the technology of choice for measuring flare gas. Yet many might not appreciate that not all such meters are capable of measuring at atmospheric pressures, or measuring velocities up to and beyond 120 m/s. This includes clamp-on and most custody transfer-type meters.

Base design conditions for flowing velocities in distribution and transmission pipelines are limited to 21 m/s in accordance to API Report 14E due to internal erosion and vibration components. Velocities at this rate may be measured using only continuous sine-wave signals with frequencies ranging from 135 to 210 KHz.

When measuring velocities in a flare line, transducers with lower frequencies — such as 60 to100 KHz — are more appropriate, along with a combination of both continuous and variable frequency signals. Just as low-frequency bass from an amplifier will travel further than high-frequency treble, the same is true in ultrasonic meters.Utilizing a continuous sine-wave signal in combination with variable frequency, also known as "chirp," will help overcome the noise generated from high-velocity gas.

For improved accuracy and resolution at the low end, it is important to first use a frequency sweep or variable frequency to define the transition time with the accuracy of one period (acoustic term for one sine wave).

Then, further increase the resolution into a fraction of a period by using a continuous wave or single frequency burst up to 20 m/s.

Figure 1 illustrates a velocity range of 0.3 to 0.6 m/s (Y axis). The meter measurements are the blue lines. The green and red lines denote an industry standard uncertainty of plus or minus five per cent. The results of an uncalibrated FGM 160 are significantly better, and demonstrate even narrower uncertainty ranges within plus or minus 2.5 per cent, and repeatability better than one per cent.

To compensate for changing process conditions, and overcome the noise generated from high-velocity gas, the frequencies are varied from 60 to 100 KHz in one transducer pair. This enhances the cross-correlation technique by providing an exact match between the transmitted and received waveform (Figure 2).

Changing process conditions or line size will have no affect, unlike for fixed-frequency transducers (Figure 3). Since ultrasonic transit time meters rely on the time difference between the upstream and downstream signals, it is critical to accurately identify the beginning and end of each frequency cycle.

Figure 4 demonstrates a variable frequency, or "chirp" signal. The combination of variable frequency and cross correlation provides an accurate time measurement for sound propagation between the two transducers.

Each transducer is dampened and considered wide band, with no oscillating behavior. This, combined with digital signal processing (DSP), enables us to follow distinct sound patterns and transmit time information more accurately than others using analogue technology. Many signals are sent out at variable frequencies to gain a high degree of statistical confidence.

Constant frequency transducers — such as 42, 80, or 135 KHz — are considered narrow band. Their frequencies do not vary, and cross correlation is achieved only to their specific pattern. For this reason, it is difficult to obtain the same tight resolutions down to fractions of one period.

Changing the physical shape by adding mass around a transducer face in an attempt to reduce noise increases the risks. The mass may act as an acoustic coupling and potentially conduct sound requiring even further amplification of the signal, eventually causing distortion.

Understanding that the hit rate of cross correlation is linked to the amount of noise in the process, it is easy to determine why a distorted signal in a high-noise environment may not produce the resolution required to measure velocities beyond 90 m/s. Cases of recorded velocities up to 120m/s have been accomplished in smaller diameter pipe with ideal gas compositions.

The combination of continuous sine wave and variable frequencies using wide band transducers and cross correlation enables superior resolution over the entire range of 0.03 to 120 m/s. Changing the physical characteristics of a transducer, or adding a second path to accomplish the same turn-down requirements of 4000:1, is not required.

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FIGURE #1

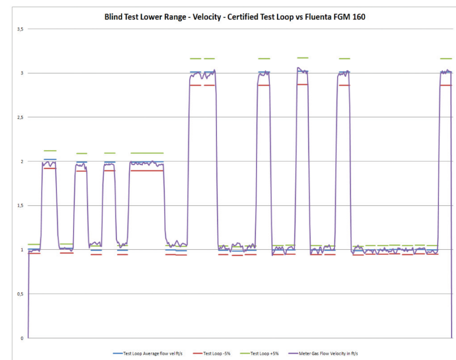

FIGURE #2

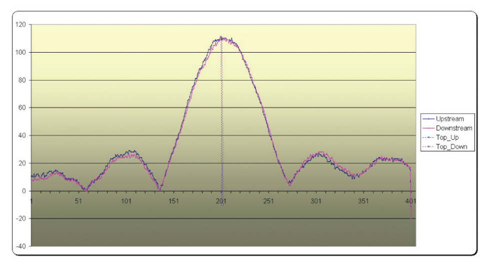

FIGURE #3

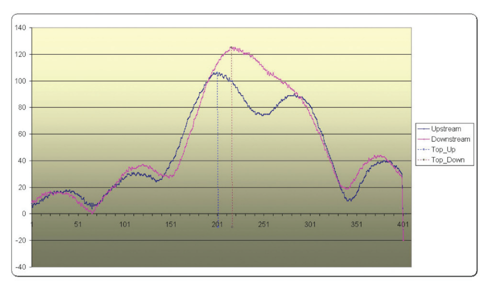

FIGURE #4