Flare Measurement – Best Practices

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, and the ability to adapt to changing process conditions that include flow rates, percent CO2, H2S, Methane, etc.

It has been well proven that transit time ultrasonic meters are the technology of choice for measuring flare gas. What isn't fully understood is not all transit time 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 generally 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 – 210 KHz. When measuring extreme velocities in a flare line, transducers with lower frequencies such as 60-100 KHz should be considered along with a combination of both continuous and variable frequency signals. Just as low frequency bass from an amplifier will travel further then high frequency treble, the same is true in ultrasonic flow 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, we 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). We 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 predominately 0.3 – 0.6 m/s (Y axis). The flare meter measurements are the blue lines with the green and red lines denoting an industry standard uncertainty of +/- 5%. As one can see, the results of an uncalibrated FGM 160 are significantly better, and demonstrate even narrower uncertainty ranges with in +/- 2.5% with repeatability better then 1.0%.

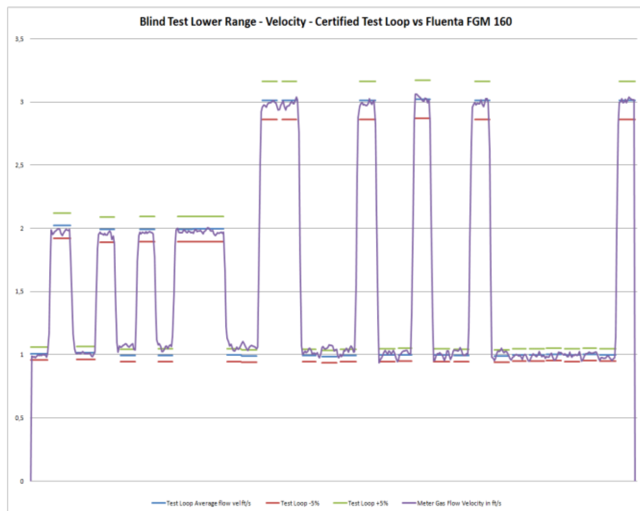

Figure 1

To compensate for changing process conditions, and overcome the noise generated from high velocity gas, the frequencies are varied from 60 KHz to 100 KHz using only one transducer pair. This enhances the cross correlation technique by providing a full exact match of the transmitted and received waveform as demonstrated in Figure 2. Changing process conditions or line size will have no effect, unlike for fixed frequency transducers as demonstrated in 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.

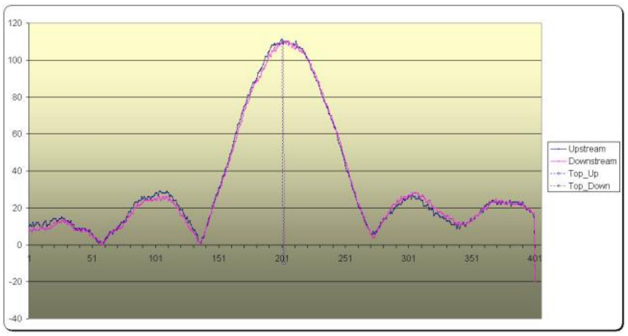

Figure 2

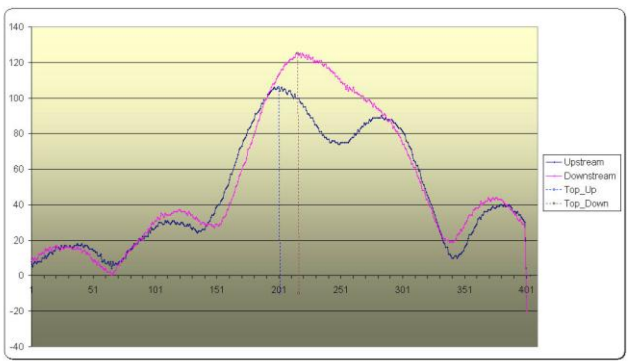

Figure 3

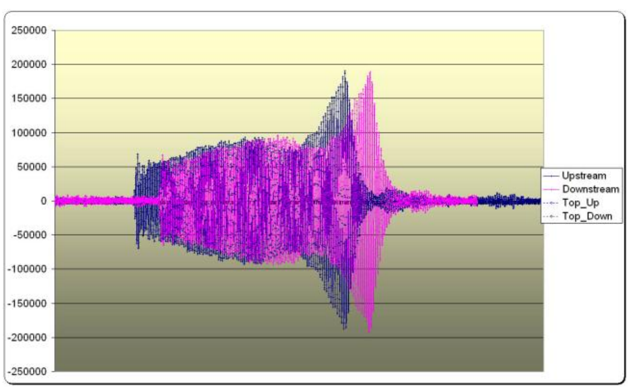

Figure 4

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. Cross correlation is a statistical term. Constant frequency transducers such as 42khz, 80khz, or 135khz 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 unless given more time, which is often not an option in rapidly changing processes found in flare applications.

Changing the physical shape by adding mass around a transducer face in an attempt to reduce noise brings added risk. The mass may act as an acoustic coupling and potentially conduct sound requiring even further amplification of the signal, eventually causing distortion. Understanding the hit rate of cross correlation is directly related to the amount of noise in the process, it is easy to see that 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 0.03-120m/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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