Effect of noise in the performance of the transducers in an ultrasonic flow meter of natural gas

Main author

R. Villarroel

Venezuela
ABSTRACT

Harvest Vinccler C.A. (Oil and Gas Operator) since November 2003 placed in operation a 12” 103 KM gas pipeline with a capacity of handling of 125 MMSCFD. An ultrasonic flow meter skid was installed at the delivery point for custody and transfer measurement of the natural gas volume to be sent to our client. After a few months of smooth operation of the system, the ultrasonic flow meter started having measurements problems caused by noise interferences in the transit times of the sound waves that are emitted for the transducers. This condition was observed by the increase of the flow velocities through the meter that limited the conditions of pressure in the delivery of gas volumes.

This work describes a statistical and systematic analysis of all the ultrasonic signal waveforms in the pairs of the transducers and performs frequency spectrum analyses of the signals from the transducers at different flowing conditions. Additionally, an analysis of different accessories that can produce noise was made. All the corrective actions that were carried out to resolve the problem are described in the report. Through this method was determined that the root cause of the problem was located in the flow conditioner and after making the corrective actions, the meter has not presented problem by this cause maintaining a reliability of 100%.
1. Introduction

The South Monagas Unit (SMU) is located in Eastern Venezuela about 800 Km from Caracas. SMU is producing Oil and Gas from 3 fields: Uracoa, Bombal and Tucupita. The produced gas enters in the compressor plants at two levels of pressure that are to 45 psig and 260 psig; the natural gas is compressed up to 1600 psig. At the moment an installed capacity of compression is good to handle 45 MMPCND in the low pressure system (45 psig) and of 60 MMPCND in the medium pressure system (260 psig).

Then a fraction of the compressed gas is transferred to the gas lift network system to lift several wells in the field, and some portion goes to the gas injection wells for reservoir maintenance and the other fraction is transported to the gas national network of PDVSA. The transference of the natural gas is performed fulfilling the specifications of water content thus is treated in a plant of natural gas dehydration and is transported through a gas pipeline of 12 inches with a length of 32 miles. In the delivery station there is a skid of measurement for the custody transfer and this made up of an ultrasonic flowmeter, gas chromatograph in line, temperature and pressure transmitters and a flow computer.

SMU started transferring gas to PDVSA (state owned) in the month of November of 2003 with the goal to transfer the natural gas coming from the Uracoa and Bombal fields, which are estimated in 198 BCF.

2. Background

On November 25th of 2003, Harvest Vinccler started to transfer gas to PDVSA at a rate of approximately 70 MMSCFD. After one month of the pipeline being in operation, we started to see missing values in the gas measurement through the ultrasonic flowmeter. when one appears this situation is come to make the inspection in site of the equipment though a software which presents the condition of each pair of transducers and the behavior of important variables present as they are the gain, transit times, speed relations and the performance of the transducers.

When it is made the analysis of frequency of signal of the transducers is observed that there is great interference in the curve as is shown in figure 1. These interferences are observed in all the pairs of transducers which affect the measurement.

When a transducer can not communicate with its pair appears a signal of fault and the configuration establishes that when having 3 pairs of transducers in fault the instantaneous measurement is 0 MMSCFD. Established the premise in the configuration it is observed as the behavior in the first month were affected as a result of the problem that was appearing in the transducers.

3. Theory of operation.

Due to this situation it was decided to form a work team, to study the cause of the failure.

The team was set up between HV and Daniel’s specialist, to investigate the possible reasons that led the meter to have erroneous measurements.

It was used a software called CUI “Computer Ultrasonic Interface” (provided by Daniel Company) which allows observing the different variables of the performance of the ultrasonic flowmeter, among them are:
Flow Profile

It is a relationship of velocities in a plane upstream of a meter that defines the condition of the flow into the meter. The flow profile or pattern across the meter is very important for accurate flow measurement. The main contributing factors that control flow profile are gas composition, and piping configuration including length, smoothness, roundness and fittings such as tees, elbows and valves.

Transducers and Chords

The ultrasonic flowmeter to which this study talks about uses eight transducers, two for each path. Each path is given a name, Chord A, Chord B, Chord C and Chord D. Each path or chord is located on a separate plane of the pipe.

Each transducer sequentially acts as a transmitter and a receiver. An ultrasonic wave is transmitted from one transmitter, travel through the gas, and is received by the transmitter located in the same plane or chord.

Transit times

It is the time it takes for the sound waves to travel from one transmitter, through the flowing gas, and be detected by the receiving transmitter on the same plane. There are two types of transit times:

- Time it takes for the sound to travel through the gas going in an upstream to downstream direction.
- Time it takes for the sound to travel through the gas going in a downstream to upstream direction.

The time for the sound wave to travel upstream to downstream is less (it is aided by the velocity of gas) that the time it takes for the wave to travel from downstream to upstream (it is slowed by the velocity of the gas).

Interference of noise in the pairs of transducers

The pressure falls affect directly in the measurement since these can produce noise in the same rank of frequency that the ultrasonic flowmeter. The ultrasonic flowmeter operate in a rank of frequency between 80 and 180 KHz, when noise presence exists, the signals that are emitted between the transducers are interfered with and it produces a direct influence in the measurement of the transit time and by consequence errors are generated in the values reported by the UFM.

4. Problem Analysis.

When it is begun to analyze the data in the tendencies of the operation variables are observed that the alarm that displays the ultrasonic flowmeter was “signal rejected-signal to noise ratio”. When we observed the alarm report this is the one that appeared most frequently thus we delimited the problem to possible causes that could be generating noise.

In figure 1 the behavior of waveforms of the transducers is observed and the presence of noise in the measurer can be appreciated. The distortion in the time is the sum of the signal of the transducer and the signal emitted by the noise, this line must be a straight line (Figure 2). When there is a distortion like which it is observed in Figure 1, immediately one is due to look for as it is the noise sourcing that is affecting the measurement.

All the studies made based the noise generation on the control valves located downstream of the flowmeter. It is very difficult to determine where the noise is generated, since once generated the noise travels as well as downstream as upstream.
When studying the mechanical scheme where the ultrasonic flowmeter was located it was observed that they were closely together the pressure control valves that were downstream of the flowmeter. In spite of fulfilling the standards established as far as the minimum distance with respect to the flowmeter, the valves produced a high noise by the pressure differential that appeared in the trim of the valve. After analyzing this situation it was determined that the specifications of the valves fulfilled the necessary requirements and were adapted for the use.

The engineering department proposed to make a new configuration in which the pressure control valves would be move to avoid that the noise caused by the valves did not interfere in the communication of the transducers. This option appears in the annexes and it had an approximated cost of 150,000 USD.

The conditions of the flow hit directly on the velocity profiles, therefore in the ultrasonic flowmeter it is recommended to use a profiler to mitigate the effects of the flow and to obtain a flow uniforms and stable in the measurement area.

It is difficult to think that the profiler can have negative effects on the measurement and to even generate noises in frequency that affect the measurement. However, because of the noise was also observed upstream it was made the decision to stop the gas transference to check the profiler. When the profiler was inspected internally, it was found that it had obstruction of about 30 % of the flow area due to some kind of debris, dirt and wire mesh etc etc. Immediately, after the obstruction was cleared the pipeline was put back in operation.

![Figure Nº 1. Waveforms Viewer Transducer A. Date 09-Jul-2004.](image-url)
After the gas pipeline was placed in operation, a diagnosis of the conditions of operation of the ultrasonic flowmeter was made and it was observed that there were not interferences of noise in the communication of the transducers and fortunate we had managed to resolve the problem. In no pair of transducers the problem was observed, therefore it was determined that the problem had been resolved.

**Figure Nº 2.** Waveforms Viewer Transducer A. Date 07-Sep-2004.

**Figure Nº 3.** Elements found in the profiler.
In figure 2 waveforms of the transducer A is observed and it notices the difference and the diminution of the effects of the noise on the transducers, the red oval marks the moment at which the signals is received by the transducer and it is observed that the frequency is distorted. The different reasons were discussed and analyzed in which we can tell, that the main reason of the problem was related with the foreign matters found in the gas pipeline.

First of all, the procedures of construction of the flow lines must carefully be reviewed and be fulfilled to avoid dirty and wastes in the line. The elastic element that is showed in figure 3 came from an electronic pig that was run in the first month of operation.

The Signal Noise Ratio (SNR) specifies for the case of ultrasonic the relation that exists between the signal emitted by the transducers and the signal of the noise that interfere in the communication. The figures 4 shows the values of this relation in the first 10 months of operation and a low relation is observed, this means that the values of the noise signal are very high and in some cases they exceeded the maximum levels established for that variable and by consequence the measurement of the volume of gas is almost null (see figure 5 and 6).

![Figure Nº 4. Sound natural ratio (SNR) in the pair of transducers.](image-url)
Figure N° 5. Sound natural ratio (SNR) in transducers in the first 10 months.

Figure N° 6. Gas flow measured by the ultrasonic flow meter.
5. Conclusions

- Due to the obstruction of 30% of the area of the profiler located upstream of the flowmeter caused a distortion and an internal noise which interfered with the communication of the transducers.

- Profit to save the expenses by concept of new mechanical configuration by the belief that the proximity of the pressure control valves to the ultrasonic flowmeter was the noise source that caused the communication problem.

- A program of preventive maintenance of the flowmeter was implemented and it was placed the slug catcher in line to avoid any drag solids that could obstruct the area of the profiler.

- The sound natural ratio (SNR) must be always over 5000 so that means that a good gas measurement exists.

6. REFERENCES

2. Lansing, J. Principles of operation for ultrasonic gas flow meter