CLAMP-ON ULTRASONIC METER APPLICATIONS

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Introduction

I have applied the Siemens clamp-on meter in many configurations in the field and will describe purposes and findings on the way to precise meter certainty. The clamp-on system provides an effective new tool for insight into the flowing regime within a pipe.

Meter Error Assessment

Simple comparisons between the clamp-on meter and a custody meter provide assessment of the custody meter operation. I expect the clamp-on to provide field velocity and actual volume data with a 0.5% uncertainty and repeatability is excellent. Southwest Research Institute demonstrated an uncertainty level of about 0.3% in their lab.[(1)] Then if we experience greater deviation between two meters, we can begin to suspect the meter under test.

Figure I. is a Texas clamp-on setting downstream of an orifice fitting. This location developed 3% deviation between the two meters. That deviation level is my threshold for detailed investigation. The orifice fitting was operating with a plate seal gap and under measuring.

I have found a number of other orifice holders with seal problems. A simple feeler gage can be fabricated to find the true dimension in the field.

Figure I. Clamp-on Compared to Orifice Meter

A series of meters of various types were investigated and Figure II illustrates findings. The first meter is a commercial ultrasonic meter with a transducer problem. The second meter bar is a rotary four-inch positive meter. The sixth bar approaching two percent error has installation effects. That permanent clamp-on check meter is installed in a straight pipe but there are four elbows out of plane with little separation and a final reducer immediately upstream. Profile distortion was confirmed by the clamp-on test meter in a fashion similar to a later section in this paper. The deviation of the orifice meter bars of Figure II was related to use of the prior month's gas composition data.

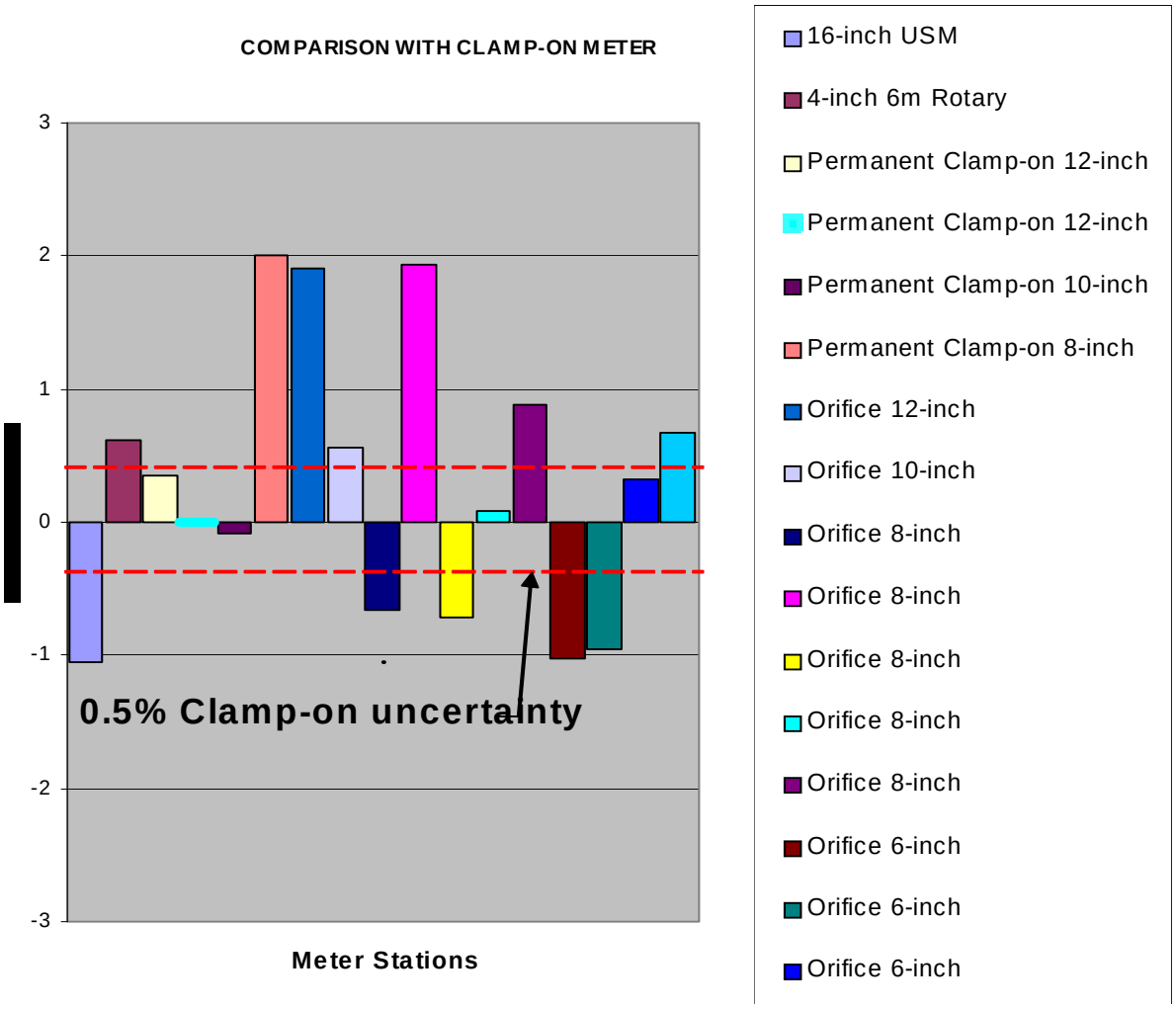

Figure II. Field Comparison Between Clamp-on and Reference Meter.

Installation Effects & Profile Distortion

Field measurements do provide data for understanding the influence of site piping on a meter and to assess flowing velocity profile. The clamp-on system is installed in direct mode with a single acoustic traverse through the pipe. Any gas velocity gradient or cross flow will affect the data. A given transducer communicates with a second transducer on the opposite side of the pipe. There are two data channels acquired at the same time. The two channels produce mirror image data similar to a phase shift that can be recovered later.

The transducer assembly is repositioned to eight or ten points around the circumference of the pipe. If the gas flow is turbulent and fully developed then all readings will be the same. If there is profile distortion, the readings will vary in amplitude and will form what can be called a wave. Refer to fig III. Note that the white bars are almost all at unity flow. That is data measured immediately upstream of a twelve inch ultrasonic custody transfer meter. The green bars derive from data on the same tube but upstream of the flow conditioner and near an inlet elbow. The green bars form a wave as the rotation around the pipe is viewed.

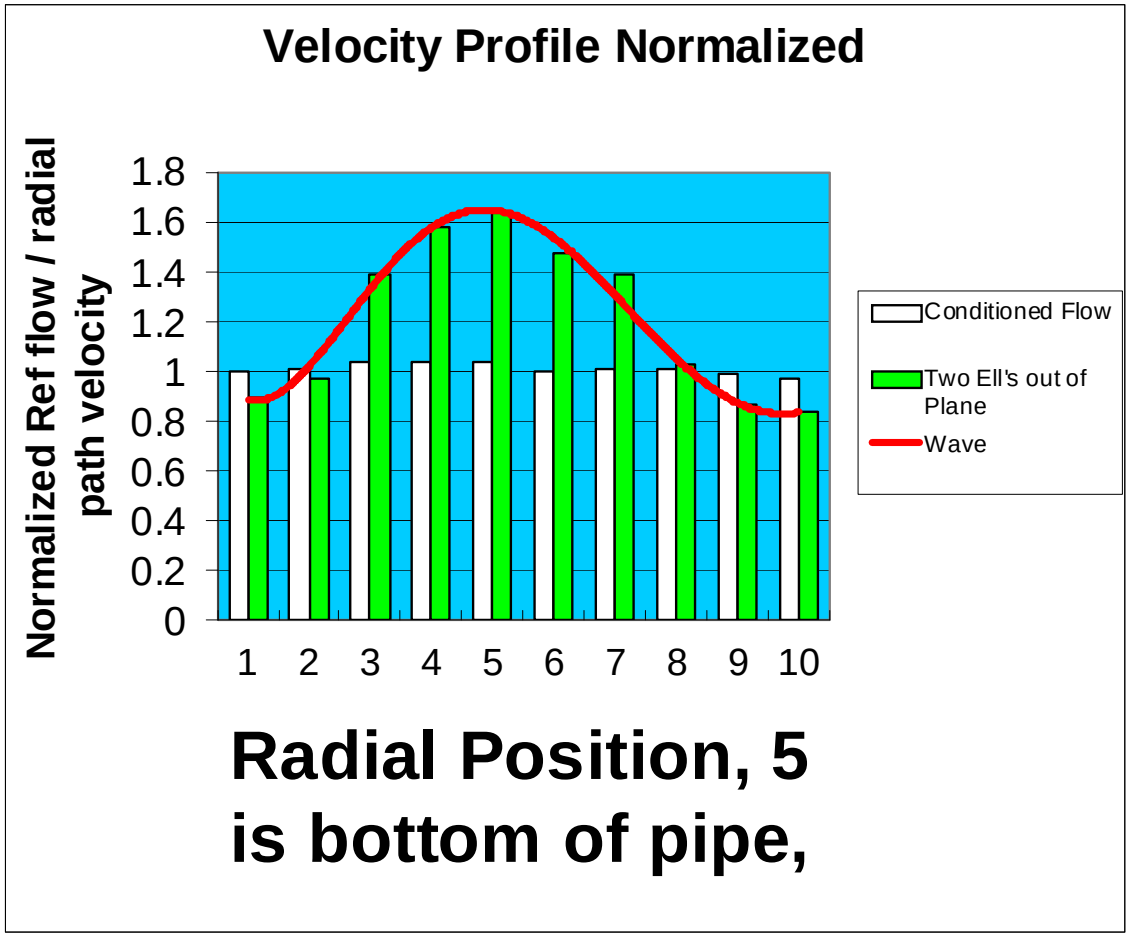

Figure III. Profile Distortion Basis

Now examine figure IV, field data from a six- inch turbine meter. This clamp-on meter was positioned close to the turbine meter inlet. Note the wave and the complimentary mirror image path data.

Site piping influences this turbine meter, an installation effect. Perhaps we can reason that an average of the measured clamp-on flow rate data indicates a lower true flow rate than the turbine meter offers. SwRI showed that the highest velocity in the pipe cross section tends to dominate a turbine meter.[(2)] This reference confirms the probable high turbine meter bias.

Another manner to view similar data is a sort of polar plot. Figure V. shows measurements in an eight-inch tube. This view is useful to visualize how gas flow could be asymmetrical and not centered within a pipe. The ultrasonic meter in this case was later shown to operate with a bias of a fraction of a percent.

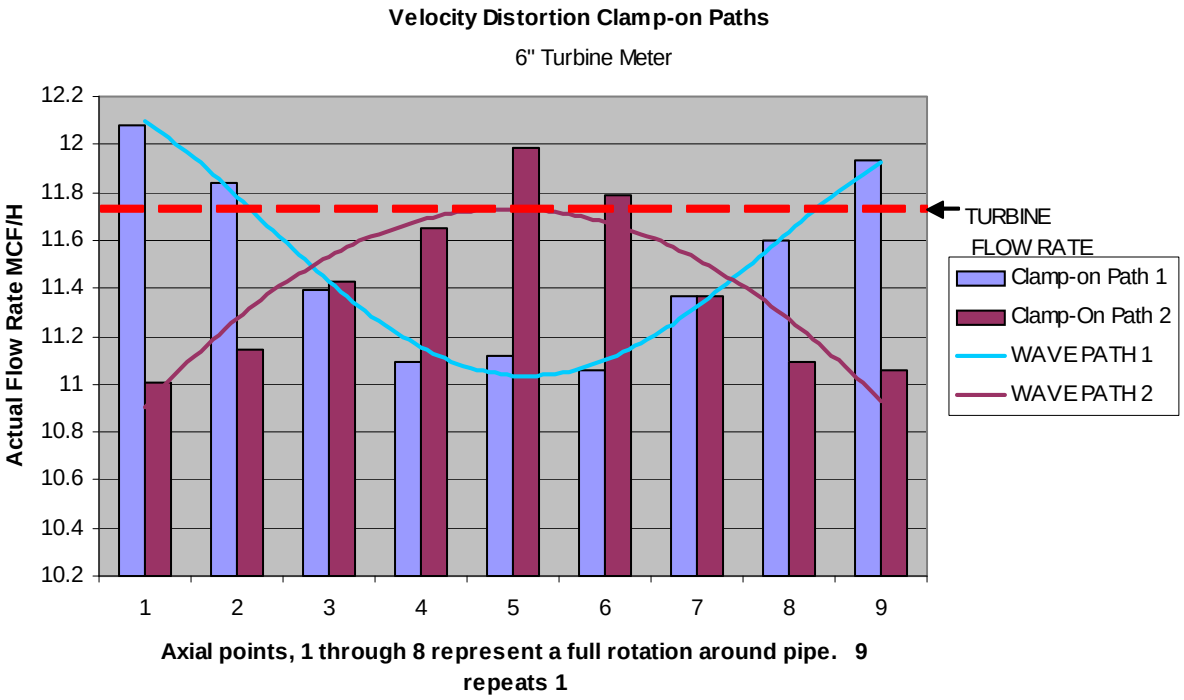

Figure IV. Profile Distortion In Turbine Meter

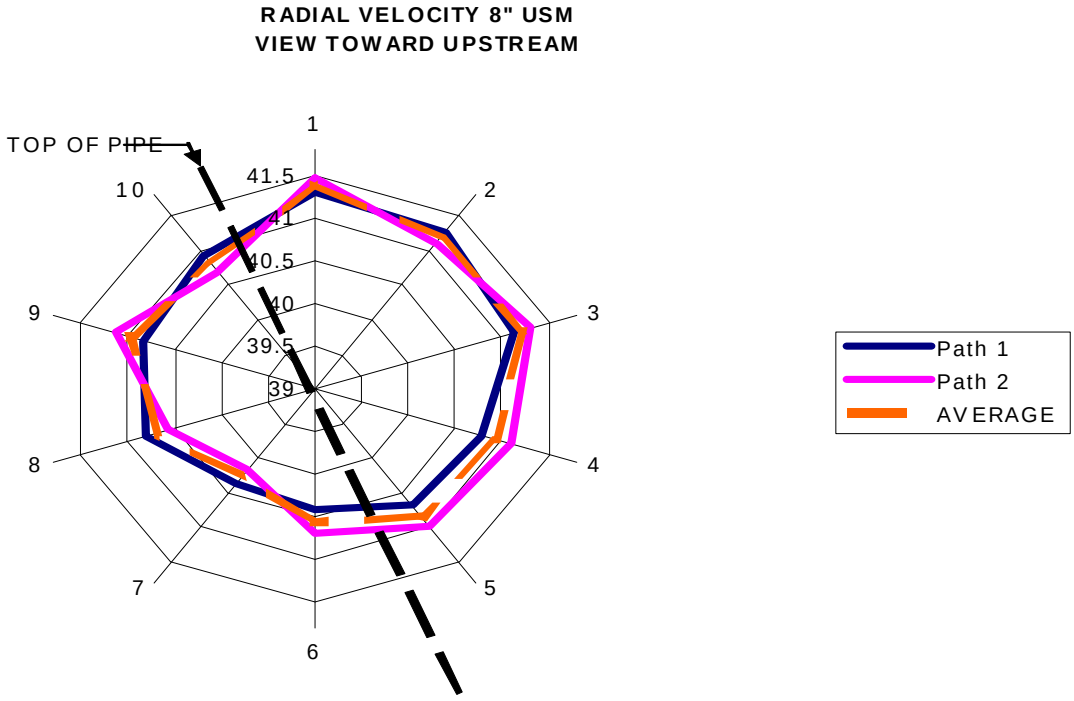

Figure V. Polar Plot of Profile Distortion Segmentation Check Meter

As pipeline systems grow larger and more complex, there is increasing difficulty knowing where to look for L&UAF volumes. I wanted a midpoint mainline measurement on Northern Border Pipeline to help identify system balance issues. A permanent clamp-on system was installed above grade on a forty-two inch mainline. The location was not ideal with an elbow only seven diameters upstream but piping modification would have been very costly. The clamp-on segmentation meter was calibrated using Siemens compensation for double inlet elbows, and the nearby CEESI, Iowa flow lab. The meter has operated with no flaw for two years and has provided continuous data and invaluable clues to occasional measurement issues.

Figure VI. Permanent Segmentation Clamp-on

Leakage Check

The Siemens clamp-on meter has a true zero. It makes use of the acoustic path through the steel pipe wall compared to the acoustic gas path to find zero flow. Other ultrasonic meters calculate zero and show some variability with an oscillatory range representing zero flow. I have tested many times to determine the threshold of low velocity detection in the clamp-on. The tests support a velocity of 0.02 feet-per-second. Above 0.02 feet-per-second, gas is flowing.

It is feasible to hand hold a pair of transducers for leak checking. That is a quick way to sample various positions. If velocity is indicated, a complete installation can be performed to obtain reliable data. Low velocity, even a fraction of a foot-per-second accumulates to significant gas value over time.

I found one site where three closed valves in series were leaking between Companies. The site had been unused for many years and likely was leaking all those years.

Another turbine meter station was found where the small summer load was not enough to cause the turbine meter to turn. The clamp-on meter registered the take and the flow went to zero as soon as the customer became aware that the flow rate was visible.

Reference for New Meter Calibration

Ultrasonic custody meters are routinely flow calibrated today prior to field installation. That is an opportunity to acquire data to help ensure that the final field installation functions correctly. The method involves installing the clamp-on meter on the meter under test at the flow lab during calibration activities. Flow test data and meter log files are recorded for each flow rate test point for both the meter under test and the clamp-on meter. Then later at the field site, similar tests can be performed to identify any relative changes between the custody meter and the clamp-on meter. This is one procedure to evaluate field installation effects.

Special Meter Tests

The clamp-on meter is useful to identify change effects for special field actions. For example, base data can be obtained at four

or more flow rates and then the related tube can be cleaned and another set of data will show the effect of cleaning.

Figure VII. CEESI Iowa Test Bay

The clamp-on meter is sensitive enough to identify small shifts on the order of tenths of a percent because of its extreme repeatability. However, the setup for such tests is important. The experiment must be planned so that the clamp-on meter will not be affected by a change in flowing condition in the meter under test. This often requires the clamp-on to be positioned well away from the meter under test.

References

1. George, D. L., Evaluation of Clamp-On Ultrasonic Meters as In-Situ Meter Verification Tools, Report to PRCI, Contract PR-015-05602, March 2006.

2. Kelner, Eric, P.E., Flow Meter Installation Effects, Factors in Gas Meter Station Design Short Course, June 28, 2005.