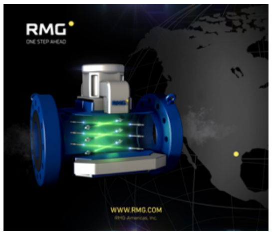
Virtual Meter Path Technology™ (VMPT)

Written by John Lansing



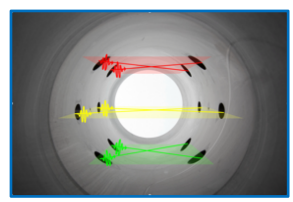
Introduction

Redundant USM check metering has been used by many gas pipeline companies as a method to identify if the primary measurement device is still measuring accurately. There are several different ways to accomplishing this. For the concept to work effectively, a flow conditioner, like the CPA 55E, is generally required to provide a stable and repeatable flow profile. One check metering method uses two meters in series with different path configurations to avoid "common-mode" profile sensitivity. The thinking is that two different path configurations will react differently if the profile is affected by changes in operating conditions. Another check metering solution available today uses a meter with a second set of electronics and one or more additional pairs of transducers. These additional transducers are typically installed in a location that will be sensitive to changes in flow profile. Both of these methods require bringing the uncorrected outputs into the flow computer / RTU and comparing them on a real-time basis. This solution adds significant cost to the installation. But what if a check metering solution were available that added no cost or complexity, and required no mechanical changes to existing or new metering installations? And suppose this solution could be incorporated by simply adding a small algorithm to the flow computer / RTU? This would then allow clients to take advantage of check metering at existing and future installations without the need to add any hardware or cost. **This patented feature is now available for RMG customers.**

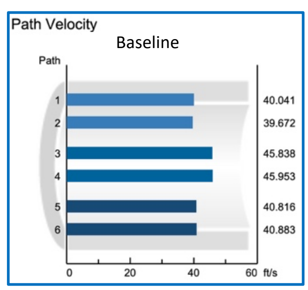
Virtual Meter Path Technology (VMPT™) Overview

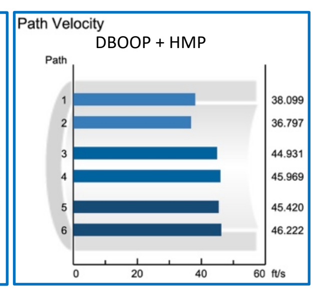
There are several USM path configurations in use today. Each manufacturer strives to provide the lowest possible uncertainty in order to comply with industry standards or regulations, and to also have a perceived competitive advantage. The location for the various paths has been selected to minimize the sensitivity to variations in flow profiles that can occur due to liquids, contamination, flow conditioner blockage, etc. A single path meter design will be far more sensitive to these flow profile changes. This is why manufacturers utilize multiple paths. All multipath meters provide individual path gas velocity information that can be acquired via serial communication. By obtaining the gas velocity from one (or more) of these paths, and then comparing this to the average velocity of all paths in the flow computer / RTU, a different method of check measurement is now available that **does not require additional meter components**. This not only eliminates the added cost associated with traditional check measurement concepts but can also easily be retrofitted to existing meter stations. This feature, called **Virtual Meter Path Technology**, is now available to all RMG GT400 gas ultrasonic meter users.

VMPT Example – A Distorted Flow Profile



The RMG GT400 is a 6-path, 3-plane crossing-path meter design as the image to the right shows. This path layout was chosen to provide excellent swirl compensation and linearity over the entire range of operation. The Gauss-Chebyshev direct path design also has lower uncertainty than traditional 4-path meters. An example of this was published in RMG Tech Notes 3 & 7 [Ref 1 & 2] where OIML R-137 [Ref 3] test results, with an 8" CPA 55E, 3D spools and GT400 meter, resulted in less than 0.09% added uncertainty. To demonstrate how the VMPT feature works, let's compare the gas velocity profile for the CPA 55E baseline condition at 43 FPS to the velocity profile for the Double Elbows out of Plane (DBOOP) + the Half-Moon Plate (HMP), also at 40 FPS. The "Path Velocity" information for the baseline (left graph) shows a very symmetrical profile with both Paths 5 & 6 reading about 40.8 FPS with an average meter gas velocity of 43.00 FPS. The second graph is for the DBOOP + HMP, and it shows Path 5 reading is 45.42 FPS and Path 6 is 46.22 FPS, with the average meter velocity of 43.41 FPS. The Baseline Path 5 ratio is 0.9492 (Path 5 / Meter Average), and the distorted Path 5 Ratio is 1.0412. This represents a change in Path 5's ratio of 9.7%. By computing Path 5's Ratio in the RTU, and comparing to the normal value, the RTU can now alert the user if an abnormal flow profile exists. This feature allows the RMG GT400 user to incorporate a check measurement feature without adding cost and complexity to their metering facility, and can be incorporated in existing and new installations.





VMPT Example – When Wet Gas is Present

Many of today's custody measurement applications encounter liquids like NGLs in the pipeline from time to time. This condition may not be present all the time, so clients would like to quickly know when this occurs. The RMG GT400 diagnostics can identify this condition. But, by using the VMPT technology, it becomes even easier to identify when liquids are present. Let's discuss an example from wet gas testing that was published in RMG Tech Notes 2 & 8 [Ref 4 & 5]. An 8" RMG GT400 meter was subjected

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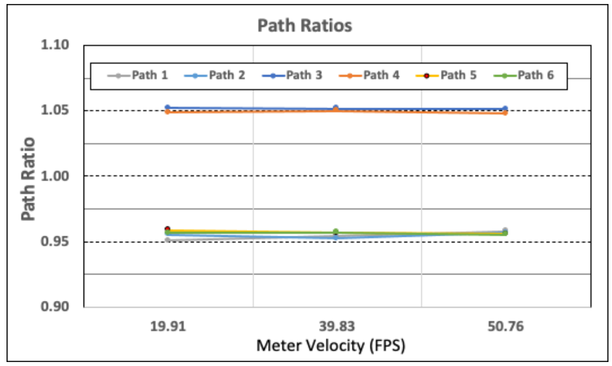
to a variety of liquid loading exceeding 1% (99% gas) in small increments starting at 0.1%. Graph 1 on the right shows the Path Ratios for all 6 pairs of transducers with clean dry gas. Typically Paths 5 & 6, which are located near the bottom of the meter, will quickly be affected when liquid is present. These path ratios are normally around 0.956 for ideal flow profiles and no liquids.

When discussing liquid loading a term called Gas Volume Fraction (GVF) is often used. This is simply a ratio of how much uncorrected gas volume is flowing vs. the liquid volume. A GVF of 1.000 means there is no liquid (100% gas). A GVF of say 0.998 means that there is 99.8% gas by volume and 0.2% liquid by volume. This series of tests was conducted at the CEESI Nunn Wet Gas Test Facility in January 2020.

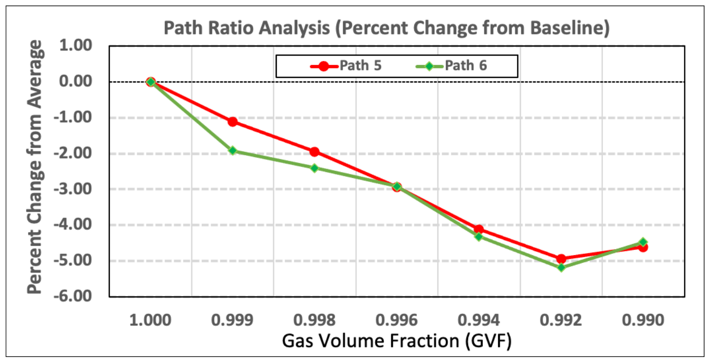


Graph 1 – Normal Path Ratios

Table 1 summarizes the Path Ratio averages for both lower pairs of transducers (Paths 5 & 6) at each of the test GVF values. Paths 5 & 6 are affected more due to their proximity to the liquids at the bottom of the pipe. These Path Ratio values were computed from the average of the Path Ratios for each of the three gas velocities (approximately 20, 40 & 51 FPS) used in the testing. Below Graph 2 shows the percent change for both Paths 5 & 6, relative to baseline, as the liquid amount increases (GVF decreases). As the GVF decreases, the percent change from baseline increases and is also relatively linear.

GVF	Path 5 Avg. Ratio	% Change from 1.000	Path 6 Avg. Ratio	% Change from 1.000
1.000	0.9571	0	0.9563	0
0.999	0.9464	-1.112	0.9380	-1.917
0.998	0.9385	-1.944	0.9333	-2.408
0.996	0.9290	-2.934	0.9284	-2.919
0.994	0.9176	-4.120	0.9150	-4.318
0.992	0.9098	-4.937	0.9067	-5.189
0.990	0.9129	-4.610	0.9135	-4.475

Table 1 – Path Ratio Changes with GVF



Graph 2 – Path Ratio Changes with GVF

Table 1 shows both Path Ratios changes are negative. This means these paths are registering less velocity relative to the meter's average. This is due to the liquids moving at a slower rate thru the meter than the gas, and thus affecting the gas velocity at the bottom of the meter. Graph 2 summarizes the effect on both paths with decreasing GVF. Note the liquid is affecting both paths about the same. With even the slightest amount of liquid loading (GVF=0.999), both Path Ratios have decreased by 1-2%. By using an algorithm to monitor Path Ratios in the RTU, the presence of liquid can easily and quickly be detected.

Summary

The use of check metering has continued to increase because it helps simplify validating the gas USM is still measuring accurately. There are several methods of incorporating check metering. Traditionally these have all incorporated additional pairs of transducers and electronics, or a completely different meter installed in series. This Tech Note summarizes a method that provides virtually all the benefits of alternative hardware solutions without adding cost. Additionally, **no hardware changes are required** to implement this VMPT feature at existing sites. RMG will license their customers to incorporate VMPT for use in new and existing RMG GT400 measurement stations. For more information, please contact RMG Americas, Inc.

RMG Tech Notes

This is the 9th Tech Note in our series. Previous Tech Notes are posted on our website, or we can email them to you. If you have any questions, please contact us at SalesUSA@RMG.com.

References

1. *Tech Note 7: Benefits of Using Flow Conditioning with Gas Ultrasonic Meters*, John Lansing, 3.1.2021, Link to Tech Note 7.
2. *Tech Note 3: Shorter Upstream USM / CPA Piping Lengths Significantly Reduces Cost*, John Lansing, 11.11.2020, Link to Tech Note 3.
3. *OIML R 137-1 & 2, Edition 2012(E), Including Amendment 2014*, International Organization of Legal Metrology.
4. *Tech Note 2: GT400 6-Path Gas Ultrasonic Meter Wet Gas Test Results Summary*, John Lansing, 8.3.2020, Link to Tech Note 2.
5. *Tech Note 8: GT400 6-Path Gas Ultrasonic & Orifice Meter Wet Gas Test Results*, John Lansing, 7.9.2021, Link to Tech Note 8.