

“How Not to Measure Gas - Orifice Measurement”

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Introduction

Measuring natural gas is both a science and an art. Guidelines and industry practices explain how to accurately measure natural gas. The ‘art’ comes in trying to minimize errors and prevent measurement problems. However, sometime it’s easier to explain “how not” to measure gas when reviewing measurement errors.

Measurement errors can be caused through poor installation practices, poor measurement practices, operational changes, and human error. The purpose of this paper is to address some “real life” cases of measurement errors.

Installation Problems

It’s imperative to follow the AGA guidelines when designing and installing a measurement station. In orifice measurement, the ANSI 2530, API 14.3 manual recommends the minimum requirements for fabrication and installation of orifice meters. These standards recommend the required upstream and downstream lengths, along with recommendations for flow conditioners.

For years, we have heard the importance of the correct length of the upstream and downstream meter run. If the meter tube upstream length is too short, it causes the approach profile to become distorted. Unfortunately, it is not easy to predict if the measurement will be overstated or understated.

When performing a field audit, always note the location of the first obstruction upstream and downstream on the meter tube. The approach and exit profile will be affected by the location of the obstruction. Determining the amount of error is dependent by the size of obstruction, flow rate, and location of the obstruction. Each problem is unique; the amount of error is unique in each situation.

Prior to the update of the standard in 1991, the fabrication of orifice meters used either a “flanged” or “pin” type straightening vanes. While straightening vanes were an acceptable type of flow conditioner, potential problems can occur in either in straightening vanes and other flow conditioners.

Straightening vanes were recommended to be fabricated out of stainless steel material. Stainless is resistant to corrosion. However, if the vanes were made from carbon steel and placed in a corrosive environment, the vanes will rust. Once this happens, the upstream profile will change, and cause a measurement error. Depending upon the location of the vanes, the error can be either positive or negative.

A high carbon dioxide concentration in a wet gas stream creates a corrosive environment. After a few years in service, the vanes can look like the picture below:



When a new installation is commissioned, it is always a good idea to purge the pipeline or facility prior to putting the measurement station into service. If the pipeline or measurement facility is not adequately purged, debris left in the pipe may end up in the meter tube. Any type of debris can be left in a pipeline during construction; the picture below shows a piece of plastic that was left in the upstream portion of the meter tube.



The effect of the plugged orifice plate is reflected in the EFM data collected from the meter site. On the 21st, the flow was completely restricted. As the plastic pushed through the orifice bore it effectively decreased the size of the orifice bore overstating the differential pressure and the volume.

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Pressure Base: 14.730 psia		Temperature Base: 60.00 °F				HV Cond: Wet		Meter Type: EFM			Contract Hr.: 9 AM		
Water Vapor Corr. Technique:						Water Vapor Corr. Method:							
CO2	N2	H2O	H2S	O2	He	C1	C2	C3	I-C4	N-C4	I-C5	N-C5	C6+
1.590	1.630					95.240	1.400	0.130	0.010	0.000	0.000	0.000	0.000
Tube I.D.	Interval	Tap Location			Tap Type	Atmos. Pressure		Calc. Method	Fpv Method				
3.068 in.	1 Hour	Upstream			Flange	14.400 psi		AGA3-1992	AGA8-Detail				
Day	Differential (In. H2O)	Pressure (PSIG)	Temperature (°F)	Hours Flow	Relative Density	Plate (Inches)	Volume (Mcf)	Heating Value (BTU/scf)		Energy (MMBTU)			
1	11.22	246.71	90.05	24.00	0.5852	0.375	47	977.60	46				
2	9.95	244.31	99.61	11.09	0.5852	0.375	20	977.60	20				
3	21.23	255.35	91.94	19.03	0.5852	0.375	48	977.60	47				
4	5.44	253.35	91.48	24.00	0.5852	0.375	32	977.60	31				
5	3.86	248.40	91.59	24.00	0.5852	0.375	28	977.60	27				
6	3.63	251.40	92.21	24.00	0.5852	0.375	27	977.60	27				
7	3.83	239.81	92.67	24.00	0.5852	0.375	27	977.60	27				
8	3.76	238.30	92.80	24.00	0.5852	0.375	27	977.60	26				
9	3.85	231.47	98.07	16.89	0.5852	0.375	19	977.60	18				
10	12.75	245.39	93.95	19.25	0.5852	0.375	37	977.60	36				
11	4.90	238.40	95.48	23.99	0.5852	0.375	30	977.60	30				
12	3.98	232.15	95.31	24.00	0.5852	0.375	27	977.60	27				
13	3.72	241.29	96.41	24.00	0.5852	0.375	27	977.60	26				
14	3.56	245.67	95.18	24.00	0.5852	0.375	27	977.60	26				
15	3.60	240.25	94.70	24.00	0.5852	0.375	27	977.60	26				
16	3.45	247.16	94.94	24.00	0.5852	0.375	26	977.60	26				
17	3.36	248.34	95.31	24.00	0.5852	0.375	26	977.60	25				
18	3.35	245.44	90.10	23.98	0.5852	0.375	26	977.60	25				
19	3.31	244.77	88.03	24.00	0.5852	0.375	26	977.60	25				
20	3.57	234.52	97.18	5.56	0.5852	0.375	6	977.60	6				
21	14.48	214.99	90.37	1.90	0.5852	0.375	1	977.60	1				
22	282.87	236.01	91.58	22.93	0.5852	0.375	218	977.60	214				
23	182.31	246.95	93.70	24.00	0.5852	0.375	187	977.60	183				
24	133.94	246.05	92.85	24.00	0.5852	0.375	162	977.60	159				
25	116.23	242.97	80.84	24.00	0.5852	0.375	152	977.60	149				
26	104.82	246.90	89.17	24.00	0.5852	0.375	145	977.60	142				
27	215.17	243.59	89.68	22.95	0.5852	0.375	188	977.60	184				
28	4.81	231.92	90.44	23.07	0.5852	0.375	28	977.60	27				
29	3.51	221.73	88.14	24.00	0.5852	0.375	25	977.60	25				
30	3.25	226.48	85.99	23.99	0.5852	0.375	25	977.60	24				
31	3.06	236.82	85.25	24.00	0.5852	0.375	24	977.60	24				
TOTAL		113.61	242.97	90.92	670.62	0.5852		1,715	1,679				
Volume at 14.650 = 1.724 Energy = 1.679													

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It is also important to design the facility so, that the production compression equipment does not effect the measurement. Separation equipment, dump valves, and compression equipment can cause the upstream profile to become distorted. Inspection “tees” or “enclosures” are a helpful addition for performing field tube or facility inspections.

Poor Measurement Practices

Good measurement practices may be defined by a “gas measurement manual”; this document will help minimize any potential errors. While it is impossible to prevent all types of errors, a good standard “document” will go a long way in preventing an obvious error.

Orifice plate inspections are a very important part of a meter station inspection. Plates can be damaged by over pressure, hydrate formation, harsh flowing conditions, and improper sealing devices.

Over time, meter tubes may begin to show signs of “wear”. A good meter tube inspection schedule is beneficial in preventing potential measurement errors. The internal condition should be noted; rusty or pitted meter tubes should be replaced. This generally causes the volume to be understated.

In older installations, vane bundles may become loose and move inside the meter tube. The vanes may partially block the upstream tap hole, or may hit the orifice plate. The orifice plate in the picture below was damaged after the straightening vanes came loose inside the meter tube.



In extreme situations, the orifice plate can be blown completely out of the orifice plate carrier. It is not uncommon for hydrates to form in the winter months. If the vane “pin” is weak or damaged, the velocity of the gas flow may cause the hydrate to move and hit the vanes. Once the pinning device is compromised, the vanes will move downstream with the flow.

Other problems occur with sealing devices. Whether the meter run is a single or dual chamber, the seal ring is always important to examine when doing a meter inspection. In extreme conditions, the seal ring can become “swelled” from exposure to rich gas streams. When that occurs, the seal ring may tear when removing it from the meter tube.



The picture above illustrates the effect of extended exposure to a rich hydrocarbon gas stream. The seal ring swelled, and the seal tore as the plate was removed from the meter tube. Always be selective on the type of seal ring, and the ANSI rating of the fitting. Be sure to install the correct ANSI rating series seal ring in the meter tube. Installing the wrong ANSI rated seal ring, may not seal the orifice plate in the plate carrier or meter run.

Caution should be taken to make sure that the flange gaskets do not protrude into the meter tube bore. This induced error can be either a positive or negative in nature. It is important to make sure that the proper size and ANSI rated flange gasket is used in the meter tube. The picture below illustrates the effect of the wrong size gasket upstream of the orifice plate. Note the deflection of gas, as evidenced by the shaded area of the tube and plate.



Operational Changes

When new gas sources are added to a gathering or transmission system, it's always a good idea to review the type and amount of gas that is added to the system. In gathering systems, it is important to confirm that any separation equipment is sized properly to handle the additional volume. If the vessels are undersized, the free water or condensate can carry over the top of the vessel and interfere with the downstream measurement. Again, the upstream flow profile is affected; the amount of the error is dependent upon the quantity of carry over liquids.



If field compression is required or added, it is always a good practice to make sure that the meter station is not subject to compressor pulsation. A shift in the atmospheric and working pressure “zeros” can indicate the presence of pulsation. If the pulsation cannot be determined by this simple test, a square error test should be used to identify the possibility of a pulsation error. Because compression facilities can cause the measurement to be overstated, it always a good practice, to install vessels between the compressor discharge, and the meter tube. The vessel provides a dampening effect for the pulsation, and knocks out the “noise” from the gas stream.

Changes in wellhead production techniques also need to be identified. In intermitted production wells, the meter station size, and differential ranges should be reviewed. If necessary, the differential range should be increased, to insure that the entire range of the differential flow is measured.

Human Error

Human error can occur in both the field and in the office. Orifice plates can be installed backwards in the meter tube in the field. Plates can be filed, cut and modified to fit into orifice flange units. Incorrect meter configurations can be setup in processing office, and go undetected for long periods of time.

A good “checks and balance” system should be in place between the field and the office. Each group can perform a review of the field stations, and help each other identify any potential errors.

Data processing software packages currently available in the industry have many features to help identify potential errors in gas quality, or flowing parameters. A well trained editor can use these tools to identify an error, and prevent the calculation of erroneous volumes. These features can also help the field personnel to spot potential problems from the field perspective.

Summary

Preventing measurement errors is a never ending process. Understanding the correct and incorrect methods of measurement can help to reduce the amount of potential errors.