Emerging Technology Program

#1100: Pulsing Gas Submeter Package

Public Project Report – Executive Summary

September 23, 2016

Technical Contacts

Robert Irmiger
Principal Engineer
Robert.Irmiger@gastechnology.org
847.942.1973

Douglas Kosar
Senior Institute Engineer
Douglas.Kosar@gastechnology.org
847.768.0725

Gas Technology Institute
1700 South Mount Prospect Road
Des Plaines, IL 60018

Nicor Gas Contact

Gary Cushman
Program Manager, Research and Emerging Technology
GCushma@aglresources.com
630.388.2392

Nicor Gas Company
1844 Ferry Road
Naperville, IL 60563

Legal Notice

This report was prepared by Gas Technology Institute (GTI) for Nicor Gas Company (Nicor Gas). Any use of or reliance on this report and/or any information contained in this report by any party is at that party's sole risk. Neither GTI nor Nicor Gas, or any person acting on behalf of either of them:

a) Makes any warranty or representation, express or implied with respect to the ownership, accuracy, completeness, or usefulness of the information contained in this report. Inasmuch as this work is experimental in nature, the technical information, results, or conclusions cannot be predicted. Conclusions and analysis of the results by GTI represent GTI's opinion based on inferences from measurements and empirical relationships, which inferences and assumptions are not infallible, and with respect to which competent specialists may differ.

b) Assumes any liability with respect to the use of, reliance on, or for any and all damages resulting from the use of or reliance on this work and/or any information, apparatus, method, or processes disclosed in this report.

The results within this report relate only to the items tested.

Full Report

The following executive summary is made publicly available by Nicor Gas as part of their Emerging Technology Program (ETP). The detailed Nicor Gas ETP report is available to qualified state and utility run energy efficiency programs upon request. Please contact the Nicor Gas ETP administrator at NicorGasETP@gastechnology.org to find out how to access the full report.

Executive Summary

Introduction

As a part of the Nicor Gas energySMART energy efficiency program, the Emerging Technology Program (ETP) assesses new technologies that have the potential to realize natural gas savings for the 2.2 million Nicor Gas customers in Northern Illinois. The Gas Technology Institute (GTI) provides program implementation for the Nicor Gas ETP. This report summarizes the findings to evaluate a ¾" pulse output gas meter and peripheral components as a low cost alternative to traditional gas submetering options and its potential to provide energy efficiency to Nicor Gas residential, commercial and industrial customers.

Background

Pulsing gas submeters provide an opportunity to collect, track and analyze real-time, interval gas usage data. When paired with energy management and information systems (EMIS) or pushed to a web-hosted graphic interface, gas submeter information can enable either on-site or third party energy management personnel to identify gas savings opportunities. It can also support tracking the effectiveness of operational and behavioral energy reduction initiatives. For utility energy programs, pulsing gas submetering data could further support measurement and verification (M&V) efforts for tracking and reporting purposes.

The manufacturer of the tested product offers a cost-effective option for a pulsing gas submeter with a remote data acquisition system (DAS) and web interface. The diaphragm style meter is designed to send one (1) pulse for every cubic foot of natural gas that passes through the meter. Pulse data can be sent to a facility's building management system (BMS) or paired with the tested manufacturer's own data acquisition systems that count and push data to a web interface allowing a user to look at energy usage statics. The manufacturer's web interface allows data to be displayed in increments of 15 minutes, hours, days, weeks, and months.

At a cost of $90/meter, plus another $375 for the pulse counting and push device necessary should automated data acquisition on the manufacturer website be desired, the tested product is very reasonably priced for an out–of-the-box solution. Installation costs are expected to increase the initial investment by anywhere form $150-$300 per meter. A comparison of costs of the tested gas meter vs. comparable industry standard meters confirms that this pricing is consistently less than what is currently common in the residential and small commercial market.

Another manufacturer, Norgas, provides a similar product under their NMT line of gas metering equipment called the 'NG4.' The NG4 meter has nearly identical specifications as the tested product but at a higher cost of $125/meter. While the Norgas product does not provide an option for a fully integrated DAS and web data collection platform, they do have a larger product line of gas submetering devices, including various pipe diameters as well as diaphragm and rotary type meters.

Although costs are significantly lower than industry standard equipment, concerns about the ability of the equipment to provide accurate gas usage information motivate further validation. One concern is the lower pulse counting rate as compared to industry standard equipment would reduce the granularity of the resulting data set. The tested gas meter provides one pulse for every one (1) cubic foot of gas while standard utility equipment typically provide 40 pulses for every cubic foot of gas. Additionally, the tested gas meter is currently only offered for pipe diameters of ¾" and 1-½" which will limit the range of potential applications.

Experimental Design and Procedure

The test apparatus was constructed by linking three flow meters in series. The meters were installed inline starting with an industrial AL-425 flow meter with a high accuracy digital encoder ("Flow Cart"), followed by a standard AC-250 residential flow meter with pulse output, and lastly the EKM gas meter with pulse output. The pipe size was 1" National Pipe Thread (NPT), reduced down to ¾" NPT for the EKM port connections. Gas was vented to the atmosphere through several flow control valves connected to a fume hood vent. A single pressure transducer was installed immediately upstream of the EKM gas meter to monitor a stable pressure setting. Temperature readings were taken from the inlet of the AL-425 Flow Cart and the inlet of the EKM gas meter. The AC-250 was a temperature compensated meter, while the AL-425 and EKM gas meter were not. Figure 1 shows the testing apparatus. The drawing indicates the flow path and measurement points; it is not drawn to scale.

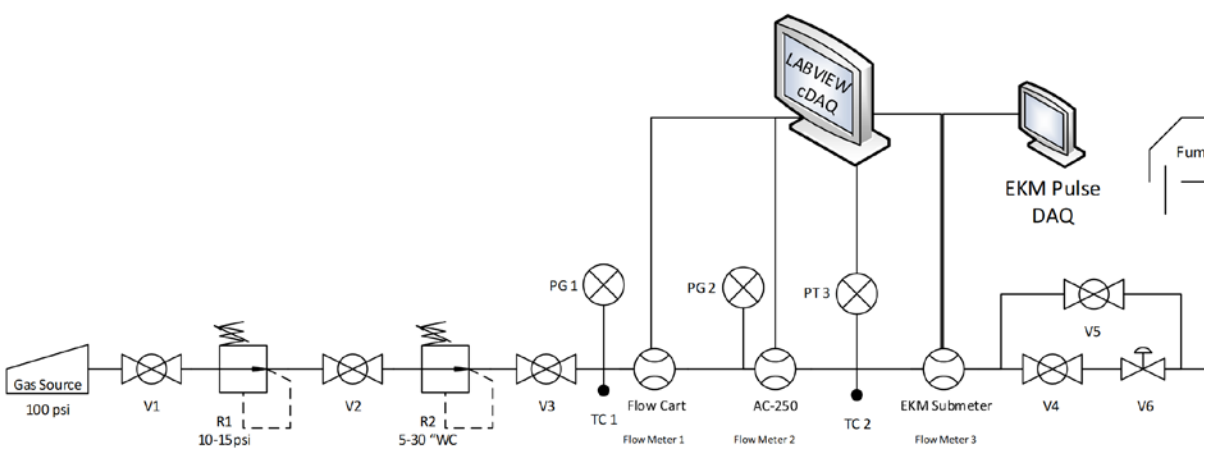

Figure 1 - Flow Test Apparatus

The Flow Cart utilized an American Meter Company AL-425 industrial flow meter. It is capable of servicing natural gas at volumetric flow rates of up to 425 cubic feet per hour (CFH) with ½" WC pressure differential at 0.25 PSI. This meter is equipped with a dial encoder that outputs 50,000 pulses per cubic foot. This capability introduces a degree of volumetric quantization sufficient for the testing protocol and serves as the reference for performance comparisons. This meter is not temperature compensated.

The AC-250 meter is a residential flow meter made by American Meter Company. The AC-250 was included to provide an industry standard baseline for comparison purposes. It is capable of servicing natural gas at volumetric flow rates of up to 250 standard cubic feet per hour (SCFH) with ½" WC pressure differential at 0.25 PSI. It is equipped with an integrated encoder that outputs 40 pulses per standard cubic foot. This meter is temperature compensated.

The device under test, labeled as the EKM gas submeter in Figure 1, was developed by EKM Metering and is their PGM-075 appliance submeter. It is capable of servicing natural gas at volumetric flow rates of up to 211 CFH. Pressure differential is not reported, however, EKM Metering publishes a nominal flow rate of 141 CFH. This meter is not temperature compensated.

High pressure dry nitrogen was used as the working fluid. The nitrogen pressure was controlled through two regulators to provide the intended steady state operating pressures. Nitrogen was chosen for this test given its safety to work with and since it allows for highly controlled input conditions to the lab test apparatus. As testing was focused toward volumetric accuracy, there was no need to use natural gas as the meters measure volume independent of the gas so long as the temperature and pressure are consistent across all testing devices.

Results

To evaluate the accuracy of the tested gas meter and peripheral pulse counting device, comparison testing to laboratory precision flow-measurement equipment and an industry standard gas meter was performed at the GTI laboratories.

Multiple test runs were performed to evaluate the performance of each meter under various flow rates and inlet pressure conditions. The flow test results are shown in Table 1. The target parameters are listed on the left and the resulting data is shown on the right. The actual flow rate that was maintained throughout the duration of the test is indicated, followed by the total volume measured by each meter. The tested gas meter and the AC-250 (residential standard) are listed with a percent error compared to the high accuracy Industrial Flow Cart.

Table 1 - Totalized Flow Summary

Test #	Target Pressure	Target Flow Rate (SCFH)	Flow Rate (SCFH)	Flow Cart Total (CF)	Tested Meter Total (CF)	AC-250 Total (CF)	Tested Meter % Error	AC-250 % Error
1	6" WC	5	6.87	120.52	122.13	120.00	1.33%	0.43%
2		25	25.44	144.81	144.91	143.58	0.07%	0.85%

Test #	Target Pressure	Target Flow Rate (SCFH)	Flow Rate (SCFH)	Flow Cart Total (CF)	Tested Meter Total (CF)	AC-250 Total (CF)	Tested Meter % Error	AC-250 % Error
3		75	72.78	113.94	113.06	112.80	0.78%	1.00%
4		150	128.95	79.73	79.73	79.10	0.40%	0.80%
5	28" WC	5	5.72	133.71	133.71	1333.53	1.26%	0.14%
6		25	26.30	162.25	162.25	161.03	0.95%	0.75%
7		75	75.51	195.05	195.05	193.35	0.08%	0.87%
8		150	142.19	89.66	89.66	88.98	0.31%	0.76%

The totalized data demonstrates the accuracy of the tested gas meter over larger intervals. Based on the performance tests, it operated well within its specified accuracy ranges of ±3% for flow rates of 1.41-21.1 CFH and ±1.5% for flow rates of 21.1-211 CFH. As expected, the tested gas meter was less accurate at low flow rates where it was outperformed by the AC-250 meter. However, under mid-to-high flow rate conditions (as defined by the meter's operational range), the tested gas meter generally performed equivalently or outperformed the AC-250 in flow accuracy tests.

Table 3 outlines the results of the tested gas meter's accuracy on a per pulse basis. Overall, these results show positive performance for its ability to accurately measure incremental (per pulse) volume. Specifically, the low mean error measured in all tests are well within the meter's rated accuracy ranges and maintained less than 1% error in almost all test cases. However, test runs #3, #4 and #8 produced less reliable results which is more likely due to DAS sampling rates than the accuracy of the pulse meter; this error is discussed further below. Low standard deviations are another strong indication of the tested gas meter's accuracy. However, again in tests where the standard deviations were larger may be attributed in part to error associated with the DAS speed. For example, tests #1, #2, #5, and #6 were performed at lower flow rates and therefore a slower sampling rate; in these tests, two standard deviations from the mean error (a statistically relevant range in data variation) are still well within the rated accuracy of the tested gas meter and in line with the strong accuracy results identified in the totalized error discussed above.

Table 2 – Tested Meter Error per Pulse

Test #	Pressure ("WC)	Flow Rate (SCFH)	%Error per measured CF **Mean %Error** (95% confidence)		Stdv	cDAS Pulse Count	Tested Meter Pulse Count
1	6.10	6.8	-0.53%	±0.05%	0.27%	122	122
2	5.99	25.4	0.25%	±0.07%	0.41%	147	147
3	6.03	72.9	0.85%	±0.86%	4.67%	115	-----
4	6.08	128.9	0.99%	±0.43%	1.97%	81	-----

Test #	Pressure ("WC)	Flow Rate (SCFH)	%Error per measured CF Mean %Error (95% confidence)		Stdv	cDAS Pulse Count	Tested Meter Pulse Count
5	28.05	5.7	-1.01%	±0.05%	0.29%	135	135
6	28.00	26.3	0.06%	±0.07%	0.43%	165	165
7	28.16	75.5	0.37%	±0.09%	0.65%	198	198
8	28.13	142.2	0.78%	±0.29%	1.40%	91	-----

While the totalized results in Table 2 indicate that the meters performed very well and within specifications, when investigating the analysis further, certain outliers and behaviors appear to be indicative of lower accuracy on a per pulse basis. However, this may be more an artifact of the DAS for these tests as multiple DAS devices were integrated to compare performance metrics. By combining multiple DAS components, error in comparative data may occur when small delays in the read time are experienced and is likely the cause for the outlying sampling errors in data. This phenomena is described in greater detail in the full report. Furthermore, tests #3 and #4 specifically had a greater error in the per pulse results related to a lower than necessary sampling rate resulting in aliasing error. The aliasing error was corrected in subsequent tests by increasing the sampling rate; however, the results from these tests are still relevant for totalized accuracy as the impacts of aliasing are effectively negated when analyzing a continuous dataset.

As a final element of performance testing, GTI verified the tested gas meter's performance when paired with a third party pulse counting device. As indicated in the "cDAS" and "Tested Meter" pulse count data in Table 2, the meter performed equivalently when paired with either the third party National Instruments pulse counter or the manufacturer's own DAS product.

Based on the test results, the tested gas meter is an accurate means of measuring interval gas usage as compared to industry standard meters and is expected to be a reliable and cost-effective alternative to higher cost pulsing meter options, such as the AC-250 meter. However, users of third party metering appliances should anticipate that the performance characteristics may vary slightly from their utility meter resulting in small deviations from their utility meter data.