

Guidelines to Improve Fiscal Natural Gas Metering Accuracy and Consistency in Custody Transfers

Chimaroke Anyanwu¹, Prof Adewale Dosunmu²

¹University of Port Harcourt, Nigeria

²Professor, Dept. of Petroleum Engineering, University of Port Harcourt, Nigeria, River State, Nigeria

Abstract - To increase profitability in any gas business, accurate and repeatable flow measurement is required for both process control and custody transfer applications.

It might seem fair to ignore a 1% error in gas volume measured. However, assuming a flow rate of 10 gallons per minute and cost of \$1.00 per gallon, it then means we will be losing as much as \$52,560.00 per year assuming operation 365 days a year. A fiscal meter that flows MMSCF/D of natural gas at \$50.00 / MSCF equates to \$37,500,000.00 per month. Improving the accuracy by 1% will work out to a difference of \$37,500,000.00 per month.

This paper identifies key issues affecting accuracy of gas flow measurement and how they all can be harnessed together to reduce error down to 0.05 %. It will also insure consistency during repeated measurements for custody transfer calibrations.

While all hands are on deck to bring Nigeria's gas master plan to fruition, boosting investors' confidence is pertinent to insuring success. Hence, implementing the findings in this paper in production designs is a right step towards accountability.

Key Words: Custody Transfer, Natural Gas, Fiscal, Metering, Accuracy.

1. INTRODUCTION

With world demand for energy growing, natural gas is increasingly seen as a more environmentally friendly option to coal, an alternative to oil and nuclear, and a more mature technology than alternative energy sources such as solar and wind. While coal is cheap and abundant, it is a major pollutant, particularly of carbon dioxide. Low-emission nuclear power is relatively cheap to operate, but it has become the subject of renewed safety concerns in the wake of the 2011 nuclear accident at the Fukushima plant in Japan. On the other hand, oil prices and production remain volatile, placing consuming countries reliant on it under considerable economic strain.

The demand for natural gas has increased manifolds in the recent past and is expected to increase more. Primarily the natural gas prices are driven by supply and demand philosophy. Hence the accurate measurement of natural gas becomes critical and essential. McCartney (2004) adds that

lack of commitment in this subject can lead to a loss of quality control which, in turn, impacts on customer relationships.

Gulaga (2008) reported that today's working environment results from numerous mergers and acquisitions, retiring baby boomers, fewer resources and less time to fully understand metering technologies and applications. There is growing dependence on product manufacturer's and vendors to provide complete solutions that fully comply with industry standards such as API, AGA and Measurement Canada.

To increase profitability, accurate and repeatable flow measurement is required for both process control and custody transfer applications as reported by Ikoku (1984). A 1% reduction in raw material that flows at 10 liters per minute and costs \$1.00 per liter generates a cost saving of \$52,560.00 per year assuming 24/7 operation 365 days a year. A 3" ultrasonic meter that flows 25 MMSCF/D of natural gas at \$9.00 / thousand SCF equates to \$6,750,000.00 per month. Improving the accuracy by 1% will work out to a difference of \$67,500.00 per month.

This paper focuses on some important aspects of Fiscal Natural Gas Measurement (FNGM) best practices and how they may be applied to improve metering accuracy.

2. What is Custody Transfer

Custody transfer" measurements are defined as measurements that provide quantity and quality information, which can be used as the basis for a change in ownership and/or a change in responsibility for materials. In most O&G producing jurisdictions around the world national regulations and directives have emerged to specify requirements for the expected accuracy and uncertainty ranges associated with "custody transfer" and other critical measurements. For such precise metering applications, the flowmeters and adjacent piping used in the measurement system are expected to meet the requirements of the relevant, preferably the most stringent, specifications of the API and ISO standards that are cited in many national regulations

The metering of natural gas presents unique challenges when compared to other fluid (i.e., liquid) flow metering. Perry et al (1997) showed that the physical properties of natural gas, particularly its dynamic relationship between

temperature and pressure, can drive metering inaccuracies unless compensated for. Accurate natural gas flow measurement usually requires the measurement of the fluid's temperature and pressure in addition to flow.

Additional constraints on natural gas metering may include the physical space available or possibly configuration and weight of the metering system. Some of the fluid metering technologies require specific lengths of pipe, both upstream and downstream of the meter for proper function. Before any technology decisions are made, discussions with equipment vendors and/or design engineers are recommended to ensure proper technology selection.

3. Fiscal Natural Gas Measurement Systems In Nigeria

The Nigerian Gas system is represented by the highlighted flows in the flow diagram in below.

According to Hart resources report, the gas system consists of:

- **Upstream Gas:** the gas fields and gas gathering infrastructure that gathers the gas for delivery into gas transmission pipeline network. This is usually a custody transfer point.
- **Downstream Gas:** the gas transmission and distribution infrastructure that transports the gas from the upstream to the consumer.

The physical structure of the Nigerian gas industry consists of the following:

- Producers who gather the gas, and pass it onto NGC at custody transfer point.
- NGC the Nigerian Gas Company who own and operate the majority of the gas transmission network, who buy gas from the producers and sell the gas on to large process uses and resellers.

NLNG, Nigeria Liquefied Natural Gas Limited, buys gas from three joint venture (JV) operators (SPDC, NAOC, EPNL) and produces Liquefied Natural Gas (LNG) for export

3.1. TECHNICAL ISSUES AT STAKE

Initially there was no local market for Nigerian and thus a number of issues surround the gas industry operations and they include;

- ◆ A proper gas law which addresses key issues including gas quality and gas metering
- ◆ Lack of efficient measurement practices to ensure gas metering accuracy
- ◆ Poor metering of gas flaring streams
- ◆ Volume sales rather than energy sales

- ◆ Sharing of transmission pipelines results in disagreements on volume discharged

The issues identified above require immediate solutions if Nigeria's gas business is to grow. Though numerous, yet ways to mitigate these problems are presented below.

4. Improving Metering Accuracy

a) Piping/ Valves:

The meter upstream/ downstream piping configuration and piping quality should be carefully selected in accordance with the relevant standard and /or as per manufacturer's recommendation. For instance, header should be designed to ensure even flow distribution, minimal swirl and minimize possible pulsations from unstable recirculation zones.

b) Fluid Properties and Environmental conditions

Gas properties / composition should be carefully considered to decide on the suitability of the material of construction to be used in FNGMS. Presence of components such as H₂O, H₂S, Hg, Sulphur etc should be dealt with for corrosion issues and for the selection of proper analyzer equipment.

c) Reference Conditions

The contract, regulatory requirements normally specify the reference conditions, Base Density, flowing density, energy content and billing units for custody transfer application. Normally the reference conditions are 60 Deg F and 14.73 psia or 15 °C and 1.01325 Bar.

d) Uncertainty

Errors in the measurement can cause both immediate and long term effects on the profit. Inaccurate measurement may result in loss of customers, substantial penalties and legal liabilities. Hence it becomes imperative that the measurement is precise and accurate with minimum errors. The overall uncertainty of the metering system is generally 0.7 to 1.5% for today's instruments & technology. The following uncertainties are common in custody transfer measurements and must be accounted for.

- Measurement methods Uncertainty
- Calibration uncertainty
- Data acquisition uncertainty
- Data processing uncertainty

Statistical methods are used to develop uncertainties in most applications.

e) Validation:

In order to maintain the reliability and accuracy of the metering system, it is recommended to perform a periodic

calibration and validation of the metering station component. Validation equipment, wherever possible, should be twice accurate than the instrument being calibrated as well as traceable to internationally recognized standards such as NIST.

f) Flow Conditions

To assure accuracy within the uncertainty stated, certain flow condition limitations must be followed:

- The flow shall approach steady-state mass flow conditions on fluids that are considered clean,
- single phase, homogeneous, and Newtonian;
- the fluid shall not undergo any change of phase as it passes through the orifice;
- the flow shall be subsonic through the orifice and the meter tube;
- the Reynolds number shall be within the specified limitations of the empirical coefficients;
- No bypass of flow around the orifice shall occur at any time.

g) Meter Correction Factor:

The in-situ calibration can provide a Meter Factor, MF, that may be used to correct the calculated mass flow rate as determined by Equation (1), if agreed upon by the parties. The MF is defined as follows:

$$MF = \frac{q_{m,p}}{q_{m,i}} = \frac{q_{v,p}}{q_{v,i} \rho_{t,p}}$$

Where $q_{m,p}$ = the mass flow rate determined by the primary mass flow system (or master meter);

$q_{m,i}$ = the mass flow rate indicated by the orifice meter being calibrated;

$q_{v,i}$ = the volumetric flow rate indicated by the orifice meter being calibrated;

$\rho_{t,p}$ = the density (mass) of fluid at the meter at flowing conditions.

5. Applications

The areas covered above that have direct impact on the accuracy of measurement have been tested for validity and the results are shown in Table 1 below.

Table -1: Improvement on measurement based on best practices

DAYS	TEMP [°F]	S.P [psia]	Vp [mmscf]	Vi [mmscf]	M.F
1	95.18	457.20088	8.327E+06	8.49E+06	1.02
2	104.23	453.2323	8.311E+06	8.39E+06	1.01
3	100.47	493.0203	5.823E+06	5.88E+06	1.01
4	93	455.2341	6.781E+06	7.46E+06	1.1
5	105.04	463.0994	7.758E+06	6.90E+06	0.89
6	101.33	458.4143	8.884E+06	7.82E+06	0.88
7	109.32	455.2887	8.292E+06	8.37E+06	1.01

The Improvement on measured volumes can be seen. More so the all the meter factors are above 1 and also closely consistent.

6. CONCLUSIONS

To ensure that a company’s strategies and forward-looking actions are based on the most robust data set and most appropriate computational methods, it is important that this data set and method be based on four key factors (“The Four C’s”).

- Comparability
- Consistency
- Certainty, and
- Confidence

There is also a need for stakeholders to draw up a standard and improved measurement procedure and train their staff to keep in mind every factor that may contribute to losses.

REFERENCES

- [1] American Gas Association (1956): Orifice Metering of Natural Gas, Gas Measurement Committee Report No 3, New York.
- [2] American Gas Association (1965): Gas Engineer’s Hand book, Industrial Press, New York
- [3] Ayoade Kuye and Uzoma EZUMA (2008): Computation of Natural Gas Flow Rate using a Spreadsheet;
- [4] Curtis Gulaga (2008): FLOW METER SPECIFICATION AND APPLICATION ANALYSIS, Class #41 CB Engineering Ltd. Calgary.

- [5] Folga S. M.(2007): "Natural Gas Pipeline Technology Overview", Decision And Information Sciences Division Argonne National Laboratory Nov.
- [6] Igwe, Godwin J. (2011): Natural gas transmission and distribution in Nigeria,
- [7] Ikoku C. U (1984): Natural Gas Production Engineering, John Wiley & Sons, N. Y.,
- [8] Kratowicz, Russ (2006): Verifying gas meter accuracy <http://www.plantservices.com/articles/2006/048.html>
- [9] Perry R. H., D. W. Green (1997): Perry's Chemical Engineers Handbook, Seventh Edition, McGraw Hill Company Inc., N. Y.
- [10] Sawchuk B. D., Sawchuk D. P, (2002): Flow Conditioning for Natural Gas Measurement, Acadiana Flow Measurement Society, 23rd Annual Show
- [11] Wiklund, David E.(2003): "Practical Considerations in the Metering of Natural Gas and Steam Flows, Rosemount Measurement Division, Ch, MN 55317, USA.