

“Unaccounted-For Gas Study in Distribution Networks”

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In the Gas Distribution business Unaccounted Gas is referred to by various names or terms such as: Lost and Unaccounted-For, LUG, L&U, and UAF. In simplest terms, Unaccounted Gas is the result of the formula “*gas receipts minus gas deliveries*”. For the Measurement Group the process amounts to a “gas inventory reconciliation” based on the recorded volumes into the system(s) less the sum of the volumes out of the system(s). This can be a town by town or a total-system reconciliation.

In a perfect world the gas receipt point is a single town border or city gate, and the deliveries are made to customers via a totally gas tight piping system. The city gate station measurement period and that of the customers’ meters are all based on the same time period. All meters have an uncertainty of less than 0.5%. All of the volume determinations and reporting is done in a single Gas Measurement System, and no revisions to “original” volumes is ever necessary. Regrettably not too many perfect world situations exist in the gas distribution business.

Accountants see in their financial reports that “the company purchased this many dollars worth of gas inventory, and the company sold some number less”. Since the company makes x.xx dollars per unit, there is a projected income loss of \$xx,xxx.xx associated with “Unaccounted Gas”. If the projected “dollars lost” are great enough to significantly impact the company’s “bottom line”, the Measurement Group can expect to get ***the call!***

In order to positively respond to, or better yet, prevent ***the call***, operations can perform an Unaccounted Gas Study. For the study to be the most effective, some key elements must be thoroughly understood:

- 1) A “Target” or acceptable Unaccounted Gas level based on specified time period
- 2) Measurement System – functional capabilities
- 3) System dynamics - volume distribution
- 4) Uncertainty (accuracy) of metering devices in service for receipts and deliveries
- 5) Possible points of gas losses
- 6) Responsibility for finding and/or fixing problems

The target or acceptable Unaccounted Gas level

The target or acceptable Unaccounted Gas level(s) may be short and/or long term based. The level(s) could be set based on regulatory tariff, regulatory maximum rate, or company objectives. As an example a value of 6% in a calendar month may be acceptable, while on an annual basis the maximum acceptable Unaccounted Gas level could be 2%. Once the target value(s) and the time period(s) are defined, the study process can reveal if targets are being achieved.

One of the reasons that a calendar month could produce values out of line with annual numbers is quite likely traceable to “cycle billing”. Typically, city gate meters are read on a calendar month basis. The Residential and Commercial (R&C) meters are read on routes or cycles throughout the calendar month. For example, assume a system indicates a 6% loss for November. The second half of November was colder than normal. The town’s R&C meters were “read” on the 15th of the month. This example shows, more than half of the town’s consumption will not be billed in November, but will be billed as part of December’s business. In order to reduce the impact of this “unbilled” consumption, some companies attempt to estimate this volume. Many use computer models that utilize daily temperature values to estimate daily flow rates. Anomalies related to cycle billing can be rather significant in a calendar month. However, their impact should normally be diluted to a very low level in a 60 to 90 day time frame.

Measurement System(s) – functional capabilities

It is very important to understanding the strengths as well as the limitations of the system(s) that provide the data that ultimately produces the Unaccounted Gas values. Many companies acquire “state-of-the-art”, off-the-shelf, measurement systems, while others design and develop their own in-house systems. Determining, reporting, and controlling Unaccounted Gas should be done through these systems, not through downstream accounting systems. Gas Measurement systems were designed for measurement, control, and reporting, and they should be most representative source of the data.

Physical measurement systems must be both complete and “user friendly”. To be complete, they must be able to do the following:

- Balance and Report on a segmented basis,
- Include all measured and unmeasured gas for:
 - Custody receipts and deliveries
 - Check measurement receipts and deliveries
 - Company used gas
 - Known gas losses (blow downs or line hits)
- Perform recalculations and comparisons,
- Flag and report "out-of-norm" conditions, and
- Control against missing and erroneous data, etc.

To be "user friendly" it must allow full access for inquiry and error report analysis.

If the Measurement system provides the "*gas receipts*" and the billing or accounting system provides the "*gas deliveries*", once a calendar month's business is closed, the likelihood that the two systems can become "out of sync" is very possible. A dynamic Measurement system has the ability to make volume adjustments or corrections to meter volumes even after the month has "closed". Accounting systems typically do not make adjustments to prior accounting periods. Adjustments are added to the current month's business. As an example, a meter is found out of calibration resulting in a volume adjustment of 100 mcf for each of 3 prior months. In the measurement system, the volume history for those months is updated, and "corrected" monthly numbers are available from the system. In the accounting system an adjustment of 300 mcf is made to the customer's next bill. As a result, the Unaccounted Gas numbers generated by the two systems are inconsistent for **four** months.

System dynamics - volume distribution

For the large or complex systems, the number of meters involved may overwhelm a "study team's" ability to perform a comprehensive review. My experience with complex systems is that most adhere to the 80/20 rule surprisingly well. In the majority of studies, my findings were that 80% of the volume was measured by about 20% of the meters. If one can isolate the population of high volume meters, then at least the meters with greatest consumption can have their accuracy validated. This approach should either confirm that the metering is acceptable or it will provide a wealth of data on the types and magnitude of the problems discovered.

Uncertainty (accuracy) of metering devices

Metering devices of all types have varying levels of uncertainty, depending on meter characteristics as well as application. As an example, a turbine meter operating at less than 2% of its rated capacity may not do as well as a diaphragm meter on the same load. On the other hand, if the turbine meter is temporarily over ranged by 5%, it should perform much better than an over-ranged diaphragm meter. A comprehensive Unaccounted Gas

study should focus on assuring that meters are properly matched to the customers' load profiles.

Volume determinations by positive displacement, rotary and turbine meters should be performed in accordance with A.G.A. Report #7. Adjustments to actual conditions must be applied to calculate the "true" metered volume if a meter operates at other than "standard" conditions.

Standard conditions are:

- (1) meter pressure equal to 0.25 psig
- (2) gas temperature of 60° F
- (3) gas composition that strictly adheres to ideal gas laws
- (4) atmospheric pressure equivalent to sea level

If metering occurs at other than standard conditions and applying all A.G.A. Report #7 factors is not practical, then the magnitude of the impact to measurement uncertainty needs to be determined. Detailed below are some examples that should be factored into the study results to assist in quantifying the potential impact to Unaccounted Gas.

Positive displacement, rotary and turbine meters used for R&C applications are usually divided into two approaches when it comes to meter pressure compensation for volume determinations. The first approach utilizes a mechanical index that matches the "regulated" pressure on the meter. Indexes that are intended for 0.25#, 2#, 5#, and 10# service are widely used. By using an internal gear ratio that accelerates or "compensates" the dial rate proportionally to the meter pressure, the index adjusts the metered volume for the 2#, 5#, and 10# pressures. Another approach for some companies is to use a standard index on the meter, and the billing system applies a pressure correction "factor" based on meter or "fixed" pressure value. The assumption is that when the meter is flowing, the meter pressure exactly matches the index value or the pressure factor. Regardless of approach used, if the regulated pressure is greater than specified, the metered volume is **understated**. As an example, if a house meter is supposed to be at 0.25 psig and the delivery pressure is 0.4 psig, the measurement error is about -1%. If a meter with a 2# setup is delivering gas at 2.5#, then a measurement error around -3% occurs.

For positive displacement, rotary and turbine meters that are not temperature compensated, a volumetric error occurs anytime the gas temperature is not 60° F. For each 5° F deviation, an error in measurement of around 1% occurs. This means a meter in the winter with a gas temperature of 40° F is under-measuring by about 4%. Conversely, in the summer a gas temperature above 60° F results in an over-statement of the measured quantity by this same ratio.

Natural gas does not adhere to ideal gas laws when elevated pressures are involved. This occurs because it is a mixture of different gases that do not “compress” uniformly. In order to achieve an accurate volume determination, a compressibility factor must be determined and applied to compensate. For positive displacement, rotary and turbine meters that operate at pressures from 30 psig to 100 psig, the omission of this factor results in under-measurement from 0.5% to 1.6%.

Possible points of gas losses

Other possible sources of Unaccounted Gas are

- 1) non-register meters
- 2) meters and/or associated instrumentation out of calibration
- 3) piping leakage
- 4) theft

Normally the best ways to flag a potential non-register or “dead” meter are through the auditing feature of the Measurement System or input from the meter reader. Although the time lag can be 60 days or more, these meters can be isolated for investigation. Knowing the age, and maybe more importantly, the “mileage” of the mechanical meters in the system should assist in isolating meters with a higher potential for failure.

A robust validation/calibration and maintenance program helps assure that meters and their associated instrumentation remain accurate. Most problems with meters commonly used for custody transfer may be eliminated by:

- 1) careful adherence to guidelines found in industry standards,
- 2) compliance with company measurement procedures manuals, and
- 3) by frequent attention to inspection and preventative maintenance programs.

Neglecting a metering system almost always results in a marked increase in Unaccounted Gas.

The volume of gas lost due to leakage is dependant on two variables: line pressure and size of opening. At 30 psig a hole the size of a paper clip can leak about 800 scf (1 mcf) of gas per hour. Since this amounts to 576 mcf per month, it could cause an Unaccounted Gas percentage level for a small distribution system to exceed target values. A review of system leak history (repaired and un-repaired leaks) could prove to be beneficial to the study.

One company reports that “theft of service” customers are typically a subset of non-pay and trouble pay customer base, and they focus investigation efforts on these. Some of the means used by customers to steal gas are:

- 1) illegal turn-on,

- 2) by-passing meter,
- 3) stolen meter, and
- 4) reversed meter.

The employees of the meter reading group may be able to assist in the effort to diminish gas lost to theft by reporting: (a) presence of a bypass, (b) missing or damaged index, and (c) locations that appear to be occupied and yet indicate no consumption.

Responsibility for finding and/or fixing problems

A key factor in controlling Unaccounted Gas is to assign responsibility. Without direct responsibility, Unaccounted Gas becomes secondary to other “day to day” operations. Of the companies assigning direct responsibility, many have placed that obligation on the operational teams who control the source of the measurement data. Individuals who are assigned these responsibilities need to be knowledgeable of:

- Industry measurement standards,
- Measurement equipment and techniques,
- How to access measurement system data,
- How to perform complex analysis,
- How to evaluate the performance of distribution balancing systems.