Managing Lost And Unaccounted For Gas Volumes

Part 2 - Measurement Hardware

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Introduction

This series of papers will focus on possible causes of what is often known as Lost And Unaccounted For (LAUF) gas. The LAUF is a calculated value which compares the amount of gas coming into a system (purchased) to the amount of gas leaving the system (sold and/or otherwise accounted for). LAUF most often results from measurement issues, improper adjustment and handling of measured values, lack of accounting of controlled gas venting, and gas lost due to damage and leakage. The series will discuss and address each of these areas, starting with measurement calculations, and ending with reporting requirements.

In this part of the series we will look at how the operation, maintenance, and installation of meters, regulators, and other measurement "hardware" can affect the LAUF value. It is not intended to be a technical handbook on measurement devices or practices, merely a discussion of LAUF related topics.

Note: This series uses nomenclature, terms, and values associated with the Natural Gas Industry in the United States. However, the concepts and issues presented are applicable regardless of the location of the operation or system.

Meter Types

There are basically two types of meters used in the gas industry. One is a displacement type meter and the other is an inferential type.

Displacement type meters "measure" the quantity of gas passing through them by counting the number of times that a internal chamber of a known volume is filled and emptied. Diaphragm and rotary meters are examples of this type of meter. Except for losses due to "slippage" (the internal leakage of gas through the valves or by the control surfaces), displacement meters measure the actual volumetric passage of gas through the meter.

Inferential type meters "infer" the quantity of gas passing through them by measurement of some value other than actual volume, such as velocity or pressure drop, and use that value to infer or calculate a volumetric value. Orifice, turbine, and ultrasonic meters are examples of this type of meter. Inferential meters require the use of an equation, formula, or calculation method to determine the quantity of gas passing through them. These calculations are commonly based on an industry standard, such as AGA 3 for orifice meters, AGA 7 for turbine meters, and AGA 9 and 10 for ultrasonic meters. Review of these reference documents will reveal that there is an expected amount of uncertainty associated with these type of meters.

Meter Selection

To properly select and size a meter, the flow or demand characteristics of the downstream utilization equipment is critical. A few points to consider:

- Are there multiple appliances and equipment being served? If so, consider the likelihood that not all of the equipment may be in service at the same time (coincident). If multiple appliances or equipment may be supplied, try to determine the most likely or coincidental demand or flow rate.

- What is the range of flow rates? If the downstream demand is an “on or off” type demand then it may not be necessary to consider low flow conditions. The rangeability of some meter types are better than others. If the demand ranges from very low flow to high flow, a meter that can accurately measure the full flow range should be considered.

Inferential meters are often less accurate at very low flow rates and more accurate at higher flow rates. Displacement meters are often able to accurately measure low flow rates, but may not be able to accommodate very high flow rates that an inferential meter can. There is always a trade off when considering rangeability. Consider selecting a meter that provides the most accurate measurement at the most common or likely flow rate. As with many measurement devices, size the device so that the most common anticipated flow rate is no more than 80 percent of the capacity of the meter. However, when using this criteria, be careful that the highest anticipated flow rate is not damaging to the meter.

A smaller sized meter may often be used to measure a flow rate higher than the meter’s “standard” rating by increasing the pressure in the meter, or increasing the differential across the meter. Elevated meter pressure must be compensated for with a corrector or by the use of an appropriate Fixed Pressure Measurement Factor. In the case of mechanical meters, increased differential can lead to premature wear and slowing of the meter. Consider more frequent testing for meters operating at increased differential pressures.

An improperly sized meter, or meter type used in an inappropriate application can negatively contribute to the LAUF value. In these cases, the gas is not lost, it is just not measured correctly and therefore not accounted for properly.

Meter Accuracy

Meter accuracy refers to a comparison of a meter’s measurement of a certain quantity of gas compared to a “reference” device’s measurement of the same quantity of gas under the same conditions. Because of the slippage associated with displacement meters, and the “uncertainty” associated with inferential meters, there is always some inaccuracy in the measurement of gas flow.

In most cases, gas meters used in the US are required to have a new (going into service) accuracy of +/- 1.0 percent. Generally, this means that the measured volume is within +/- 1 percent of the actual volume passing through the meter. The required new accuracy of meters is established by various standards organizations. For example the ANSI B109 series of standards covers a variety of gas displacement meters, and AGA Report Number 7 covers turbine meters.

With mechanical meters, the accuracy generally decreases with age. It is usually considered acceptable for aged (coming out of service) meters to have an accuracy within +/- 2 percent, meaning that they are allowed to be less accurate than a new meter. The required accuracy of meters coming out of service is often established by the jurisdictional public service commission (or similar).

The implication of meter accuracy, is that LAUF should not be expected to be any better than the accuracy of the devices used to measure the gas coming into and out of the system. For example, for a system using older diaphragm meters, the LAUF should not be expected to be much better than +/- 2 percent. A value less than that is likely due to coincidence, or due to some causes contributing to the plus side and some causes contributing to the minus side of the LAUF equation.

Meter Testing

As noted previously, the accuracy of a mechanical meter changes as the meter ages and wears. Mechanical meters tend to “slow down” with age, meaning that they under-report the quantity of gas that passes through them as they get older. This occurs due to slippage and leakage through the valve mechanisms and control surfaces, and increased friction in their moving parts.

It is recommended that each meter be tested before it is placed into service, and again upon its removal from service. However, it is not always practical to test every meter because of the shear quantity of devices involved. In these cases, meters are often “tested” under a statistical meter testing and exchange program. There are a variety of approaches to meter testing and exchange programs. In general, the process requires the removal and testing of “batches” of meters, followed by additional processing depending on the results of the tests. In this approach, it is seldom the case that all meters are actually tested either going into service or coming out of service. However, the results should be statistically similar to testing each meter individually.” Data from individual testing or statistical testing can provide the operator with valuable information about the accuracy of the meters that it has in service. The data may yield that the meters have been left in service too long, or that the meters were removed from service too soon.

Most meter exchange programs, statistical or not, are generally based on the length of time a meter is in service. A more prudent approach might be to consider the total volume of gas measured by the meter (basically the meter mileage) when establishing exchange periods. Meters with higher mileage should be considered for exchange before meters with lower mileage, regardless of the time in service.

No matter the exchange criteria, the coming out of service accuracy (and consequently the LAUF value) can generally be improved by removing or exchanging meters at shorter periodic intervals. However, the operator should consider the benefit of improving the LAUF value versus the cost of more frequently exchanging its meters.

Since regulator delivery pressure to the meter directly affects the quality of the metered results, in addition to a meter testing and exchange program, a service/meter regulator testing and exchange program should also be considered and implemented. It is sensible for these two programs to work in parallel as companion programs.

Instrumentation

Larger capacity meters are often equipped with electronic or mechanical correction instruments (correctors). Modern correctors are largely electronic, older correctors are mechanical. In either case, these devices are susceptible to errors and malfunctions. They should be periodically tested to ensure that they are properly working, adjusted, and set-up.

Particularly important for new electronic correctors is the review of the factory settings. These values should be reviewed and revised to reflect appropriate local conditions. Common setting errors include incorrect Base Pressure or Atmospheric Pressure values. These values can be revised or corrected by the operator using manual entry methods. Additional parameters that might change with time or season, such as gas composition, compressibility, and specific gravity, should be periodically reviewed to ensure that they represent current operating conditions.

As with any device, meter correctors have certain operating ranges, accuracies, and uncertainties associated with them. Ensure that these values are within the limits, expectations, and requirements of the specific application.

Pressure gauges are often used to check regulator set pressures. These “instruments” may be either mechanical or electronic. In either case the gauge must be periodically checked and calibrated to ensure accurate measurement of regulator set pressures, and thus delivery and metering pressures.

Electronic pressure gauges are now quite common. They often have very good pressure accuracy ratings, although this accuracy can be greatly affected by the temperature of the environment that the gauge is operating in. Higher quality electronic pressure gauges have temperature compensation algorithms that correct for this behavior. However even when the temperature is compensated, they will have an allowable operating temperature range for accuracy. Be sure to use a gauge with an appropriate operating temperature range.

The issue of Atmospheric Pressure (local barometric pressure) also plays a role in electronic pressure measurement. Barometric pressure is naturally compensated for in the design of mechanical gauges. Barometric pressure is not naturally compensated for in electronic gauges. In higher quality electronic gauges, a “zero” function is provided to compensate for varying barometric pressure. When this feature is available, the gauge should always be zeroed before using.

When using either type of gauge to measure a pressure value, use a gauge appropriate for the application. Use a gauge where the anticipated pressure value is within 20 to 80 percent of the gauge’s full range. In other words it would not be advised to use a 100 Psig range gauge to measure pressures less than 20 Psig or over 80 Psig. Although in these cases the gauge will report a value, the value is not necessarily valid or accurate.

An inaccurate, uncalibrated, or inappropriately ranged instrument can negatively contribute to the LAUF value.

Regulator Selection

To reemphasize, the quantity of gas passing through a meter is directly affected by the pressure inside the meter. Except for “line-pressure” meters, that pressure is usually controlled by a pressure reducing regulator directly upstream of the meter. The quality and accuracy of this regulator directly affects the quality of measurement. Line pressure meters do not have a regulator directly upstream of the meter. In these cases, the pressure in the meter fluctuates up and down as the supplying system fluctuates.

For measurement purposes, the upstream regulator should be able to maintain the set pressure with minimal “droop” or “boost”. Droop refers to a drop in regulator outlet pressure compared to the set pressure. In regulators susceptible to droop, the droop value increases as flow increases. Boost refers to an increase in regulator outlet pressure compared to the set pressure. This usually occurs as the flow is rapidly reduced from a higher rate to a lower rate. Since boost generally occurs at low or no flow, it does not affect the quality of measurement as much as droop does. Some manufacturers publish this information, others do not. If the information is not published, consider another model, or if practical, perform in-house testing to determine the ability of the regulator to hold its set pressure under a range of flow conditions.

For measurement purposes, the regulator should be installed as near to the meter as practical. For gas to move along a pipe, a pressure drop must exist. In other words, gas moves from higher pressure to lower pressure. Intrinsically, the pressure at the meter will always be less than the outlet pressure of the regulator due to the pressure drop required to move the gas from the regulator to the meter. The closer the regulator or regulator sense point is to the meter, the closer the pressure in the meter will be to the outlet, and presumably the set pressure, of the regulator. Realize that the pressure in the meter will never be exactly the same as the regulator set or outlet pressure.

As with many devices, the service/meter regulator should be sized so that the anticipated operating range falls within about 20 to 80 percent of the capacity of the regulator. In many measurement cases, the required operating range of the regulator is from zero or near zero flow to some maximum flow rate. The regulator should be sized so that the most anticipated flow rate falls within the 20 to 80 percent range, while ensuring that the maximum anticipated flow rate can also be accommodated. This will ensure that the customer can be adequately supplied under full flow conditions, and that the most accurate measurement will occur under the most common flow conditions.

An improperly sized regulator, or a regulator type used in a inappropriate application, can negatively contribute to the LAUF value. Similar to meter selection, the gas is not lost, it is just not measured correctly and therefore not accounted for properly.

Regulator Adjustment

From a measurement viewpoint the purpose of the regulator is to maintain a consistent pressure in the meter. Remember that the quantity of gas measured by a meter is directly affected by the absolute pressure within the meter. It is critical that the pressure supplied by the regulator is consistent, and accurately set.

For some regulators it is common for the outlet pressure of a regulator to reduce or droop under flowing conditions. This is often caused by fundamental characteristics of the regulator which cannot necessarily be changed. However, in many cases this condition can be corrected for by setting the regulator outlet pressure under anticipated flow conditions. The most common reason for a low regulator outlet pressure under flowing conditions, is adjustment of the regulator set pressure under no-flow conditions.

It is best to adjust a regulator's set pressure under anticipated flow conditions, but this is not always possible or practical. When this cannot be done, it is critical to have at least some flow through the regulator when the set pressure is being adjusted. When it is not possible to develop flow for adjusting the regulator by operating the downstream equipment, some gas will need to be vented. Although this vented gas is lost, it does not necessarily need to be considered as unaccounted for. If the details of the venting process are known, along with the duration of the venting, an estimate of the vented gas can be made and accounted for.

It is prudent to periodically review and audit the set pressure of your service/meter regulators, especially for elevated Delivery Pressure meters. It would be prudent to periodically sample and check set/delivery pressures of all service regulators. Perhaps this should or could be done at the same time and frequency as meter testing and exchanges.

An improperly adjusted regulator can contribute negatively to the LAUF value. In this case, the gas is not lost, it is not measured correctly and therefore not accounted for properly.

Line Pressure Meters

Sometimes a meter is installed without an immediate upstream regulator. These installations are often referred to as line pressure meters. This type of installation is most often found on large volume customers where the increased pressure allows additional capacity through a meter, or allows an elevated delivery pressure to the customer.

The only way to ensure accurate measurement for a line pressure meter installation is to install a pressure corrector or instrument on the meter. Because of the lack of immediate upstream pressure regulation, the pressure in the meter varies. Varying pressure cannot be accurately accounted for by a static pressure correction factor.

A line pressure meter without a corrector will contribute negatively to the LAUF value. Lack of a corrector does not result in lost gas, it merely results in incorrect measurement and therefore the gas passing through the meter is not accounted for properly.

Summary

In Part 1 of this series we discussed the many adjustments and corrections that can be applied to measured volumes to more accurately report the measured values. In this Part 2 of the series, we looked at how the devices that report those values can affect LAUF. From that perspective, it seems that it would be difficult to expect a LAUF value to be any better than the best accuracy of the hardware and devices being used to measure the gas. It would be unreasonable to expect the LAUF to be any better than +/- 1.0 percent for systems with largely newly installed meters, or perhaps no better than +/- 2.0 percent for systems with predominately older meters.

Following good installation, operation, and maintenance practices can help reduce LAUF, and help maintain the best accuracy possible from your measurement devices. Proper meter set or station design, installation, operation, and maintenance is critical to ensuring accurate measured values. The AGA, and many manufacturers, provide extensive recommendations for these activities. These resources should be reviewed and consulted to ensure the best results.

What's Next

The next part of this series will focus on field operations and practices, and their impact on LAUF.

About The Author

Bradley Bean is the manager and senior partner of B3PE. Through its predecessor company (Bradley B Bean PE) the firm has been providing engineering software and services to the Natural Gas Industry since 1992. Mr. Bean has been involved in the industry since 1982.

B3PE (www.b3pe.com) provides software tools to assist in properly sizing regulators and meters, and to calculate all of the adjustments and corrections mentioned in Part 1. The firm also provides services to assist in the design and sizing of measurement devices.