Managing Lost And Unaccounted For Gas Volumes

Part 3 - Non-Measurement Causes of LAUF

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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 to damage and leakage. The series will discuss and address each of these areas, starting with measurement calculations, and ending with reporting requirements.

The two previous parts to this series focused on measurement related topics, both calculations and hardware. This Part 3 will focus on possible and potential non-measurement sources of LAUF. Although most are obvious and easy to identify, they are not necessarily easy to quantify and account for.

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.

Operations and Maintenance

A variety of operations and maintenance activities involve releasing or consuming gas from the system, some of these include:

- Venting gas during regulator station maintenance and testing
- Venting gas during relief valve maintenance and testing
- Gas used for line and pilot heating
- Vented gas used for pneumatic controls
- Gas used by “bleed” type devices
- Compressor fuel usage
- Flaring
- Relief valve venting
- And more...

Although “lost” in terms of gas being released or consumed, the gas used in some of these activities can sometimes be accounted for. Let’s explore each of the above topics and see what we can learn.

In the context of this section, the term line, pipeline, and system are used interchangeably. The use of one term includes the others.

Venting Gas During Regulator Station Maintenance and Testing

Often when performing maintenance on regulator stations small amounts of gas are released into the atmosphere. These amounts are not measured and are difficult to estimate. This gas is truly lost and unaccounted for. Even though generally very small in quantity, the amount of gas released can be minimized through good practice.

- When venting gas between devices, let the downstream device bleed as much of the gas as practical into the downstream system before shutting it in.

- When adjusting set pressures, develop flow across the regulator by allowing the downstream system flow to pass through it, instead of venting gas to the atmosphere to develop flow. If the downstream system flow is very low, shut the outlet valve for a while, letting the downstream pressure drop a bit, then re-open the downstream valve slightly to allow flow through the regulator set. Adjust the regulator while flow is present.

- When placing a section of the station back into service, it is always a good idea to purge any entrained air from the station piping. This process always involves the release of some amount of gas into the atmosphere. Before purging a section, consider the quantity of air that might be contained in it. If the quantity is very small compared to the downstream system volume, it is generally not necessary to purge the air from the section. Very small amounts of air may be released into the gas system without negative results. Once released into the system, the air will naturally mix with the gas through molecular action, quickly dissipating and will not result in a negative impact.

Venting Gas During Relief Valve Maintenance and Testing

It is inevitable that some gas will be released when adjusting and testing relief valves. However the "gas" does not necessarily need to be natural gas. Compressed air or nitrogen can be used to check and adjust set points. By designing the station or set to allow a connection to an outside pressure source just upstream of the relief valve, inert gas can be used to check and adjust the relief valve.

Unfortunately, if a capacity test is required, it will generally be necessary to release natural gas from the system to ensure that the upstream device or system is adequately protected by the relief valve.

From a design viewpoint, relief valve maintenance can be limited or eliminated completely by using a monitor regulator for over-pressure protection ("OPP"). With this configuration, no relief valve is necessary. However sometimes it is desired to install a token (or tattler) relief valve to alert when the monitor has taken control. These types of relief valves generally have a very small capacity and vent very small amounts of gas when activated or being tested.

If the downstream system can accommodate a disruption in service, a security valve or shut-off valve may also be used in lieu of a relief valve to provide OPP. Although this type of device does not release gas, it does interrupt service to the downstream system when activated. This may not always be acceptable.

Gas Used for Line and Pilot Heating

Sometimes it is necessary to heat the gas stream flowing through an entire station or through the feeds to the regulator pilots to prevent operational issues. Line heaters are often fueled by gas from the system that they are connected to. Depending on the location of the fuel feed line connection, the fuel gas to the heater may be measured as part of the downstream flow, or it may not.

The fuel gas used by a full line heater is burned to produce heat, and the products of the combustion are vented to the atmosphere. Therefore the fuel gas used by a heater is not available for use downstream and is "lost" but it may be possible to account for it. Full line heaters use a relatively large amount of fuel gas. Their flow is large enough that a meter could be used to measure the fuel usage. If not measured, and if the operating conditions, burner rating, and duration of operation are known, the fuel usage can be calculated and accounted for.

There are two types of pilot gas heaters that use gas to produce heat; one that burns fuel (catalytic), and another which burns no fuel and uses friction of the gas flow to produce heat (vortex). The amount of fuel gas used by a catalytic heater is quite small. With this type of heater the fuel gas is burned, the combustion products vented to the atmosphere, and the gas used is lost. The usage rates for these type of heaters is too small to be practically metered. However, if the operating conditions, burner rating, and duration of operation are known, the fuel usage can be estimated by calculation and accounted for.

Vortex type heaters bleed the gas used to produce heat back into the downstream system. Because all of the gas used by this operation remains within the associated gas system, no gas is lost and no further accounting is required.

An alternative to gas burning heaters are electric powered heaters. These type heaters use no gas and vent no gas from the system. However, they require an outside power source to operate.

Vented Gas Used for Pneumatic Controls

Some control systems and devices used in the natural gas industry use gas from the system to operate valve controllers, solenoids, and pumps. The gas used by these devices is vented to the atmosphere and lost. The amount of gas lost is generally quite small, and it is not practical to meter these amounts. However, if enough detail is known about the usage characteristics and duration of use, it may be possible to estimate the amount of gas lost through calculation and account for it.

Electrically controlled devices can be used in lieu of pneumatic control devices to eliminate the gas lost through pneumatic control operations. Where practical, an on-site compressor can be used to supply the required pneumatic pressure.

Gas Used By "Bleed" Type Devices

Some control devices use upstream gas to control or actuate the device, then bleed the gas to the downstream system. Most "flexible element" type regulators use this type of control and actuation. In these cases, the gas is not vented or released from the associated system, it is merely moved from one part of the system to another. The gas is not lost and no further accounting is required.

Compressor Fuel Usage

Similar to line heaters, some compressors use gas from the system to fuel their operation. Along transmission lines, these are generally large devices with sophisticated control systems that can monitor and account for their fuel usage. Smaller machines used in the gas fields may not have these types of controls or metered fuel gas usage. In these cases, if the operating characteristics and duration of operation are known, the fuel gas used by these machines may be estimated by calculation and accounted for.

In lieu of using gas powered compressors for smaller installations, the compressor may be electrically powered. In these cases no gas is lost from the system and no accounting is necessary.

Flaring

Flaring is the practice or operation of venting gas to a flare device which then burns the gas and releases the products of combustion to the atmosphere. This commonly occurs in oil production for a variety of reasons. That type of operation is not associated with our discussion of LAUF. However in non-production cases, gas may be flared as part of the gas system operation and is lost. In these cases, it may not be practical to meter the flared gas. However, if the characteristics of the flare device and duration of operation are known, the amount of lost gas may be estimated by calculation and accounted for.

Relief Valve Venting

When a relief valve is activated, it generally releases gas into the atmosphere, this gas is lost. Once activated, the relief valve may remain open, or may cycle open and closed. If the characteristics of the relief valve are known, along with the pressure conditions in the pipeline and duration of the venting, the amount of gas vented can be estimated by calculation. However, in most cases, the duration of the venting, especially if the valve is cycling, is not known. Because of this, the gas lost to relief valve venting is often unaccounted for.

Other

Other sources of LAUF could include natural gas used to fuel vehicles, generators, heaters, or other devices used by the system operator. Although these uses may involve the loss of gas through combustion, they are almost always metered and accounted for. If they are not metered, and if the operational characteristics of the device or equipment and the duration of the operation are known, the amount of lost gas can be estimated by calculation and accounted for.

Purging and Clearing

Purging and clearing are similar operations in that they generally displace one gas in a pipeline with another. In this context, *purging* will refer to placing a line into service by displacing the air or nitrogen in the pipeline by introducing natural gas. *Clearing* will refer to removing a pipeline from service and displacing the natural gas contained in it by introducing another gas, usually air or nitrogen.

Purging most commonly occurs when a newly constructed pipeline is placed into service. The line may have been constructed as a new system extension, a replacement, or a repair. In any case, the line has been open to the atmosphere and contains air, or has been tested and contains air or nitrogen. To place the line into service, the content of the pipeline needs to be displaced or removed and natural gas needs to be introduced. If a physical separation, such as a pig, is not used between the two gases, they will naturally mix. Because of this, it is always necessary to release some natural gas, either through venting or flaring, to ensure that the mixture in the pipeline is at a very high concentration of natural gas. The vented or flared gas in this process is lost.

It is unusual to meter the gas that is released during this operation. Even if the gas were metered, it is not a consistent mixture throughout the entirety of the operation. It would not be clear how much of the “gas” that passed through the meter was natural gas, air, or some mixture thereof. The amount of gas lost during a purging operation can be estimated by calculation and accounted for. There are several methods available for calculating this value.

In the clearing process the pipeline pressure is usually reduced to atmospheric pressure either by venting (blowing down), downstream usage, or by cross compression. Once the pipeline is at atmospheric pressure, the remaining gas is displaced by introducing air or nitrogen.

If the pipeline pressure is reduced by venting, that gas is lost. If the pipeline pressure is reduced by downstream usage the gas remains in the system and is not lost and is accounted for. If the pipeline pressure is reduced by cross compression, the gas is not lost, but may need to be accounted for depending on its destination.

The gas lost during blowdown as well as the gas remaining in the pipeline after blowdown may be estimated by calculation and accounted for. There are several methods available for calculating this value.

An interesting new technology first draws the pressure in a pipeline down to a near complete vacuum (0 Psia), allowing a pipeline to be purged with nearly zero loss of the natural gas. The technology has been used for many years in Mexico, and is now being studied by GTI. This purging method would only require the filling of the pipeline to be considered.

Line Filling

Once a purging process has been completed, the pipeline is generally at a very low pressure and must be filled to achieve its required operating pressure. This at first might seem like the gas used to fill the pipeline would contribute to LAUF. However, considering that the gas being used to fill the line has generally been measured upstream somewhere, and that it will remain in the pipeline until it is used, when it will be measured as it leaves the pipeline or system. In this case no gas is lost and no gas is unaccounted for.

Leakage

For various reasons leakage will occur from a pipeline or system. Leaks may be large or small. The gas vented by these events is lost. If the physical size and shape of the leak, the system pressure, and the leak duration are known, it is possible to estimate the amount of gas lost by calculation. The duration of the leak is rarely known with any certainty in these cases. Because of this, lost gas due to leakage must generally be unaccounted for.

Damage

Unfortunately, almost every pipeline or system is subject to some sort of damage in its lifetime. As with leakage, these events may result in large or small releases of gas that are lost. Also similar to leakage, if the physical size and shape of the damage that is allowing the gas release, the system pressure, and the release duration are known, it is possible to estimate the amount of gas lost by calculation. Many times the duration of the gas release is often known with some certainty. Because of this, lost gas due to damage may generally be accounted for.

Theft

Theft is fairly rare in the US, but it does occur. It can take the form of bypassing a meter, increasing the delivery pressure through a meter, or other means. Gas lost through theft is certainly unaccounted for from a measurement sense, but is it lost? We will leave that for the reader to determine. As with other circumstances, it may be possible to estimate the amount of gas “lost” in these situations, if enough appropriate information is available. The largest obstacle in making such an estimate would be the duration of the event. In the case of theft, the amount of “lost” gas may remain unaccounted for.

Permeation

All pressure containing vessels, pipelines included, naturally "leak" through a process known as Permeation. Permeation occurs when gas inside the pipeline diffuses through the pipe material. The gas released through this process is lost, but can be accounted for through calculation.

The rate of loss through Permeation is related to the pipe material, the size of the pipe, the properties of the gas, operating temperature, and the pressure in the pipeline. Consider the following:

- The more dense the pipe material, the lower the Permeation rate. The less dense the pipe material, the higher the Permeation rate. Plastic pipe has a higher Permeation rate than steel.

- The larger the pipe diameter, the more area available for Permeation to occur. Larger diameter pipe will have a higher Permeation rate than smaller diameter pipe.

- The lighter the gas contained in the pipe, the higher the Permeation rate. Lower specific gravity gas will have a higher Permeation rate than higher specific gravity gas.

- The higher the pressure in the pipeline, the higher the Permeation rate.

- The higher the temperature of the pipe material and/or the gas, the higher the Permeation rate.

Knowing the above properties and parameters, the Permeation rate of a pipeline or system may be calculated and accounted for. It is not a large value, but it is definitely a value that can be quantified.

Billing Cycles

The timing of billing cycles can affect the LAUF value. Generally when calculating LAUF for reporting, the amount of gas purchased over a period of time (usually 12 months) is compared to the amount of gas sold or otherwise accounted for over that same period. For distribution systems, the gas purchased is usually taken from monthly billing data provided by the gas transporter. It most often represents the amount of gas delivered to the gate stations from the first day of the billing month to the last day of the billing month. Gas sales are usually taken from the monthly billing values of the operator. In the case of a distribution system, this is the billed volumes delivered to the customers attached to the system.

In many cases the billing period for these accounts does not necessarily coincide with the actual first or the last day of the month. Depending on the number of customers involved, multiple billing cycles may exist for the same "month". Because of this, the sold volumes may not necessarily represent the same period of time as the purchased gas volumes, and may skew the LAUF results. If the "read" dates are known for the first, last, and following month in the "reporting" period, adjustments may be made to the sold volumes to correct for this mis-reporting, allowing the LAUF value to be correctly calculated and reported.

Summary

There are many ways for gas to be lost from a pipeline or system. However, lost gas does not necessarily mean unaccounted for gas. If the required parameters, characteristics, and properties are known, many times a very good estimate of the amount of gas lost can be made by calculation and accounted for. Any accounted for gas reduces the LAUF.

The following are a few operational practices to consider for reducing LAUF:

• Reducing operating pressure to as low a pressure as is practical, yet sufficient enough to maintain adequate service, will reduce the amount of gas lost through leakage, damage, and Permeation.

• Always try to use the gas before venting it. When possible, allow the downstream system to draw down the gas pressure through usage before blowing down or venting a system.

• When using the gas before venting is not practical or possible, consider cross-compression. This allows moving the gas from one system to another without loss.

• When purging, consider the required duration. Many operators will purge well beyond the time required to achieve a viable purge.

• Limit the use of relief valves and implement the use of alternative over-pressure protection methods.

• Use compressed air or nitrogen when checking and adjusting the relief valve set pressures.

• Limit the use of pneumatic controls that use gas as the "air" source.

What's Next

The next and final part of this series will focus on the various reporting requirements for 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 estimating lost gas due to purging, clearing, blowdown, and damage, including tools for properly sizing regulators and meters as mentioned in Part 2, and to calculate all of the adjustments and corrections mentioned in Part 1. The firm provides services to assist in estimating the amount of gas lost to the various events and operations mentioned in this part.