LOST AND UNACCOUNTED FOR GAS
"THE PROCESS"

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Introduction

The search for Lost and Unaccounted-for Gas (LUAF) has been a priority for pipeline companies for many years. As an industry, we have an incredible depth of knowledge in how to measure and account for natural gas. However, the successful outcome of a LUAF study sometimes requires fresh eyes. It is not unusual to find people that know the answer to the problem, but having looked at it for so long they have become blind to the fact they have a problem. This paper will highlight some of the ways the industry should be approaching the determination of LUAF by looking at:

- Review of the Tariff
- Review and Verification of Audited Volume Statements
- Interviewing Technicians
- Analyzing the Measurement Processes
- Meter Testing and Inspection
- Reporting and Recommendations

Review of the Tariff

As they say, "if you don't know where you are going, then how do you know when you get there?" The first thing to look for is what was agreed upon by … Looking over the tariff and making note of the Pressure Base, Temperature Base, Limitations or Stipulations to BTU or Gas Quality, and any other specifics is the basis of the audit. Again, knowing where you are going is critical! Utilizing this information, the auditor can move forward without making assumptions.

Review and Verification of Audited Volume Statements

Having a secondary audit of the volume statements is a very important part of this process. This paper will not go into the specifics of this audit, but the results and review of this data is critical. Not performing this as a precursor to the field audit could cause you to be chasing your tail.

Reviewing this data for anomalies, and again verifying the proper use of the information found in the tariff can give you a direction in which to focus your attention. Be open minded while performing this review, and don't let preset ideas distract you. What are we looking for?

- Low Differential Pressure (DP)
- Beta Ratios
- Over ranging
- DP Zero
- Consistent recalibrations
- How recalibrations were handled in the back office
- Pressure Base
- Atmospheric Pressure
- Gas Quality and how it is applied
- Missing Data
- Line Segment Accuracy
- Inlets vs. Outlets

As an example of low DP, look at Figure 1 below. You will notice that in this scenario the difference between 99" of differential and 100" is approximately 14 Mcf/d. But if you look at 1" of differential, it is 277 Mcf/d. Low differential can create much more of an error than over-ranging the differential and not measuring it at all. The

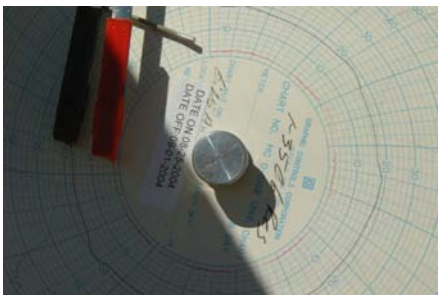
square root effect on DP is staggering to the lost and unaccounted-for gas. We find that this is a very common error in the field and should be avoided.

4” Meter Run
2” Orifice
1% CO_2
1% N_2
14.73 PB
14.7 AP

Figure 1

DP	Mcf/d
1”	277
25”	1,385
99”	2,765
100”	2,779

Image 1



After the review of the volume statements, the determination of locations for site visits is made. Breaking the system up by Line Segments and then priority weighting the sites by volume results in the top 20% of stations chosen to visit on the first pass. A review of these sites compared to any findings in the volume statement audit could add a few sites to your list.

Interviewing the Technician

The technician can be a tremendous source of information. This is the person that sees these sites on a regular basis and should be reporting potential errors. In almost all cases, the technicians are found to be working hard and trying to do the best job they can with the time and resources given to them. Spending some time with the technician, and letting him know that this is not a witch hunt can lead the auditor to many of the problems. Give your technician an idea of what you are looking for, and make him a part of the solution. Also, give him the credit for what he knows. The last thing you want is to make the technician feel that he is not doing his job.

Analyzing the Measurement Processes

It is sometimes assumed that every piece of information is reported to the appropriate person or reflected in the correct system or line segment. The review and analysis of this process is the next step in determining the actual LUAF of the system. Breaking the process down and verifying that the reporting of information is being accurately reflected in the correct system, that failures and corrections have been properly accounted for in the volumes, that line pack and fuel gas adjustments are correct and have been applied correctly, and finally that the testing and sampling of the measurement facility is proper and reflects the critical need based on volume and/or Tariff requirements is critical in determining the LUAF.

The analysis of the measurement processes would include:

- Reporting and Tracking of Data
    - Volume Adjustments
    - Calibration / Orifice Change Reports
- Line Pack
- Fuel Gas
- Recovery of Liquids
- Scheduled Testing and Maintenance
    - Monthly / Quarterly Meter Inspections
    - Meter Tube Inspections
- Sampling Types and Frequencies
    - Gas Chromatograph
    - Composite
    - Spot

Meter Testing and Inspection

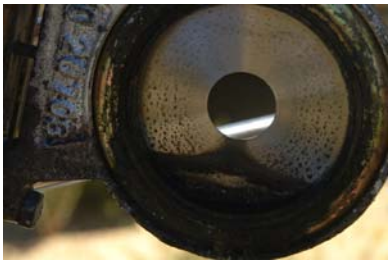
After all the office work is complete, the last place to look is in the field. An overall assessment is performed by looking at that top 20%. These may not be the only sites visited, but they are the place to start. Having the Measurement Technician test the meter while a witness verifies the accuracy does not complete the test. As part of this visit, the auditor should be looking at the following:

- Certification of Test Equipment – Check the equipment being used for testing. Proper certifications should be kept with the equipment.
- Leak Checks – All tubing, fittings and sampling equipment should be checked for leaks. In Image 2 the high side of this direct mount manifold is leaking causing a lower differential than what was actually flowing.

Image 2

- Test Procedures – As Founds / As Lefts and Calibrations should be accurately recorded for the back office to be able to make the necessary adjustments.
- Orifice Plates – The following should be checked and verified. In Image 3 fluids were damming up against the orifice.
    - Beta Ratio
    - Cleanliness
    - Sharp and Straight
    - Seal Ring

Image 3



- Data Verification – Verify the accuracy of the calculation data within the flow computer. This information should be a combination of what is found at the site such as Tube ID, Plate Size, Pressure, Differential and Temperature Ranges as well as information found in the tariff.
- Calculation Comparisons – A secondary calculation should be performed to verify the flow computers calculation.
- Pulsation Induced Errors - Square Root Error / Gauge Line Error – High speed transmitters can detect pulsation within the measurement device. Pulsation is defined in this case as periodic changes in pressure and velocity. This is typically caused by:
    - Compressors
    - Pressure Regulators
    - Controls Valves
    - Fluctuating Loads

- Gas Quality Issues – In Image 4, a sample probe is being used, but a probed regulator should be utilized to provide a sample to the on-line GC. Heat tracing should also be part of this sampling system. Low temperatures below the hydrocarbon dew point will cause the heavier components to drop out of the gas. On the other end of this same sampling system in Image 5, a knock-out bottle was installed to collect the liquids mentioned above just before entering the sample conditioning system mounted on the wall.
    - Sample Procedures
    - Sample Probe Location and Depth
    - Gas Chromatograph – Testing should be performed to verify the accuracy. Analyzing a certified gas standard as an unknown and verifying the results is the easiest way to accomplish this in the field.
    - Sample Conditioning / Heat Tracing
    - Calibration Standards – Proper Handling and Certifications

Image 4

Image 5

- Meter Tube Inspection – Meter tubes should be inspected at least every 5 years, unless a known problem exists and a more frequent check should be performed. In Image 6, you can see that the thermowell is very dirty which obviously means the inside of the meter tube is in the same condition and should be check and cleaned. Verification of the following should also be checked during the audit:
    - Meter Tube Lengths / ID's
    - Straightening Vanes / Flow Profiler

Image 6

Reporting and Recommendations

The determination of LUAF in the system may have come as easy as finding the smoking gun, however in many cases it is a combination of many small things that add up to the unacceptable losses sometimes found in pipeline systems. The proper reporting of findings and giving a good explanation as to how to correct the errors can become the blueprint as to how to avoid these losses in the future. It may also be necessary to continue looking based upon the findings in the initial report. Square Root Error (SRE) and/or Gauge Line Error (GLE) Testing may need to be performed, meter tubes may need to be pulled and cleaned or additional site visits may need to made. Documentation should be made to all findings and the recorded changes after the correction.

Conclusion

All systems have loss, but a well designed system with line segmenting and a proactive program to keep LUAF to a minimum is the only good way of preventing large losses from occurring. LUAF is a costly and many times unnecessary cost that loses millions of dollars a year to transmission companies all over the world. This paper looks at many of the major items that are investigated during a LUAF audit, but it does not include everything. Systems are different, and some problems are complex. The key to controlling LUAF is developing a culture within the pipeline company. The causes and solutions often change and evolve. The pipeline company should learn to control the LUAF, not allow the LUAF control them.