ELECTRONIC GAS MEASUREMENT AUDITING

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INTRODUCTION

It has been stated that measurement is the cash register in the exchange of natural gas. The natural gas business is based on the buying and selling of this commodity. Measurement is responsible for balancing the input (buying) and output (selling). Errors, on either side of this equation, effect the balance the entire business is based upon. Add the fact that natural gas measurement can be extremely complicated, auditing not only becomes desirable, but necessary. As it implies, auditing an electronic gas meter (EGM) requires careful examination of large amounts of data in order to verify volumes and to verify the cash register. An experienced auditor is the most valuable tool in this process. In order to maintain the scope of this paper, a general knowledge of natural gas measurement and EGM fundamentals will be assumed.

STANDARDS USED

It is not necessary for the auditor to be an expert, but is very helpful for the auditor to at least be aware of standards used in natural gas measurement and volume calculation.

Field specifications and calculation specifications used are the American Gas Association (AGA) Report 3 Orifice Metering of Natural Gas or the American Petroleum Institute (API) 14.3. This report details manufacturing, installation, operation, and calculation guidelines used throughout the natural gas industry. EGM manufacturers follow guidelines or standards published by the American Petroleum Institute (API). This standard is known as the API 21.1 Flow Measurement Using Electronic Metering Systems - Electronic Gas Measurement. These standards were developed by the natural gas industry and manufacturers in order to set minimum standards regarding EGM and providing for EGM audit trails. For this paper, we will assume the meter station and data meet AGA/API specifications.

A knowledge of company policy and contract guidelines will also be required. Policies and contracts vary widely regarding auditing, corrections, and settlements.

AUDITING PROCEDURES

With the introduction of electronics in gas measurement, new challenges were encountered in volume auditing. Many of the same processes used in auditing of chart recorders also apply to EGM auditing. Parameters and data that are applied in the calculation of volumes must be verified in both cases. The differences in auditing are found in the characteristics of the devices themselves. Chart recorders provide visible records that can be reinterpreted and recalculated. EGM volume report variables are often averaged daily or hourly at best. This often makes recalculation of EGM volumes become uncertain on varying flow rates.

One of the best possible tools used in auditing EGM volumes is a check meter measuring the exact same gas. Check meter volumes and all other data can be directly compared to the audit station, increasing the probability of detecting errors and increasing the likelihood of settlement of a discrepancy. If the check station consists of an entirely separate meter tube and plate, most errors can be traced. If the check meter is located on the same meter tube, error detection is reduced to the secondary devices (recording equipment) since both meters use the same primary element (i.e. meter tube, orifice plate). If a meter is located on the same physical orifice taps, then effectiveness of the check meter is reduced even further. A chart recorder, used as a check meter, often becomes helpful when determining errors in measurement. We often recommend using a chart recorder backup, in the event that the EGM becomes unreliable or inoperable. If check measurement is not available then a balance may be used from other meters. As in any balancing process, care must be taken to account for all gas. This also opens the scope of the audit and possible error points to the other measuring stations included in the balance.

In summary, it is extremely valuable, from an audit perspective, to have some form of check metering in place. Ideally, the best form of check measurement is achieved using an entirely separate station (meter tube & meter), measuring the exact same gas. Realistically, any form of check measurement is better than nothing at all. The effectiveness and reliability of the check measurement, just as with the station being audited, is totally dependent on the quality of the measurement. For the check measurement to have credibility, check stations should follow the exact same AGA/API guidelines as applied to the audit station.

Proper meter testing, sampling, and reporting in the field are the most important exercises in preventing problems

from occurring in the first place. Good practices in these areas will directly effect the outcome of volumes and the frequency of errors found in auditing. It is also good to witness meter tests to reduce the chance of mistakes made by the tester. This also gives the auditor one more source of information when problems arise.

AUDIT DATA

EGM auditing requires careful scrutiny of an array of data. In order to complete an audit, the first step is to acquire all existing information used in the determination of volumes. EGM data usually consist of reports generated directly by the EGM, field location, or office. These reports provide volume information and other details used in volume determination. Reports differ by manufacturer and company, but most provide similar basic reports. The following are typical EGM reports and other data required to perform a complete audit.

- *Characteristic Report* - Provides details on station name, location, calculation factors, AGA data, analysis data, alarm data, and calibration data.

- *Volume Report* - Provides daily (or hourly) volumetric readings with averaged differential pressure (DP), static pressure (AP), and temperature.

- *Alarm Summary* - List daily alarm conditions such as low differential, high differential, low static pressure, high static pressure, low power, and many others.

- *Event Report* - Details all station activity such as meter tests, calibrations, plate changes, and any other change made to the station parameters.

- *Meter Test Reports* - Along with the events report, most companies complete hard copy meter test reports when tests are performed or changes are made to the station. This is absolutely necessary to maintain the audit trail.

- *Change Reports* - Some companies use separate reports when changes are made (i.e. plate change, meter tube change, range change, etc.).

- *Witness Reports* - Meter tests witness report verifying tester's results.

- *Analysis Reports* - Gas composition information taken from spot samples, composite samples, or on-line chromatography.

- *Check Station Data* - Volume and other reports from any check stations available.

Once all of the related reports and data are obtained, the actual audit begins. Always verify station name and ID. Volume reports should be reviewed for obvious errors, such as missing days or any abnormal data. The characteristic report should be reviewed to determine that proper composition data was used, and that all other station parameters are correct. This should be done for each audit, even if the audit is on a continuous basis. Occasionally, parameters are unintentionally modified or lost due to meter problems.

Review alarm summary to detect problems in the EGM. EGM manufacturers provide daily alarm summaries that can be a valuable audit tool. The alarm summary details many conditions of interest to the operator as well as the auditor. If there are numerous low DP alarms, the orifice plate may be too large. If there are high DP alarms, the orifice plate is too small. These conditions may not be corrected by orifice plate changes if parameters fall outside allowable beta ratio (orifice plate/meter tube) or uncontrollable flow conditions. Generally, the differential should be kept above 30% of differential scale to maximize orifice accuracy. However, this is not always obtainable due to flow characteristics of the station. The alarm limits are reported in the characteristic report and should be verified. The alarm summary also reports errors in the EGM transducer signals, caused by over-ranging transducer or other transducer trouble. Alarm summary reveals errors in the calculation process that can be caused by invalid parameters or meter problems.

Review event reports to ensure proper calibrations and that changes (i.e. plate changes, composition, etc.) are posted properly. Most manufacturers provide detailed events in this report that can often explain discrepancies. Any changes made to the station should be verified closely. Any time changes are made, volume accumulators should be reset in order to ensure that correct parameters are used for calculations from the time of the change forward. Depending on contractual tolerances and obligations, corrections or adjustments may be required from meter tests. This can be determined from the events reports. Test and found points should be recorded during each meter test to provide this audit trail.

Volumetric data can often be obtained in electronic format allowing for integration, recalculation, and comparison by computer. The computer will reduce time spent on audits by automatically flagging potential problems. Volumes should be compared to check station, if available. If a problem is detected through reviewing the volumes or by check meter comparison, more detailed research should follow.

Measurement problems and/or errors can result from a wide variety of sources. Some problems are easily detected and corrected, others are impossible to correct. This is where experience is beneficial to the auditor. For the sake of this paper, we will divide errors into two categories, Field and Office.

FIELD ERRORS

With EGM, the bulk of responsibility of the meter station and resulting volumes is with the field personnel. With this added responsibility and the inherent dynamics involved in measuring natural gas, most, but not all, errors can be traced to the field. For this reason, adequate training and clear communication with field personnel are essential ingredients in the natural gas measurement process.

With any type of measurement, unique characteristics of the measurement devices in use and the actual gas being measured all effect the measurement results.

Primary Element

Many errors or discrepancies are a result of operational or physical properties. Fluids in the gas stream can render false differential readings. Fluids in gauge lines can cause differential zero shifts. Pulsation, caused by compression, can result in differential error. Gauge line error due to compression, flow obstructions, or piping, can also cause differential error that is sometimes difficult to detect. Freezing causes problems when liquids or hydrates form solids in piping or gauge lines. This condition can occur even when ambient temperatures are above freezing (32°F), as long as hydrates are present in the gas stream. This freezing typically results in a shifting zero or "wandering" differential. This is often difficult to detect on EGMs unless the data is graphed or carefully reviewed. Most EGM data will be averaged over daily periods, so this differential error can easily be overlooked. This is especially true when there is no check measurement or balancing available.

Not only do physical properties of the gas effect measurement, but also flow characteristics. When flow patterns are steady and pressures are constant, any type of applicable gas measurement device is capable of measuring gas accurately. Typically, our chart recorder check meters will run well less than 0.5% of EGM volumes, even with nominal fluctuations in flow patterns. When flow patterns become erratic, measurement becomes more difficult. Initially, it is sometimes difficult to properly size the orifice plate when the differential is extremely erratic. Stations on intermitter controlled wells are examples of this situation. These erratic flow patterns are difficult to measure and even more difficult to audit accurately. These extremes in flow rates often make recalculation difficult if not impossible. EGMs normally calculate volumes once per second, but accumulate volumes and averages on an hourly or daily basis. This makes recalculation of EGM data somewhat inaccurate. The best practice, in every case, is to work towards designs and policies that prevent and eliminate the possibility of these errors.

The meter tube and orifice plate are absolutely essential elements. AGA-3 report, as mentioned previously, provides specifications for meter tubes, orifice plates, as well as piping configurations. This is normally handled during design and installation, or handled in the field. Meter test reports and change reports should all be reviewed to verify meter tube and orifice plate information. It is good practice to inspect the orifice plate and orifice seal ring each meter test. This will help find any mystery plate changes. Often errors occur when changes are made. Sustained changes in differential are suspect when they occur at the time of a meter test or other meter work. Occasionally, the tester or operator may change the orifice plate without properly reporting it or possibly replace the orifice plate backwards. Orifice plates are installed with bevel down stream. When an orifice plate is installed backwards, the differential will be reduced. This error is difficult to measure because it depends on the meter tube, orifice plate size, and applicable flow rates. Most often, corrections are made by comparing the error reading with the corrected reading.

Plate changes, as well all other changes, are automatically reported in the events report. Use the events report to verify that the orifice plate change was recorded and applied properly. Volume accumulators should be reset any time any change is made, in order to ensure that correct parameters are used in calculations.

Secondary Element

Always verify the meter station ID. Using incorrect data or volumes can prove tiresome in the auditing process. The characteristics report defines all parameters used in the calculation of volumes by the EGM. All of these parameters must be verified as correct. With EGM, field personnel are often charged with not only testing, but also updating plate changes, compositional data, and other calculation parameters. Often, data is entered incorrectly or omitted entirely. Care must be taken when heating values (btu) are entered. The heating value entered must be as set forth by contract (saturated, dry, or actual) and at the same pressure base as was the volume computation. It is a common mistake to disregard pressure base for btu resulting in a error in MMBtu. The btu is not used in EGM calculations, however, they are often collected with the rest of the EGM data and imported into reporting systems where MMBtu is calculated.

EGMs typically have a zero cutoff feature, which is used to prevent calculation of volume when there are slight zero shifts in transducers. If this option is set too high and low flow conditions exists, it is possible for the meter to ignore this low flow. Conversely, transducer zero shift above zero cutoff, can result in calculating flow during no flow conditions. Always verify zero cutoff and differential recordings, along with low DP alarms. Over-ranging of the meter is also a severe problem. If this occurs, volumes will be understated. Check measurement or estimates must be used. Always check high DP alarms in the alarm summary to verify that the

differential is not being over-ranged.
EGM has become very reliable, however, as with any electronic device, failures will occur. Transducer or transmitter failures are usually detected during the meter test or by erroneous readings reported by the EGM. Occasionally, boards or power supplies will fail resulting in missing data. Most EGMs are battery powered with solar charging systems. With long periods of cloudy weather, units will power down ("sleep") in order to conserve power. Batteries also malfunction, resulting in loss of power. These situations can usually be detected by missing data. Occasionally, meters will report erroneous readings, especially after "sleep" periods, board malfunctions, lightning strikes, or other environmental damage. In either case, check measurement or estimated volumes must be used.

OFFICE ERRORS

Most EGM errors do originate in the field, however, problems do occur in the office. EGM data is collected in the field or by remote, imported into data handling systems, edited, manipulated, recalculated, and sent out in reports. There are many potholes along this highway of data.

Depending upon company policy, contract requirements, and availability, composite compositional data is often applied and volumes recalculated in the office. Analysis or composition reports should be reviewed carefully to ensure application of correct specific gravity, components, and btu values.

Estimates are often inserted in the office. Estimates should come from check measurement or third parties if possible. Company policies regarding volume estimates vary widely.

Incorrect volume calculations can result from recalculating with incorrect or incomplete data. Since raw unedited data is the most accurate, data should not be recalculated unless absolutely necessary.

CONCLUSION

The business of natural gas measurement is truly a complicated, specialized task. The fact is that mistakes will be made no matter who is measuring, what is being measured, or how it is being measured. This fact makes auditing absolutely necessary. The auditor must be knowledgeable in all aspects of measurement, from the field to the office. The obvious goal in natural gas measurement should be accuracy and it is up to the auditor to verify the measurement accuracy.