CHART AUDITING

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INTRODUCTION

The main reason for auditing natural gas charts is the economic benefit derived from it. Because audits require skilled manpower to be performed and administered, there are costs involved. However, audits are advantageous because their benefits generally outweigh their costs, many times significantly.

One of the principal responsibilities of the management of any group organized for profit is risk assessment. Once goals have been established for the growth of the organization, contingency plans need to be developed which anticipate possible and probably obstacles to achieving the goals, the impact of likely scenarios, and the resources and methods required to overcome these obstacles. When company goals require the purchase or sale of certain amounts of gas, the accuracy of gas measurement becomes critical.

Auditing natural gas charts allows the company to maintain revenue levels and decrease liabilities associated with underreported volumes. Other economic benefits include: increased credibility with suppliers and customers, increased accountability of departments and personnel, mitigating losses attributable to costly reruns, and pointing out areas of process improvement within the organization.

The plan for auditing charts should function within management's risk assessment. A simple plan might include auditing a random sampling of stations where higher volume or volumes more important to the companies overall objectives are given more weight. The audit plan may include witnessing meter inspections/ calibrations and/or regenerating chart volumes. Critical stations may require check meters whose volumes are continuously compared to the custody transfer stations' volume. Ideally, the check meter configuration mimics that of the master meter — when the plate is changed in the master meter, it is also changed in the check meter. Check meter volumes found outside a control range when compared to the custody transfer meter require auditing to determine causes. Although more costly than ongoing chart audits, the use of check meters allows the company to isolate many measurement problems much more quickly.

SCOPE OF THE AUDIT

When it comes time to perform the audit, one of the first considerations is the scope. Different auditing procedures may be required for different types of meters or stations. The scope of the audit can range from the field operations to the paycheck calculations or any portion therein. Within the scope, the audit may be performed internally or externally.

Internal audits tend to focus more on procedures and operations. They are generally less expensive than external audits. Of course, the internal audit will seek to validate accurate volumes. Also of concern may be: punctual availability of data to other departments, customers or suppliers, and compliance with governmental regulations, tariffs, contracts and industry standards. Another concern of management will be the optimum use of resources in accomplishing the company's objectives.

The objective of an external audit is an expression of a professional opinion about whether volumes in which an organization has interest are fairly determined, in all material respects, in conformity with generally accepted industry standards and according to specific contractual requirements. External audits tend to be more expensive than internal. Therefore, in an effort to keep costs down, external audits usually focus attention on one or a few parts of an operation as opposed to the entire range. External audits focus on results and not necessarily how efficiently the results are attained. The advantages of an external audit include: increased credibility, access to more expertise and a different (hopefully unbiased) point of view.

FIELD OPERATIONS

The chart auditor is usually charged with regenerating the volumes for comparison and is at the mercy of the office. Some areas of discrepancy cannot be reconciled or resolved from the office alone. Some meter malfunctions cannot be discerned by viewing the charts and a trip to the field is necessary to get to the root cause of a problem. Other problems in the field may not be readily evident by looking at the chart, such as: meter out of calibration, two phase flow, leaking fitting/seal, swirling and pulsation. An understanding of these field related problems, how they are discerned, and their remedies, helps the chart auditor excel at his or her job.

Many field problems are not conducive to accurate adjustment factors. When problems are found it is always good to leave as many conditions as possible the same (e.g., no new wells brought into the system). When all of the problems are uncovered and corrected, a corresponding adjustment factor should be developed. Only when ample time has passed and both parties agree the discrepancy is resolved should other operational changes be made. Then, comparing previous flow rates to flow rates after the error has been corrected can provide a basis for a correction factor or confirm a calculated factor.

Field problems are effectively handled with regularly scheduled meter inspections. In certain instances, like when check or well meters differ significantly from the custody transfer meter, special field inspections may be made. Calibrations are almost always checked at this time. Calibration readings and documentation should provide for equitable means of adjustment.

When the meter is purged, you can see if liquid is in the gauge lines or bellows housing. When the run is depressurized to check the plate, it is easy to see if liquid is in the meter tube. Liquid in the meter tube, meter gauge lines or bellows housing can cause errors, but determining the extent of the error can be difficult.

Blind plate tests will uncover errors resulting from leaking fittings and/or seals. Adjustments can be determined by correcting relative flow rates before the change to match those after the change.

Swirling is difficult to detect. The absence of straightening vanes or flow conditioners can provide a clue. Correcting this problem can be time consuming because re-piping may be necessary to remove bends upstream of the meter tube, install flow conditioners or an upstream tube with straightening vanes. Correcting previous volumes should use readings before and after the change as their basis.

Pulsation can be checked by watching the differential zero as one of the tap valves is closed while the meter is in service. Alternate closing and opening each tap valve and watch to see if the differential zero recording shifts or drifts. If so, pulsation is present. If not, pulsation may still be present and, if pulsation is suspected, a pulsameter will be necessary to detect pulsation. Pulsation can be reduced by moving the meter and the cause of pulsation farther from each other or by putting a large vessel (preferably with baffles), flow conditioner(s), or small orifice plate(s) between the meter and the pulsation source. Erroneous volumes due to pulsation errors are difficult to adjust. Again, the best method will use readings before and after the changes are made.

The chart auditor usually does not have the luxury of checking these items in the field. And these items are not easily detected (if at all) by looking only at the charts. But, sometimes there are clues on the charts which indicate a meter needs attention and many more items which are evident from the chart which can cause erroneous volumes.

INFORMATION GATHERING

The first step in the chart auditing process is to gather the necessary information. All of the information may have been provided with the charts and what is in the station's file if it has been audited before.

Items of concern will include any existing meter inspection/calibration reports, meter configuration change reports (such as plate change notices), and gas compositional analyses. These should cover the entire period being audited. This includes the test and analysis just prior to the audit period and just subsequent to the audit period (if yet performed). Without meter test reports an audit can be performed, but its accuracy would be suspect. Also, many volume statements do not display all of the configuration data. It is hard to argue for an adjustment when you have no facts to back up your claim. If some reports are unavailable, this should be noted in the auditor's report.

The audit will require the original volume statements and, of course, the charts. Also, it is nice to have the corresponding check meter or well meter charts, volume statements with their station documentation. Sometimes, flow and station diagrams can be helpful in determining error causes. Another beneficial tool is a copy of the contract.

It is always good to check the measurement clause of the contract for base conditions, volume calculation method and remedies for discovered errors. If the entire contract is available and depending on the scope of the audit, there are many other items worth noting. If time allows, the entire contract should be read. It may be difficult to understand the meaning of some of the phrases (or why some were put in), but with each reading your understanding grows. Soon you will be catching things others missed.

Things to specifically look for in the contract will include the duties of each party in relationship to measurement. The contract may indicate what type of equipment is to be used and the frequency of testing the metering device and the gas quality. If the contract calls for meter testing or gas quality testing every quarter and you are getting a report every six months, a phone call is in order to locate the missing document. If the testing is not being performed as required in the contract, it should be documented in the auditor's report.

ATTITUDE

Like anything done with excellence, it's good to start the process with the proper attitude. There is a tendency for auditors to integrate charts as marked by the original integration company. This is contrary to the purposes of an audit. The auditor should ignore all original interpretations of data and develop his or her own conclusions based on the information available and the principles of accurate gas measurement. Information on meter configuration, device sizes, gas quality data, etc. should be regenerated from the original sources and not copied from the original volume statement, whenever possible.

The auditor should also approach the audit with the utmost integrity. Any and all determinations may be subject to the scrutiny of a court at some time in the future. Therefore, the strictest confidentiality and devotion to equitable measurement should be heeded. In the author's opinion, it is poor business practice to conduct yourself otherwise at any time.

RECONCILIATION

Many times the difference is discovered in erroneous data during the information gathering phase of the audit. This happens when conflicting information is found on various reports or when it is noticed the original volume's statement information does not match the corresponding data from source documents.

Otherwise, it helps to isolate the period during which the difference occurs. As an extreme example, if the whole month shows an error of three percent, its possible that one 24 hour chart is off by 90% and all the other charts for the month are within tolerance. Isolating your review to this one chart drastically improves your odds of finding the cause of the error quickly.

Other times, more data elements and calculations must be compared for differences. A systematic approach provides the most cost-effective way to reconcile the differences found between the original volume and the audit volume. An effective system isolates the root cause(s) of the difference as quickly as possible. This is best accomplished through consideration of the size of the difference and likelihood of error. A good system compares the following original and audited items in a general order according to the size of the difference: orifice plate size, clock rotation, range sizes, integration, gravity, temperature, pressure base, tap location, pressure tap location, analysis components, and temperature base.

As an example, if the difference is 200%, the vast majority of time it will prove fruitless to look at the pressure tap location to see if it is causing such a big difference. The difference is more likely to be found at the top of the list (i.e., orifice plate size, range sizes, rotation, etc.) Likewise, if the error is 2.5%, the difference will most likely be at the end of the list (i.e., integration, temperature, pressure base, tap location, etc.)

Knowledge of the size of the difference erroneous data can generate must be coupled with where the error is most likely to occur. Although plate size errors may not make as big of a difference as a clock rotation error, the orifice size plate error is more likely to occur. The same is true when considering gravity and integration. Gravity errors tend to be of greater magnitude, but integration errors are much more common. Of course, there are always exceptions to this general rule. Conceivably, if the integrator was not properly calibrated, the difference could exceed most range size errors.

Of all the things that can possibly go wrong when processing a chart, integration mistakes are by far the most common. Integration is a pivotal point in the process requiring precise machine set-up/calibration and operator skill, and is subject to individual interpretation.

If all the data elements are correctly presented on the volume statement, this does not mean they were correctly used during integration. Errors can result from improper calibration of the integrator machine, improper pressure range or incorrect atmospheric pressure offset. Detailed volume statements help to determine if the difference occurs in the integration of the differential pressure recording, static pressure recording, or the flow time.

More common are errors of skill and individual interpretation. These problems usually surface on charts with widely varying flow patterns. Differential spikes (or kicks) are difficult at best to integrate and interpret. Because volume is a function of the square root of the differential pressure, the amount of the error is exacerbated when the differential recording is near zero. Extreme changes in differential over short periods of time will require additional information to be accurately integrated. This information can come in the form of a fast clock test, the installation of a fast/slow clock or a flow computer. In the absence of better data, the differential should be integrated at the average of the square roots of the minimum and maximum of the recording.

Other areas subject to interpretation include: high/low differential zero, pens that stop inking, meters left out of service, meter malfunctions, fast/slow/stopped clocks, meters freezing, over-ranging recordings, and overlapping recordings. Also, some handshakes must exist between all of the processes, including those preceding and succeeding integration. For example, if the integrator readings are entered into the computer by hand, there exists the possibility of a data entry error. Even if the integration readings are transmitted directly to the computer, there is the possibility of a key identification error.

ADJUSTMENTS

When errors are found, adjustments are in order. The type of error discovered will impact the manner of adjustment. Some of the common problems are discussed with proper adjustment techniques.

One common problem is how to estimate for missing or erroneous records. Missing records can result from lost charts, stopped clocks, meters left out of service, and pens that run out of ink. The importance of a check meter is readily evident when trying to adjust for these problems. With a check meter, comparable data is available to make an accurate estimate. Without a check meter, the best remedy is to estimate the same rates based on an average of the previous and subsequent flow rates from records that are available. Because charts are usually processed as they are taken off the meter, many times the original estimates are based only on previous flow rates. Any significant change in subsequent flow rates may shed light on an inequitable estimate.

Adjustments for erroneous records are treated the same way as missing records (i.e., estimated based on previous and subsequent flow rates). However, more care must be taken to determine when the error occurred and when it was corrected. The time of correction usually takes place at the time the error was found. Questions can arise as to how long the error has existed. When the time the error began is unknown, some contracts will specify the period to which the adjustment can be applied. Errors which cause erroneous or false readings include: meter freezing, plate in backwards, nicked plate, dished plate, dull plate, dirty plate, missing plate, loose straightening vanes/flow conditioners lodged against plate, protrusion/pits inside meter tube, liquid in meter run, leaking fittings, leaking seal rings, leaking or partially open meter manifold valve, broken range spring, broken bellows, and broken static or temperature element.

Meter freezes are an area subject to much interpretation — not only the determination of the flow rate during the period of freezing, but also the recognition that freezing actually occurred and not just a change in flow rate. Sometimes it is obvious. Other times it is not. When there is no check meter for comparison, adjustments for meter freezes are based on preceding and succeeding flow rates. Recognizing meter freezes can be more difficult than the adjustment.

At temperatures of 32° Fahrenheit and below, liquid water freezes. At certain operating conditions and in the presence of liquid water, hydrates can form. Hydrates are solid combinations of water and other molecules containing hydrogen. Conditions for hydrate formation are improved as pressures increase and temperatures decrease. Hydrogen sulfide is more conducive to hydrate formation than any of the hydrocarbon gases because of its small size and solubility, so its presence increases the likelihood of hydrate formation. Temperature plays more of a role in the formation of hydrates than pressure and hydrates can form at temperatures above 32° Fahrenheit. Therefore, meter freezes tend to occur in the evenings and at night as ambient temperatures lower, affecting the temperature of the gas. Unfortunately, the dissipation of the ice and hydrates in the morning makes it difficult for the pumper to recognize the freezing after the fact.

Gas flowing through a restriction in a pipeline, such as an orifice plate, causes a pressure drop. Pressure drops cause a drop in temperature. Therefore, a likely place for hydrate formation is just downstream of an orifice plate. The hydrates begin to collect on the pipe walls, in and around the downstream tap. Soon, the downstream tap hole is occluded. As the occlusion (or restriction) increases in size, the pressure drop from the meter tube to the downstream gauge line of the meter increases. Therefore, the meter bellows senses less pressure on the downstream side of the meter than actually exists on the downstream side of the meter tube, causing the differential pressure to rise. This rise is usually gradual with the gradual occlusion of the pipe tap. Because static pressure is normally measured at the downstream tap, there may also be a small dip noticed in pressure, especially with a small pressure range.

REPORT OF FINDINGS

After all the errors are corrected and correct adjustments are made, the auditor's job is not quite finished. The findings or results of the audit must be communicated to the customer (internal or external customer). This communication should be done in the form or a written report.

The auditor's report should be written in clear, easy to understand language. The level of gas industry terminology should be commensurate with the understanding of the person(s) who will review the audit to determine if further action is required. The report should document any unavailable information, and qualify and quantify any material differences and may include any speculation about the cause of the error with an equitable method of compensation. Depending on the scope of the audit, all deviations from contract specifications should be documented, even if they do not constitute a material difference. The purchaser and seller should be fully aware of these matters and decide if they should continue to operate in the current manner. It is good practice to have acknowledged documents of all implied waivers.

Any attempt to surmise the cause of an error in the original volume is speculation in most all cases and the auditor should communicate this in his report. While speculation as to the cause of an error is valid in most every case and helps the auditor to solidify his position, the auditor should refrain from speculating motives involved in the use of erroneous data to determine the original volume.

The opposite is true in respect to the auditor's motives. The auditor's report should deliberately communicate the auditor's intentions in every questionable area. This provides proof the volumes were regenerated without bias and helps to prove the auditor's position. This is particularly true in the section of the report which declares a fair method of compensation.

Depending on the charge to the auditor, the report should recommend action when findings show material differences. Recommended actions should be precise and concise. The aggressive auditor will be assertive on behalf of the customer and recommend action in their favor whenever any questionable areas are uncovered. The auditor should consider costs of changes as compared to benefits when making recommendations.

The auditor may decide to forgo recommendations for action when costs outweigh benefits. However, a good report will explain the costs and benefits of any action. Otherwise the logic involved in determining the action (or inaction) may prove ineffectual.

In addition, the auditor should recommend any changes in practice or procedure which will provide for more accurate measurement in the future. Some of the more common recommendations in this area are: a systematic calibration and meter inspection witnessing program, faster clocks, fast clock tests, dual meter runs with different ranges, or flow computers for stations with varying flow rates, and right-sizing equipment. Orifice plates or differential ranges should be changed when differential recordings are too low as a percent of scale. Chart changing cycles should be shortened when recordings consistently overlap or clock rotations may be lengthened when recordings are relatively steady. Static ranges should be changed when pressures exceed the scale or are too low as a percent of scale while gas is flowing. Differential recordings which vary too fast can result from a separator that is too small causing a wide band differential recording. Sometimes this can be remedied by installing a throttling dump valve, a smaller diameter dump line or an orifice placed in the dump line. Remember to consider the effects of cavitation when recommending these remedies.

CONCLUSION

The auditor's report is the culmination of his or her work and becomes an important document in the continued success of the organization. Armed with a systematic approach to isolating, adjusting and reporting errors, the auditor has the potential of providing tremendous economic benefit to their organization or customer(s). The systematic approach also provides a platform for the auditor to build upon with experience. In time, the auditor learns new techniques to handle diverse situations easily. Even the experienced auditor can rely on the systematic approach to produce results when intuitive methods are not working.

With the proper attitude, the auditor uncovers more errors and spends less time having to support disingenuous assertions. As proficiency is gained, the auditor realizes more and more the importance of the availability of station information. Soon, the auditor is making a significant impact on the economic viability of his or her organization or customer(s).