OIL & GAS PRODUCTION AUDITING

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Basic Measurement Audit Steps

I. Select location (s) to be reviewed.
II. Review contracts, commingling agreements, process handling agreements, tariffs, and so on to determine audit rights, measurement equipment standards and maintenance requirements, and allocation procedures.
III. Perform an onsite visit to inspect measurement equipment in use, operating procedures, and maintenance procedures.
IV. Review historical maintenance records to determine if the equipment was being maintained per contract, standard, etc.
V. Determine data accuracy by: comparing pipeline volumes with check meter volumes, gas and liquid quality (i.e., Btu, GPM, Shrinkage, Flash Gas, and Gravity), shakeout procedures for oil, field balancing procedures, and so on.
VI. Review Allocations to determine if they were performed according to contract/agreement.

Before you can review oil and gas measurement practices, you must understand both the business/quality objectives and services/responsibilities of measurement

Measurement Business/Quality Objectives

Provide accurate and timely measurement data for the determination of revenues, generation of cash flows, and protection of company assets without future litigation in the most cost effective manner.

- Ensure equipment is appropriate and properly functioning in order to provide accurate measurement.
- Gather and provide accurate and timely product volumes to customers/users.
- Gather and provide accurate and timely product component data to customers/users.

- Communicate all operational and flow changes that affect accounting and the proper recording of product revenues.
- Comply with company, contractual, and governmental requirements.
- Physically protect the product while in company's custody.
- Provide information to Engineering for decisions and design of equipment. Verify and recommend sizes and types of measurement equipment for Engineering. Review contracts and commingling permits.

Measurement Services/Responsibilities

- Ensure that appropriate meters are calibrated/witnessed.
- Ensure that meter stations and equipment are maintained.
- Ensure the handling, filing, and distributing of measurement associated paperwork.
- Assist in requests concerning measurement issues by government, pipelines, customers, accounting, and third parties.
- Assist Production Accounting concerning measurement issues.
- Provide preventive maintenance scheduling and reporting for measurement equipment.
- Ensure that custody transfer volumes and Btus are tracked, investigated, and resolved.
- Track measurement equipment breakdowns/repairs to initiate predictive maintenance.
- Perform data tracking and analysis on measurement equipment (e.g., meter factors, flow rates, S&Ws, and gravities).
- Ensure that gas and oil samples are taken for analysis and data enter appropriate databases.
- Handle measurement specifications and installations of new measurement devices.
- Assist in all upgrades, changes, and modifications of measurement equipment.
- Provide information and recommendations on new measurement equipment and technologies.
- Provide development and implementation of new or additional data tracking and analysis applications for all measurement related issues.
- Provide training to measurement and non-measurement personnel.
- Provide procurement, stocking, and shipment to field of standardized measurement equipment, spare parts, and accessories.
- Assist in well test issues.
- Provide allocation factor tracking and analysis.
- Ensure that proper revenues are received for volumes measured.

Although this may seem to be a long list, we can break the audit down in 3 main questions:

- Is the equipment sized correctly to gather accurate data?
- Is the equipment properly maintained to assure you and others of accurate readings?
- Is the data used to properly allocate the product and ultimately cut the check?

GAS CONTRACTS

Most gas contracts are similar in content and most contains provisions related to gas measurement.

Measurement Section – A review of the measurement section gives you a detail of measurement specifications relating to the type of equipment, the standards under which the gas is measured, the frequency and type of test to be made, acceptable tolerances of measurement and procedures for measurement corrections and audit provisions.

Equipment – The contract should state the type of meter to be used for measurement, any manufacturer's recommendations, and AGA/API or other specifications.

Standards – Specific standards under which gas is measured are generally not detailed in the contract; however, reference is generally made to AGA/API or other publications indication computations of volume shall be made in accordance with the basic factors defined in these publications.

Frequency and Type of Tests – Frequency of test may be designated as monthly, quarterly, semi-annual, annual, or not at all. Monthly tests are desirable, especially if there are large volumes and the compostion of the gas stream fluctuates. The type of test may include calibration and inspection of measurement equipment and calculation of Btus, specific gravity, and gallons of natural gas per though feet (GPM).

Btu A Btu is the amount of heat necessary to increase the temperature of one pound of water one degree Fahrenheit. A gas stream may contain numerous hydrocarbon compounds; however, usually field gas streams contain about 14 compounds.

The Btu per cubic foot of these hydrocarbon compounds range from 1,009 for methane to 5,502 for decane; therefore, the quantity of each compound in the gas determines the Btu of the total gas stream. Since most produced gas streams are over 90% methane, actual Btu values will fall in the lower range of these two extremes.

The Btu content of gas also determines the dollar value of the gas. The Federal Energy Regulatory Commission established a policy to adjust the price of natural gas that contains a Btu other than 1,000. The zero adjustment base of 1,000 Btus was established because a Btu of 1,000 is almost equal to the Btu of pure methane; therefore, the price for gas with a Btu greater or lesser than 1,000 will be adjusted accordingly.

The most common method of determining Btus is by chromatographic analysis. The chromatograph senses the electrical resistance of the different hydrocarbon compounds in the gas stream and records the result.

Specific Gravity The specific gravity of a gas is the weight of a cubic foot of gas compared to the weight of a cubic foot of dry air under the same pressure and temperature conditions. The specific gravity of air is 1.0000. The hydrocarbon compounds mentioned above also have specific gravity that varies for methane to decane, from .5539 to 3.2596, respectively. Considering the gravity of each compound in the gas stream and that most gas is over 90% methane, field gravities will be in the lower range of these two extremes. The specific gravity factor is one of the primary values used in determine a gas volume.

GPM The GPM is the gallons of natural gas liquids per one thousand cubic feet of gas. These tests are made when the gas is contracted for processing in a plant. The GPM may be determined by charcoal absorption and standard compression tests that physically remove the liquid for measurement or by chromatographic analysis.

A comparative schedule should be made of the above data to determine that:

- Actual tested dates are consistent with the contractual frequency.
- Applicable measurement errors found in calibration and inspections are reflected in volume adjustments.
- Equipment changes are reported to the proper departments.
- Btu, specific gravity, and GPM values are reasonable.

Tolerance and Measurement Corrections

Historically, differences between the sales meter and the check meter or calibration of +-2% were acceptable; however, because of more accurate equipment, some contracts are now written with a +-1% tolerance. In the event the equipment is found to be inaccurate to the extent these tolerances are exceeded and check meters are not present to determine the correct volumes, the volumes may be calculated based on delivery conditions when the measurement equipment was registering accurately.

Quality of Gas

This section will familiarize you with the tolerances of impurities permitted in the gas stream (e.g., water, hydrogen sulfide, carbon dioxide, and nitrogen).

All impurities except water may be determine by chromatograph analysis. Water content is determined with water vapor analyzers or dew point tests.

If these tolerances are exceeded the purchaser/transporter usually has the right to refuse the gas or deduct form the base price of the gas any costs incurred to upgrade the quality to acceptable standards.

Gathering System

Most contracts specify that the purchaser must provide, maintain, and test the measurement equipment. The producer also has the right to install check measurement equipment.

Equipment Sizing

Review production rates to see if the equipment sizes are adequate to record accurate data.
Make an onsite visit and review the placement of the equipment to determine if they are in accordance with API/AGA and manufacturer standards. Look for liquid traps, length of straight piping upstream and downstream of metering points,

GAS MEASUREMENT

There are three common areas in gas measurement where errors may occur:
- The meter run where the vast majority of the errors cause the seller to deliver gas free to the buyer/transporter because the gas is not being measured.
- The recording instrument where errors can go both ways.
- Terms of the contract. These “errors” are legally binding and are only changed by consent of both parties.

ORIFICE METER RUN

The application of the orifice meter to the measurement of flowing fluids is based on the physical principle that the pressure loss of a fluid flowing through a restriction in the line is propo9rtional to the square of the velocity of the fluid. The means of restricting the flow necessary for volumetric calculations is the orifice plate. Gas flowing through a meter run and orifice plate causes the loss of

pressure (differential) which is used in calculating the gas flow rate. In addition to the differential pressure, the static (line) pressure must be measured.

Measurement Errors

Anything that happens to the orifice plate ID will result in enlarging the hole, causing gas to pass unmeasured. Nicks, cuts, scratches, erosion, corrosion, bening, and so on will cause an increase in the plate ID, reducing the differential across the plant, and reducing the volume of measured gas.

Examples

- If something caused the ID of a 2" plate in a 4" meter run to increase by 1/8 inch, the producer would give away 14% of the gas.
- A notch of .05" will results in a loss of .6% of the gas.
- A plate bent toward the gas flow 1/8" will result in a loss of 2.8%.
- A coating of grease 1/16" on both faces results in a 15.8% loss.
- A coating of grease 1/8" results in a 17.9% loss.
- A coating of grease 1/4" results in a 24.4% loss.
- If the orifice plate carrier is raised about 3/8" from bottom, 8.2% of gas is lost.
- A slight dulling of the edge gives away .5%.
- If the orifice edge is beveled just .01", 2% is lost.
- If the beveled orifice plate is put in backwards, it will result in a 20% lost.
- One clean cut through the plate-sealing unit next to the tap holes gives away 6.1% of the gas.
- If a 4" meter run had deposits of only .2", the loss is 1%.
- If the deposits were .874" thick, the loss is 6.4%.
- Liquid 1" deep in the bottom of the meter run tube results in the loss of 11.3% gas.
- Grease and dirt deposits in the meter tube gives away 11.1% of the gas.

OIL SALES BY LACT

Lease Automatic Custody Transfer (LACT) equipment is frequently used at tank batteries or commingling facilities to sell the crude oil production where there is an oil gathering pipeline system, and the production rate is large enough to warrant this type of equipment. LACT units serve four major functions:

1. The unit transfers the custody of the crude oil production to either the purchaser or the transporter.
2. The unit measures the volume of oil transferred.
3. The unit samples the crude being transferred.
4. The unit monitors the quality of the crude being transferred and halts delivery if the crude fails to meet the required S&W specifications.

LACT Oil Measurement

1. A KNOWLEDGABLE company representative should be present at the proving of the LACT unit.
2. The KNOWLEDGABLE company representative should request the prover operator to display the calibration data for the prover.
3. The sample container contents should be thoroughly mixed to eliminate stratification of the oil. However, do not mix the sample for long periods. The pump is doing work on the sample that increased the temperature of the samples. As the temperature increase, so does the vapor pressure. Generally, a pressure of 5 psig (+-20 psia) is held on the sample container to prevent the loss of the light hydrocarbons form the oil. If these light molecules are flashed from the oil, the API gravity decreases and the S&W increases.
4. Insulate, cover, or protect the container from the sun and heat. In the direct sunlight of summer, the temperature in the container may easily reach the vapor pressure of the oil and cause flashing of the light molecules.
5. After processing the sample for API gravity and S&W, pump the sample into the sales line or to the storage tanks. Clean the samples container. Use solvents and clean clothes. Not cleaning the container will allow a buildup of heavy hydrocarbon molecules, and entrapped S&W. This will result in a lower API gravity and higher S&W for the oil in the container.

Oil Provings

1. Flowing pressure during the year was within the range of the LACT.
2. Meter factors for malfunction (.25%).
3. 5 0f 6 (2 of 3) runs within .0005 of each other.
4. Witnessed by a qualified representative.
5. Proving equipment itself calibrated.
6. Shakeouts
    a. Solvents used is checked for contaminates.
    b. Sample pod is mixed for approximately 5 minutes.
    c. Sample container filled from the bottom up
    d. Sample heated to 140 degrees (+-5 degrees).
    e. Sample spun at the correct RPMs
    f. S&W content recorded at actual (no minimums).
    g. Sample pod cleaned periodically for fields having high paraffin and sediment build-ups.
    h. Thermohydromater is check periodically for accuracy.