Auditing Electronic Gas Measurement Per API chapter 21.1
Class # 7030

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INTRODUCTION

API 21.1 is recognized as an international industry standard documenting the Electronic Gas Measurement (EGM) system audit and record requirements for differential and linear meter measurement. This standard is used by the measurement community to reduce the overall EGM system uncertainty and improve measurement data integrity.

Measurement data integrity plays a critical part in overall measurement accuracy for all organizations and has a direct impact to the financial bottom line. Measurement integrity is also vital for ensuring compliance with regulatory and industry standard requirements.

On August 1st, 1993 the first edition of the *American Petroleum Institute (API) Manual of Petroleum Measurement Standards (MPMS) Chapter 21.1 Flow Measurement Using Electronic Metering Systems-Electronic Gas Measurement* was released following a four year collaborative effort. This document provided the industry with a much needed standard to use as a reference for several key areas related to custody transfer gas measurement when performed with flow computers.

Highlighted topics contained in the standard include:

-Electronic Gas Measurement Algorithms
-Data Availability
-Audit and Reporting Requirements
-Equipment Installation
-Equipment Calibration and Verification
-Security

The August 1993 API 21.1 publication served our industry well; however, in February 2013 the *API MPMS Chapter 21.1 Flow Measurement Using Electronic Metering Systems-Electronic Gas Measurement 2nd Edition* was released.

In the second edition, several new technology advancements have been addressed to provide a more comprehensive view of an Electronic Gas Measurement (EGM) System including the corporate measurement system. Some examples include Onsite *and* Off-Site Data and the coverage of additional intelligent devices such as chromatographs, pulse generators, pulse counters, gravitometers, and other intelligent devices.

Additionally, new terms related to the EGM system are covered in the second edition including:

Quantity Calculation Period (QCP),

Quantity Transaction Record (QTR),

Corrected Quantity Transaction Record (QTRcorr),
Quantity Transaction Record Time (QTR Time)

Also, a number of additions relating to "operating span, limit and range" are defined and explained in the second edition.

With the introduction and continued focus of the Sarbanes-Oxley (SOX) Act of 2002 which focuses on the integrity and consistency of all financial based transactions for an organization, the importance of an updated standard is further increased. A SOX auditor will refer directly to API 21.1 as the reference standard for all flow computers throughout an organization.

This paper will focus on the key areas for review when performing an audit based on the latest API 21.1 requirements. Additionally, we will cover several new areas the measurement group should be made aware of regarding this latest update. Please note that this paper does not address the audit of internal calculations regarding the flow computer itself.

WHY AUDIT?

The United States (US) consumes approximately 25 trillion cubic feet of gas per year[1]. Accounting of this gas as it is recovered and processed involves measuring the gas at each point of the process from wellhead to consumer. This involves measuring the gas:

1. extracted from the well
2. delivered into a processing plant/gathering system/production system
3. transferred into a pipeline,
4. transported into a Local Distribution Company (LDC) system,
5. and delivered to the consumer.

To illustrate the importance of accurate measurement within the EGM System, consider that with 25 trillion cubic feet of gas consumed in the US, the gas would have been measured once at the well and then again when delivered to the consumer. However, the gas most likely was measured three additional times – through a processing plant, pipeline, and LDC. That would be 5 different measurement instances which would introduce 5 independent possible sources of error. Therefore, with 25 trillion cubic feet of gas measured 5 times we have a total of 125 trillion cubic feet of gas measured annually through EGM systems. To be conservative with our example, let's assume half of the measurement points are utilized in the EGM System. Based on the US Data Library Henry Hub January 2013 Calendar Month NYMEX Natural Gas Price of $3.356 MMBtu[2] this equates to approximately $210 billion dollars of gas measured annually. Loss or uncertainty of volumes of just 0.05% would equate to $105 million dollars per year of lost or unaccounted for gas.

AUDIT SCOPE AND OBJECTIVE

A typical audit historically has consisted of three elements, a verification of the primary device (e.g. inspecting the Orifice Plate), the secondary device that includes the pressure, temperature, and differential transmitters; and a final verification that has included a confirmation of the flow computer as the tertiary device.

Based on the current API 21.1 revision there are several additional areas that may be included in a more comprehensive audit scope to validate measurement integrity.

These areas are:

- Required Audit Records
- End to End Operation Check
- Verification/Calibration of On-Line Analyzers
- Ambient Temperature Effect
- Line-Pressure Effect
- Atmospheric Pressure Effect
- Commissioning Documentation
- Verification and Calibration Equipment

Each of the focus areas identified in this standard, if adhered to, will significantly improve the measurement integrity of the facility you plan to audit. When establishing the scope and objective of the audit, the auditor must consider the potential audit benefits versus the potential losses in time and operational efficiency experienced while performing the audit. .

AUDIT RECORD MINIMUM REQUIREMENTS

API 21.1 states that the requirements for an audit of an EGM system "shall include, but not be limited to, QTRs, Configuration Logs, Event Logs, Field Test Reports, and QTRcorr and reason for correction (edit)." [3] The data retention for the EGM system audit trail is not addressed by the document but rather it refers to the regulation entity, tariff, or contractual obligations[3].

AUDIT RECORD REQUIREMENTS-QTR

The QTR is the original record calculated by the flow computer to support the volume, mass, or energy; including the meter number or "unique identifier".

The established criteria for a differential type meter QTR includes [3]:

- Date and time or date/time identifier;
- Quantity (volume, mass and/or energy);
- Flow time;
- Integral value/Average extension;
- Differential pressure average;
- Static pressure average;
- Temperature average;
- Relative density, energy content, composition, and/or density average if they are live inputs.

The established criteria for a linear type meter QTR is summarized below [3]:

- Date and time or date/time identifier;
- Quantity (volume, mass and/or energy);
- Flow time;

- Integral value;
- Meter output (accumulation or average);
- Static pressure average (if required by meter type);
- Temperature average (if required by meter type).
- Relative density, energy content, composition, and/or density averages shall be included if they are live inputs.

For linear meters that generate a pulse count, the value should be included as part of the QTR; if, however, the primary device does not generate a pulse count, it is not required to artificially calculate a pulse count.

The QTR record should be verified in your audit to meet the new reported standard.

AUDIT RECORD REQUIREMENTS – CONFIGURATION LOG

The Configuration Log is a vital part of the measurement process and documents all of the Meter Characteristic Values. This log should be audited to ensure that it includes the flow parameters and calculation criteria that are used in the continuous volume, mass, and/or energy calculations performed by the EGM system.

AUDIT RECORD REQUIREMENTS – EVENT LOG

The Event Log is designed to record each change made to the EGM system that could affect the calculated volume reported in the QTR. 21.1 requires that the Event Log be maintained and held current. The event log should be pulled from the EFM system with a frequency such that no device events are lost. Associated, but separate from the Event Log is the Alarm and Operating Data Log. The alarm and operating data log is designed to record operating and alarm conditions at the site. It is important that both the Event and Alarm and Data Logs are polled frequently by managing the polling frequency of your EGM system. The Event Log and Alarm and Data Logs should be reviewed for completeness and update frequency during the audit.

AUDIT RECORD REQUIREMENTS – QTRcorr

The corrected Quantity Transaction Record (QTRcorr) documents the corrected quantity transaction record from a corporate gas measurement system. Corrections may be required due to many reasons including:

- Failure by the primary device (plate, turbine, coriolis, etc.)such as wrong reported orifice plate size or a dished plate
- Failure by the secondary device (pressure, temperature or diff pressure transmitters) such as transmitter failure or calibration
- Failure by the tertiary device (flow computer) such as power failure
- Updated gas analysis values from a sample
- Various other conditions that affect the operation of the EGM system

The original QTR must be fully maintained in a corporate measurement system along with any updated QTRcorr that includes an edit reason documenting why the change was made. These records should be reviewed as part of the audit.

AUDIT RECORD REQUIREMENTS – CORRECTION METHODOLOGY

There are new requirements relating to the off-site recalculation through the use of a Correction Methodology referenced in Annex C [3] that should be considered when doing an audit. The Correction Methodology ensures measurement integrity throughout the verification and editing process and is highly recommended to use in your corporate measurement system. Errors can easily range from 0.2 – 20% whenever the centralized measurement system does not apply a Correction Methodology. The Correction Methodology applies directly to the volume. An example calculation for the Volume Correction Factor (VCF) found in Annex C [3] is shown below.

$$VCF = \frac{Reported\ Volume}{Recalculated\ Volume_{ORV}}$$

Where:
ORV = Original Reported Values

If the audit scope includes a review of data processed through a corporate measurement system, the auditor should ensure a correction methodology is being applied to any corrected data.

AUDIT RECORD RECOMMENDATION – SNAPSHOT REPORT

A Flow Computer Snapshot Report captures a snapshot of the last QCP (Quantity Calculation Period) as well as the inputs and constants used to calculate the QCP volume, mass and/or energy.

The Flow Computer Snapshot Report is another new recommendation in the standard and should include the following:

- Last Quantity Calculation Period (QCP)
- Integral Value / Average Extension
- Meter Characteristics
- Calculated Values
- Algorithm to Calculate the QCP

The last QCP should correspond to the current meter's flow characteristics. If the meter's flow characteristics are updated, a new QCP should be created that will correspond to the updated QCP (e.g. when an orifice plate change or k-factor update occurs). The snapshot record will provide visibility to enable your corporate gas measurement system to stay in synchronization with the EGM system.

The snapshot report may not be required in an audit, but it is recommended to review the report as part of the audit process to ensure events are not lost in the EGM system.

AUDIT RECORD RECOMMENDATION – METER TEST RECORD

The meter test record is another key area that should be addressed during your audit. The test record may be electronic or hard copy documenting the "testing or operation of metering and analyzer equipment that would affect the calculation of measured quantities [3]." The test record documentation will include test, calibration, and verification reports along with the "primary device inspection report,

equipment change tickets, and peripheral equipment maintenance and inspection reports [3]." A more detailed description of the test records will be addressed in the equipment verification section update.

AUDIT RECORD REQUIREMENTS – SUMMARY

It is recommended all audit record requirements be included in the scope of an API 21.1 audit. The following sections provide additional insight to the audit record requirements and should be considered in defining the scope and objective of your audit.

DATA AVAILABILITY – EGM SYSTEM

For EGM systems performing on-site calculations, a minimum of seven days of hourly (or more frequent) QTRs are required in the device.

For EGM systems performing off-site calculations, a minimum of seven days of daily operational data based on the QTR shall be available with an understanding flow rate would not be included. Be aware that there is a note with respect to this requirement in the standard declaring that "This requirement is operational and can be amended based on agreement of the parties involved [3]."

DATA AVAILABILITY – OFF-SITE SYSTEM

The off-site data requirements for a centralized measurement system may be provided either electronically or by hard copy and are summarized below [3]:

- Event Log
- Alarm Log
- Test Records
- Original QTR
- QTRcorr

The data retention time period is not addressed in API 21.1 and allows the "regulation, statute, tariff, or contract" to define the off-site data retention period.

EQUIPMENT VERIFICATION

The equipment verification and calibration component of 21.1 provides the minimum requirements for documenting the calibration and verification of the EGM system components used in custody transfer. This section will provide an update summary for the changes included in API 21.1 plus the audit opportunities that should be addressed.

EQUIPMENT VERIFICATION – MAINTENANCE PRACTICES

Within 21.1 a new maintenance practice is defined for EGM systems included as Table 1- Maintenance Practices. [3]

Table 1—Maintenance Practices

Maintenance Practice	Verification	Calibration
Field calibrated	Comparison to verification equipment	Field calibrated
Factory calibrated	Comparison to verification equipment	Factory/laboratory calibrated
Transmitter redundancy	Comparison periodically to verify with redundant transmitter	Field or factory/laboratory calibrated

The option for redundancy verification is available for differential pressure, static pressure, and temperature transmitters and a sample comparison report is included as Annex I in the document. The example comparison can be based on either a daily, weekly, or monthly percent of reading comparisons between the primary transmitter and the check redundant transmitter. This verification may be performed in lieu of periodic field verifications.

EQUIPMENT VERIFICATION – CALCULATION OF DIFFERENTIAL "AS FOUND"

A reference note is included as Annex H which references an important change in calculating the error associated with the differential pressure at working pressure vs atmospheric pressure as expressed in the equation below [3]. The new calculation should be a part of the test record and included in the audit documentation.

$$DP_{WP} = DP_{AP} + C_{SP}$$

Where:

DP_{WP} = differential pressure at working line pressure
DP_{AP} = differential pressure at atmospheric pressure
C_{SP} = static pressure correction

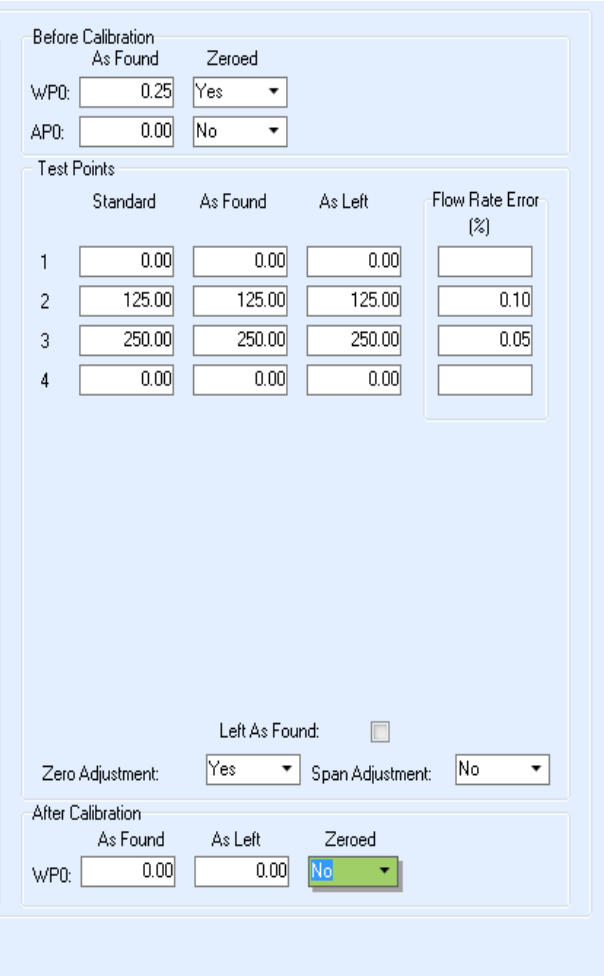
And:

$$C_{SP} = Z_{WP} - Z_{AP}$$

Where:

Z_{WP} = zero at working pressure
Z_{AP} = zero at atmospheric pressure

In the practical application of the new correction percentage calculation please see the example below Image 1:



COMMISSIONING

"Commissioning is the process of the initial verification and documentation that the electronic gas measurement system is installed and functioning according to its specification, design, and regulatory/contract requirements [3]."

The commissioning section of the new API 21.1 was increased significantly and will not be included in a typical audit. However a summary is included herein as a reference.

The update now includes the Primary Device, Secondary Device, Tertiary Device, and End-to-End Operational Check. There is an Example Commissioning Checklist – Annex F incorporated into the standard. The checklist consists of two sections 1) Commissioning Tasks – Before First Delivery and 2) Commissioning Tasks – During or Shortly After First Delivery.

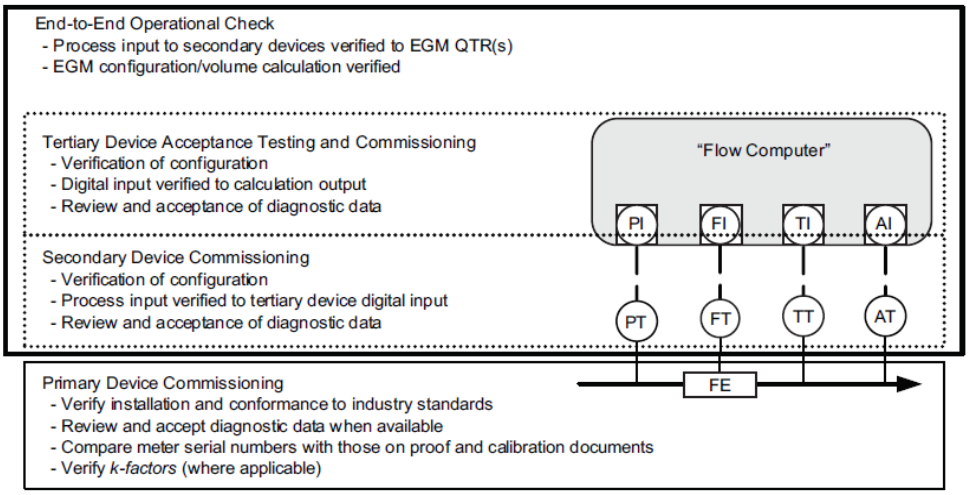


Figure 3—Conceptual Representation of an EGM System

Figure 3 – Conceptual Representation of an EGM System

It is recommended to "Follow the manufacturer and, where available, industry standard meter commissioning and verification procedures" for the primary, secondary, and tertiary devices [3]."

SECURITY AND DATA INTEGRITY

The updated Security and Data Integrity section covers the "primary, secondary, and tertiary devices, data collection systems, data editing processes, quantity calculation systems, and data storage systems [3]."

21.1 states the EGM system shall be designed to incorporate restricted access, intelligent device data logging and communication integrity. Historically, this area has not been addressed in a typical audit however with the awareness of security concerns you may elect to incorporate a security and data integrity section in your audit.

CONCLUSION

Time invested conducting a thorough API 21.1 audit is important to ensure compliance with industry standards, contractual obligations, and improve the gas measurement data integrity in your EGM system. API 21.1 2nd Edition contains a number of comprehensive, value added improvements with which all measurement personnel should be familiar. By following API 21.1 2nd Edition, your organization will reduce the measurement uncertainty of the original volume calculated in the flow computer, and reduce the introduction of measurement calculation bias or error into your corporate measurement system.

CLOSING THOUGHTS

I would like to encourage you and your organization to get involved with API by becoming a member and joining one of the many working groups that are shaping our industry. Your involvement as an industry representative is critical to the success of our industry standards going forward.

Spend the time to familiarize yourself and your organization with the practical application of the standard in order to stay in compliance. If there is an area you do not agree with in the standard, get involved.

I would like to thank all of the individuals and organizations who invested the time, research, and collaboration to facilitate the publication of API MPMS Chapter 21.1 2nd Edition released in February 2013.

CREDITS

[1] – DOE/EIA-0383(2012) Annual Energy Outlook 2012
[2] - US Data Library Henry Hub January 2013 Calendar Month NYMEX Natural Gas Price
[3] – ANSI/API MPMS Chapter 21.1Flow Measurement Using Electronic Metering Systems – Electronic Gas Measurement Second Edition
[4] - AGA Report No. 3/API MPMS Ch. 14.3
[5] - AGA Report No. 9
[6] - AGA Report No. 11
[7] - AGA Report No. 7