GAS AND LIQUID MEASUREMENT VALIDATION

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INTRODUCTION

Fundamental to all electronic gas measurement (EGM) and electronic liquids measurement (ELM) systems is the ability to accurately measure, review, correct, and report data. Any weakness in this chain undermines the accuracy and data integrity in the system.

Recent industry standards and practices have greatly expanded the emphasis on data integrity. The Sarbanes-Oxley (SOX) Act of 2002 focuses on the integrity and consistency of all financial-based transactions for an organization.

A SOX auditor will directly reference the American Petroleum Institute (API) Manual of Petroleum Measurement Standards (MPMS) Chapter 21 (popularly known as "API 21") as the standard for all steps in the measurement process throughout an organization. Therefore, measurement personnel must possess a thorough understanding of API 21 and put its requirements to practice in order to satisfy the audit process.

Natural gas operations must comply with API MPMS Chapter 21, Section 1 ("API 21.1"), Flow Measurement Using Electronic Metering Systems—Electronic Gas Measurement. A second edition, published in 2013, includes substantial revisions to the original, 1993 edition.

Over recent years, a number of companies in the industry have acquired natural gas and petroleum liquids operations. Measurement departments tracking both natural gas and liquids must comply with API 21.2 as well as API 21.1.

API MPMS Chapter 21, Section 2, Electronic Liquid Volume Measurement Using Positive Displacement and Turbine Meters, was released in 1998. An addendum, Flow Measurement Using Electronic Metering Systems, Inferred Mass, followed in 2000.

EVOLVING REQUIREMENTS OF API CHAPTER 21

Although readers of API 21.1 and 21.2 will notice much common ground, there is minimal "boiler plating" between the two documents. This fact not only highlights the major differences between gas and liquids measurement, it also demonstrates the evolving nature of the API MPMS chapters and industry standards, in general.

Exemplifying the differences between gas and liquids are the descriptions of measurement algorithms, descriptions of reporting requirements, particularly in terms of report content, and lists of reference publications.

Evolution is exhibited by requirements for auditing and records, commissioning, calibration and verification, and security. Users who have tracked API 21 since 1993 realize that the evolving requirements underscore the importance of measurement data integrity.

The second edition of API 21.1 expands the scope of the electronic measurement system beyond the meter site to include all elements of the corporate measurement computer system. While the text is subtle, the section begins with a scope that uses a cloud to represent the system. The scope mentions change management functionality and off-site calculations. Off-site calculations are further described in other areas, including the definition of "EGM." Management of off-site data is introduced.

The second edition goes on to define new terms that account for re-calculation and maintenance of corrected transaction records—functions that are performed by downstream editing software or the corporate measurement system.

Compared to the original edition of API 21.1, API 21.2 considerably expanded on requirements for calibration, commissioning and verification. The API 21.1 second edition has picked-up the expanded definitions and has taken them even further. Calibration and verification requirements include on-line analyzers and "other EGM equipment"—the latter to ensure that any component in the measurement process complies with the standard.

The second edition recognizes many potential sources of errors including expansion factor, as described in the calculations requirements, and requires verification to account for effects of ambient temperature, line pressure and atmospheric pressure.

Additional areas that may be included in a more comprehensive audit scope include an end-to-end operation check, all commissioning documentation and all verification and calibration equipment reports.

Finally, in the second edition of API 21.1, the title, “Security,” has changed to “Security and Data Integrity” and two, new paragraphs briefly describe requirements for intelligent device data communication integrity and integrity of transferred data.

Each of these requirements will significantly improve the measurement integrity. However, incorporating them will result in a substantial increase in the amount of reporting information that must be maintained within the measurement system.

For more information on the differences between the first and second editions of API 21.1, please refer to the technical paper listed in the footnotes.1

THE INCREASING IMPORTANCE OF DATA VALIDATION

Evolving requirements for auditing and records, commissioning, calibration and verification, and security have substantially increased the amount of information that flows through the electronic measurement system. Increased information regarding calibration and verification of additional devices and recalculated reports equates to a much larger number of potential anomalies and more information that must be validated.

Data validation is critical. It ensures the overall measurement information integrity that not only meets industry and regulatory audit requirements but directly impacts the bottom line.

In an electronic measurement software application, identifying data anomalies should be a key application. A data validation process flags potential anomalies and brings them to the attention of the measurement staff. Numerous “checks and balances” are applied to flowing parameters, quality information and “rolled-up” historical averages and totals.

For a measurement analyst, this can save significant time that would otherwise be taken sorting through considerable data to find problems long after their inception. Instead, the system flags the problems and analysts can immediately work to solve them.

Validation set-points are built-in to the measurement data management process based on limits imposed by the various calculation standards. Users can add set-points to meters and quality sources in order to flag data that is outside the normal operating boundaries. They can manually enter validation set-points or use an optional set-points calculator which uses historical data to calculate the appropriate set-points.

Information that fails a validation test creates an exception in the measurement system. The exceptions are reviewed by the measurement staff, periodically, typically on a daily basis. Through this review, the staff identifies and resolves most issues in the same day. Issues are tracked throughout the year to determine if equipment needs to be upgraded or replaced or if a new design is needed in order to resolve an ongoing problem. Prior to closing each month, all exceptions are either resolved or flagged as process-pending.

VALIDATION METHODS

Data analysis capabilities for user-defined validations include the following:

- Validate on import
- Flowing Parameters
- Analysis
- Single-run
- Multiple-run
- Expert system
- Frozen values
- Final form

The first line of data validation for meters occurs directly on import and is based on the list of logical rules available in the measurement system. This type of validation detects fundamental measurement mismatches such as the following:

- Zero volume reported for the period with a differential pressure or pulse reading greater than the low flow cut-off;
- Zero differential pressure or pulse reading reported for the period with a volume greater than zero;
- Density out of range for the product’s API calculation table;

- Missing variables, such as temperature, pressure or uncorrected volume, needed to perform volume and mass calculations and validations;
- Flow time greater than an hour for an hourly record and/or a flow time greater than 24 hours for the daily total; and
- Data that is received for a disconnected meter or out-of-service meter.

Flowing parameter validations include differential pressure, pressure, temperature, volume, energy, indicated volume, net standard volume, CTL, CPL and volume correlation factor.

For flowing parameter validations, key areas include:

- Volume correlation factor calculations and comparisons on every record to determine calculation deviations between the meter/EFC and the volume or mass calculated by FLOWCAL;
- Static pressure high/low validation that flags data where the static pressure is operating outside the normal operating range or contractual delivery pressure;
- Temperature high/low validation that flags data where the temperature is operating outside the normal operating range. The temperature range is a seasonal value. Based on seasonal norms, analysts make adjustments throughout the year.
- Volume and energy high/low validation that flags data where the volume and/or energy are outside the normal range or contractual minimum and maximum quantities.
- Differential pressure and extension high/low validation that flags data where the differential is operating outside the normal operating range of the meter;

Analysis validations enable the user to validate the sample quality being used to calculate the volume, energy, component volumes and net allowable as well as the sediment and water (S&W) percentage.

Quality Analysis parameter validations are adjusted based on history and include the following:

- Minimum and maximum validation of each of the analysis components used by the meter for volumetric calculation and by the quality reporting device (chromatograph or laboratory).
- Component total, using a range of 99.8% to 100.2% normalized sample.
- Rate of change validation to flag significant swings in the gas quality. This validation will flag values that can have a significant impact on the volumetric calculation or contractual agreement, i.e. Heating Value, Wobbe Index, Hydrocarbon Dewpoint, Cricondentherm, N_2, CO_2, C_6+, O_2, He, H_2S, and many additional critical mole percent and condensate based values.

The ability to detect repeating values from a chromatograph is critical to flagging suspect data. Whenever a chromatograph fails, the unit typically repeats the last good values until the issue is resolved. For example, FLOWCAL's frozen value validations can determine when the same value is being received repeatedly from a chromatograph based on user defined tolerances.

Single-run validations are useful for meters in which flow is fairly constant or cyclical. Validations can be run against the prior record or prior day and set-points can be in terms of units or percent difference.

Multiple-run validations are used to compare one meter with up to four other meters. These validations are useful for meters that are within a multiple-run meter station or between a check meter and a custody meter.

"Expert system" validation compares a record with a running or weighted average of a user-specified number of prior records to look for deviations from the trend.

"Frozen values" validation performs a comparison of selected flowing parameters to prior records to recognize an interruption in a live data feed. Typically, this could indicate a meter that is locked in manual mode.

The "final form" validation allows a user to validate that rolled-up hourly, daily and monthly totals for volume, energy, mass and net standard volume are within defined set-points.

Typically, measurement groups validate values received directly from the meter/EFC. However, these subsequent activities are not performed:

- Validate totals for an hour relating to split records (i.e. plate changes / k-factor changes).

- Perform daily level validation for points on the pipeline where the volume is being batched for a specific time period. Similarly, this validation cannot be performed for a plunger lift well where hourly flow is very erratic, but daily flow is very predictable.
- Perform monthly level validation that will flag a lower or higher than expected value according to contract quantity level criteria.

A key validations issue has been the ability to flag only the exceptions that are important and avoiding those that are not necessary. Flow-Cal's experience is that, when powerful validation parameters are configured properly, they can provide significant time savings for the measurement group. However, many organizations configure the validation limits too tightly creating an excessive number of exceptions and masking real issues. Conversely, if the validation criteria limits are too wide, exceptions that would identify problems in the operations of a facility or well may not be realized.

CONCLUSION

The evolution of API 21 emphasizes the increasing importance of measurement data integrity and data validations. Measurement departments consider the validations function to be critical.

A Sarbanes-Oxley (SOX) auditor will directly reference API 21 as the standard for all steps in the measurement process throughout an oil & gas industry organization.

Measurement departments tracking gas and liquids must abide by both API 21.1 and API 21.2. There are significant updates in the second edition of API 21.1, which was released in 2013, over the original, 1993 edition.

Resulting from the latest API 21 updates is a much larger quantity of information that flows through the measurement system. There are more devices, more verification information, corrected quantity transaction information and more effects on the measurement to account for.

The result is a much larger number of potential anomalies and much more information that must be validated—thus, making the validations function an even higher priority.

REFERENCES

1 – "Auditing Electronic Gas Measurement per API Chapter 21.1," Duane A. Harris, Flow-Cal.