MEASUREMENT DATA CAPTURE, PROCESSING, AND RETENTION

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Introduction

Capturing and processing measurement data relies on ever-evolving technology, equipment, and procedures. Current industry practices use flow computers located near the primary measuring device to capture, calculate, and store measurement data. Supervisory control and data acquisition (SCADA) systems or polling engines (PEs) are used to collect measurement information on a scheduled frequency using microwave, fiber, satellite, or cellular communication channels.

After the SCADA/PE system collects the measurement data, the information is made available to the measurement system. The measurement system provides a processing layer that validates data to ensure integrity and compliance with regulatory and industry requirements.

Data retention policies are then determined by organizational standard operating procedures (SOPs) and regulatory and/or contractual requirements.

Evolution of the Measurement Process

Historically, field operators in almost every upstream and midstream company in North America collected charts and hourly electronic flow computer (EFC) records, and manually reviewed them for data integrity. Conversely, downstream companies relied heavily on SCADA and PE systems to collect and process measurement data.

By the late 1990s, as hardware and software became more widely available and cost-effective, many upstream and midstream companies began implementing SCADA/PE systems and auto validation processes. Today, capturing, processing, and retaining hourly measurement data is a fundamental part of operations for upstream, midstream and downstream companies throughout the industry. Figure 1 depicts the general process used by large gas companies today.

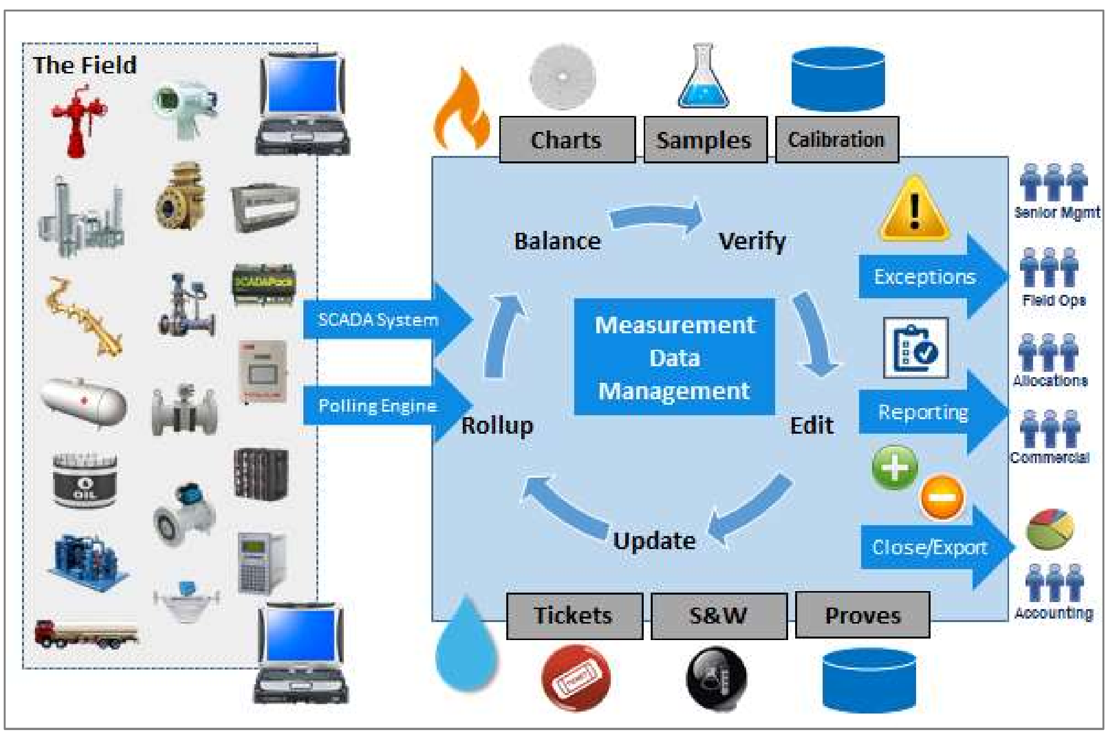

Figure 1. Measurement Data Management Process

Measurement Standards

On August 1, 1993, the American Petroleum Institute (API) published the first edition of the *Manual of Petroleum Measurement Standards (MPMS) Chapter 21.1 - Flow Measurement Using Electronic Metering Systems-Electronic Gas Measurement* (a.k.a., API-21.1). This document provided a standard for performing custody transfer gas measurement with flow computers. In February 2013, API published the second edition of Chapter 21.1, providing key updates to accommodate new technology and industry trends.

Measurement System Components

Electronic Flow Computers

Electronic flow computers (EFCs), also called remote terminal/transmitting units (RTUs) or electronic flow meter/measurement (EFM) units, receive and log inputs from various measurement transmitters and make these values available for collection by the SCADA/PE system. While processing these inputs, the EFCs are concurrently calculating gas volume and energy every second, based on values from instantaneous pressure, temperature, differential pressure, and other output pulses from orifice or turbine flow meters. For orifice flow meters, these calculations are described in API MPMS Chapter 14.3 - *Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids - Concentric, Square-edged Orifice Meters* (a.k.a., API-14.3). This standard is also published, under the same title, by the American Gas Association (AGA) and is known as their Report No. 3 (a.k.a., AGA-3). For turbine flow meters, these calculations are described in AGA Report No. 7 - *Measurement of Natural Gas by Turbine Meter* (a.k.a., AGA-7).

Accumulation of calculated volume and energy and the averaging of flow parameters is critical to the integrity of hourly measurement data. Prior to 2013, many flow computers were configured to calculate flow-weighted averages for flowing parameters. Today, based on API-21.1, flow computers should be configured to calculate time-weighted averages when gas flow exists.

A typical EFC system will include at least one meter, although some may contain multiple meters. The physical meter configuration, historical data values, gas composition, and meter events and alarms are stored for every meter along with the flow computer firmware, configuration, events, and alarms. Some systems are designed simply to record measurement for the gas company measurement group, while other systems are designed to provide flow and pressure control, as well as measurement. Figure 2 depicts the typical modern-day gas company EFC system architecture.

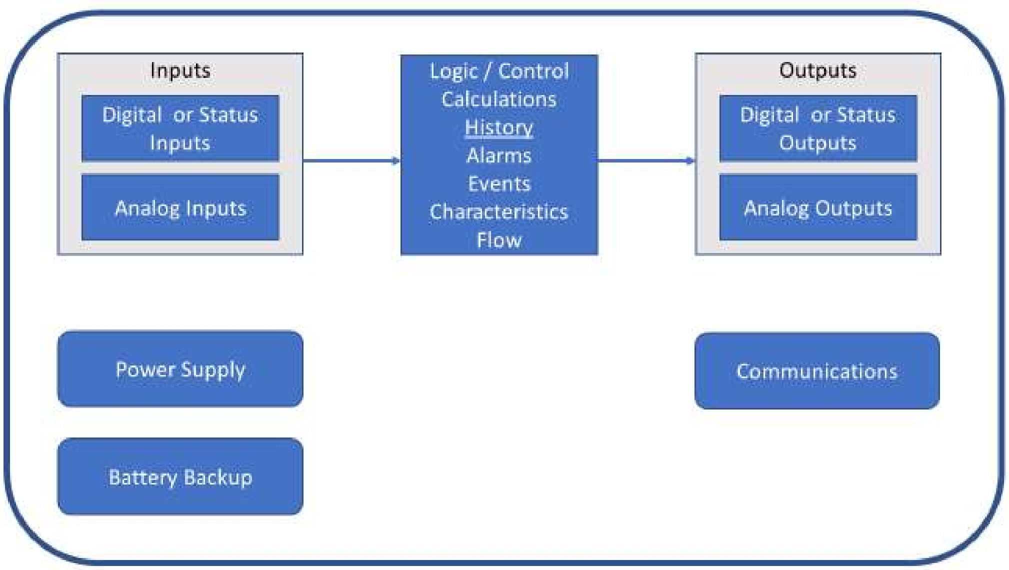

Figure 2. Example Electronic Flow Computer System Architecture

Most EFCs support the storage of up to 35 days of hourly flow measurement history records, event, alarms, and the current meter characteristics configuration. As discussed earlier, the EFC should be configured to accumulate and average the flowing parameters per API-21.1 and/or company contractual requirements.

SCADA/PE Systems

SCADA/PE systems have two key objectives. The first is to collect data and provide instantaneous input to the gas control group monitoring pressure, flow, gas composition, temperature, and other data. These values are then collected, processed, and reviewed in real time to comply with pipeline regulations and maintain system integrity. For instance, the Maximum Allowable Operating Pressure (MAOP) is a key pipeline regulatory compliance focus for a SCADA /PE system.

The second objective is to collect measurement data records. This includes the configuration for each meter, hourly history records, gas composition records, events, and alarms. Measurement data are typically collected on an hourly or daily basis. The frequency of data collection depends on the communication bandwidth and reporting requirements of the gas company.

A robust SCADA/PE system will ultimately be able to:

- Provide system monitoring and control
- Perform alarm functions
- Acquire and present data
- Act as a data historian
- Provide security functionality

Figure 3, showing a modern-day SCADA control room, illustrates the complexity and technical sophistication of the measurement data capture and processing function.

Figure 3. SCADA Control Room

Measurement Data Processing

Every segment of the petrochemical supply chain - upstream, midstream, and downstream - relies on the same key elements to effectively process measurement data.

Manual Imports and Additional Data Gathering

Most measurement data is typically collected by the SCADA/PE system. However, there are still additional data that must be collected manually. During extended communication outages due to hurricanes, tornadoes, ice storms, etc., measurement technicians will typically collect the measurement data manually from the EFCs in the field and then transfer the data files collected to the corporate office.

Results of the gas quality analyses are loaded through a file, periodically, throughout each month. This file represents the results from samples that were collected in the field and sent to a gas laboratory for analysis. The gas lab processes each collected sample bottle through a chromatograph. The gas company agreement with the lab will control the pressure base of each sample received and the extent of each gas analysis, e.g., C_{6+}, C_{7+}, or a more extended analysis. Most companies rely on a C_{6+} analysis and will run an extended analysis periodically to verify the C_{6+} component split characterization.

Another area that requires importing data beyond what is available through the SCADA/PE system relates directly to third-party measurement data. The collection of third-party data is required for those meters that the organization is not responsible for custody transfer measurement. The gas company may have "check" measurement collected by the company SCADA/PE system at such locations; however, the gas company will need to collect the data either manually or through a text file. References to this section are discussed during the Unaccounted-For gas loss session presented earlier.

Meter and Gas Quality Data Validation

Data validation helps ensure information integrity that not only meets industry and regulatory audit requirements but that directly affects the gas company “bottom line.” As evolving requirements continue to increase the amount of information that flows through a measurement system, the process becomes critical. Increased scrutiny on the hourly periodic values, gas composition data, meter characteristics, and calibration data all contribute to a growing number of potential anomalies and the amount of information that must be examined within the organization.

Identifying data anomalies is a top priority for any measurement software application. Using a data validation process, numerous “checks and balances” that are applied to flowing parameters, meter characteristics, quality information, and “rolled-up” historical averages and totals. This allows analysts to quickly identify and address problems with the original measurement data received.

Validation set points are generally built into the measurement data management process based on limits imposed by several different areas, e.g., calculation standards, measurement guidelines, SOPs, unique meter conditions, etc. Set points can often be enabled to determine validation parameters based on the historic flow pattern of each value. This covers differential pressure, meter output pulses, static pressure, temperature, volume, energy, and mass, along with heating value, relative density, N_2, CO_2, and C_1 - C_{10+}. The set points will be utilized by meters and quality sources to flag data outside of normal operating boundaries.

<u>Validation Types</u>

Validations are set to examine multiple data types and parameters to ensure data consistency and integrity. Typical validations include:

- **Import data –** Using measurement system logic, this validation examines data during the initial import to detect fundamental data discrepancies.
  - Missing hourly records
  - Missing variables needed for calculations e.g. differential pressure, static pressure, temperature, relative density, heating value, etc.
  - The hourly record reflects a flow time greater than an hour
  - Daily flow time exceeding 24 hours
  - Data received for a disconnected meter.
  - Etc.

- **High/low parameters -** Parameter validations examine high and low values for data, such as differential pressure, static pressure, temperature, volume, energy, mass, and volume correlation factor for flow. Additionally, high/low parameters are critical for gas quality data to flag suspect sample data. Ideally, suspect gas quality data should be reviewed prior to loading/downloading to an EFC. Investing the time to ensure correct flowing parameters and gas quality data is being used in every meter by the EFC and measurement system will reduce measurement errors. Data that occur outside of the established parameters, such as differential pressure outside of the industry-recommended range or volume outside of the range of contractual minimum and maximum quantities, will be flagged.

- **Meter/quality comparisons -** Comparing current readings to prior readings and data from one meter to other meters in the measurement management system can quickly reveal data anomalies. For example, a rate of change validation will flag significant variations in gas quality that should be reviewed along with potential liquid issues indicated by significant swings in the differential pressure. This validation enables the measurement group to work with the pipeline integrity group to track gas quality issues that can have a significant impact on the pipeline, as well as improving the overall measurement integrity.

- **Meter configuration** - When performing meter configuration comparisons, results found in the meter/EFC are compared to the measurement system database. These comparisons verify that no lost meter/EFC events exist and that no value has changed without an indication. Too often, a keypunch error or erroneous change is made in the field that goes undetected until an audit occurs, in some instances, as much as two years later. If this validation was being incorporated into the measurement process, the keypunch error or erroneous change would have been flagged for review and resolved by the measurement group in a timely manner.

- **Statistical analysis** - Statistical analysis (standard deviation or percent difference) of current versus historical data is a sophisticated validation rule that enables measurement groups to flag values that may have been entered incorrectly or received from a wrong meter/EFC. It can also flag significant changes in routine flowing parameters of a meter/EFC. This validation level is becoming more common in the industry as a key validation parameter.

- **Hourly, daily, and monthly level validation** – Typically, validations are performed on the data received. If hourly data is being received, the validation parameters are set to run on hourly data. However, this does not cover daily values, monthly values, or even an hourly record that is made up of two or three split records due to multiple orifice plate changes. Applying validations to rolled-up data (generated hourly, daily, or monthly) can help reveal problematic data trends. Examples include validating totals for an hour relating to split records (such as orifice plate changes or turbine flow meter K-factor changes) or performing monthly-level validations to flag values that are lower or higher than expected, based on sales contract criteria.

Exceptions

Exceptions are created when a validation parameter is tripped and are designed to flag the measurement group regarding measurement-related issues that can affect the volume, energy, and/or mass. Measurement staff members review these exceptions to identify and resolve the flagged issues. Trends and recurring issues are tracked throughout the year to determine if equipment should be upgraded or replaced or if a new facility design is needed to resolve an ongoing problem. Prior to closing each month, all exceptions are either resolved or flagged as process-pending.

Validations should be configured for all meters and gas quality data. This also includes third-party measurement data, gas quality lab analysis data, and all the data received from the SCADA/PE system(s).

Validation Configuration and Edited Data

When measurement data must be modified, the measurement system is required to maintain an audit trail that includes the original data, subsequent edits to the data, and a reason for the edit. Configuration of key validations is critical in flagging suspect data without creating an excess of validation exceptions. When validation parameters are configured properly, they provide significant time savings for the measurement group; however, configuring the validation limits too tightly can create an unmanageable number of exceptions and interrupt operations. Conversely, if the validation criteria limits are too wide, problems in facility operations may go undetected.

For each generated exception(s), several logical options are available to help work through the problem to determine the resolution plan.

- The exception identified an issue with data that will trigger an edit to the original data and may also trigger a callout to a measurement technician. For instance, a temperature transmitter failed and began repeating the same value.
- The exception identified a potential issue that, after communicating with the measurement technician, was determined to be OK. In this case, the exception is simply acknowledged.
- The exception identified a potential issue that, after communicating with the measurement technician, was determined to be a validation range / criteria needing updating. The pressure high validation range was set @ 625 lbs. Due to operational changes, the meter is now operating @ 650 lbs. In this case, the validation criteria is modified so additional exception(s) are not created going forward.
- The exception identified a potential issue that is not resolved by the measurement technician prior to the period closing. This may be due to the measurement technician being on vacation or waiting on a response from the customer regarding the issue. In this situation, the data are flagged with a pending or in-progress status until the issue is resolved, potentially, after the period closing.

Balancing/Gas Loss Validation

Balancing and determining unaccounted-for gas loss is a specialized, complex validation process that encompasses the summary of meters, meter stations, pipeline segments, and system balances. Summary-level validation allows a measurement group to flag stations, segments, and balances where values exceed expected hourly, daily, and/or monthly quantities. In addition, the percentage of unaccounted-for gas loss can be flagged when the percentage exceeds the acceptable value. This validation can then alert the entire measurement team anytime a gain or loss in volume, energy, or percentage has been exceeded for the configured balances in the system.

Closing Measurement Data

The measurement group generally performs a monthly close on the measurement data every month. Regulated pipelines and downstream companies typically close the data from the previous month on the third to fifth working day of the following month, e.g., they would close September on October 3rd - 5th, if Monday was October 1st. Upstream and midstream companies generally close data from the previous month on the 10th to 20th of the following month.

Prior to closing, the measurement group will review and resolve all known anomalies for each meter, gas quality device/sample, meter station, pipeline segment, and system balance. This requires the field and office staff working together to review and resolve all identified anomalies. Each group provides a different perspective into the issue and is generally able to offer insight into the resolution of the identified exception. The team should work together to resolve each exception.

Prior-Period Adjustments

After the measurement data are closed, any adjustments to the closed data will require a prior-period adjustment (PPA). There are many reasons for adjusting data after closing, including:

- Late reported third-party volume
- Late reported gas analysis
- Field equipment issue identified after closing
- Undetected measurement data anomaly during the month

The objective is to identify and resolve all measurement-related issues prior to closing; a single measurement PPA could result in several additional allocation- and accounting-related adjustments to measurement quantities. Often, measurement groups will track what caused a PPA and will strive to reduce the number of PPAs processed each month and year. By reducing the number of PPAs processed, customer service can improve.

Retention

Retention rules for measurement data are often based on contractual requirements, documented standard operating procedures, and government regulations. Retention periods typically span two to seven years, although some may span the life of a facility. The measurement group will need to review the requirements in this area with the company legal team prior to archiving, purging, deleting, or removing any measurement data.

A retention period of seven years has been used by many upstream, midstream, and downstream companies for decades. Many companies may elect to keep two years of information in the online production database and keep an additional 5+ years in an archive database. There are also occurrences in which there may have been a prior lawsuit that would dictate that the measurement data be archived for the life of a facility. The measurement group, in conjunction with the information technology support team, will need to develop a maintainable retention strategy.

Retention practices should be reviewed during any acquisition or divestiture and addressed from the perspectives of all parties involved. Final decisions should be made based on contractual terms for the liability for prior periods and data retention.

Training

Training is an integral part of the measurement data capture, processing, and retention strategy to ensure understanding of data collection, validation, and retention criteria, exception notifications, and industry standards and recommendations, such as those established by organizations such as the American Gas Association, American Petroleum Institute, and GPA Midstream.

The following organizations offer many measurement-related resources and training opportunities:

- AFMS – Acadiana Flow Measurement Society (Lafayette, LA)
- AGA – American Gas Association (Various)
- AGMSC – Appalachian Gas Measurement (Pittsburg, PA)
- ASGMT – American School of Gas Measurement Technology (Houston, TX)
- CCGMS – Corpus Christi Gas Measurement Society (Corpus Christi, TX)
- CEESI – Colorado Engineering Experimental Station Inc. (Nunn, CO)
- CGA – Canadian Gas Measurement School (Various)

- CSHM – Canadian School of Hydrocarbon Measurement (Calgary, Alberta, Canada)
- Entelec (Houston, TX)
- GCGMS – Gulf Coast Gas Measurement Society (Houston, TX)
- GCI – Gas Certification Institute, LLC (Houston, TX)
- ISHM – International School of Hydrocarbon Measurement (Oklahoma City, OK)
- MMS – Midwest Measurement Society (Oklahoma)
- PETEX – Petroleum Extension Service UT (Various)
- RMMS – Rocky Mountain Measurement Society (Denver, CO)
- SGA – Southern Gas Association (Dallas, TX)
- SwRI – Southwest Research Institute (San Antonio, TX)
- TGA – Texas Gas Association (Dallas, TX)
- WGMSC – Western Gas Measurement Short Course (Various)

Conclusions

Measurement data integrity throughout our industry has seen significant improvements in timeliness of data collection, validation and estimation processes within upstream, midstream, and downstream companies, and data retention policies. Additionally, widely available, high-quality training has helped to provide a better understanding of the overall process.

These improvements help measurement groups identify and resolve flow meter, gas quality, station-level, pipeline segment, and system balance issues in a timely manner. Large-scale losses and unaccounted-for gas loss issues are identified and, typically, resolved prior to each accounting period closing.

This has improved the overall measurement accuracy of the metering and piping system. In turn, the level of customer satisfaction has increased, thanks to timely validation and a comprehensive review process that reduces required PPAs.

The benefits of investing time into the data capture, measurement management system processing, and measurement data retention guidelines of an organization will be instrumental in improving the overall measurement system integrity of the company, and the measurement industry as a whole.