GAS AND LIQUID MEASUREMENT VALIDATION

Making Data Meaningful

Stephen C. Anson

W Energy Software

INTRODUCTION

Advancements in electronic gas and liquid measurement systems, SCADA systems, data management, and business intelligence software is increasing the access to reliable data. This is both good and bad for the measurement staff who rely on this data to make decisions. This abundance of reliable data is good because the analysts have more data to use to perform historical comparisons and statistical evaluations, however, this abundance of reliable data is also bad because it can become overwhelming and often disguise, or hide, an outlier in the data.

The term ‘validation’ is defined by Merriam-Webster as “an act, process, or instance of validating; especially, the determination of the degree of validity of a measuring device”. To better understand this definition, it is helpful to know the definition of ‘valid’. Merriam-Webster defines ‘valid’ as “well-grounded or justifiable; logically correct”. By these definitions, one can assert that a ‘validated value’ is one that is determined and applied through a combination of human and machine intelligence, and possibly including some mathematical analysis.

This paper will provide information on why, and how, measurement data can be validated to improve the overall quality of the measurement data and offer some techniques to determine logical setpoints for the data one wishes to validate.

BACKGROUND

“In God we trust, all others must bring data.” – W. Edwards Deming

“Trust but verify.” – Russian Proverb.

As measurement technicians, analysts, and engineers, we trust our equipment and the results of this equipment. This is because large sets of testing and comparisons have been performed over the years, and we have been able to trust these results against other equipment, system balances, and other means because the data the equipment has produced was reliable.

In oil and gas measurement we perform an abundance of verifications on the equipment and data we have come to trust. We certify the test equipment. We use the certified test equipment to verify and calibrate the field equipment. The field equipment produces values and data used in the office and reviewed for completeness and accuracy of each meter. A collection of meters can be used in a system balance to verify what went ‘in’ to the system also came ‘out’ of the system. It is a process of constant verification. Using validation processes is one step in an ongoing pursuit of endless refinement for measurement staff.

Before electronic measurement, data acquisition systems, back-office software, and ‘the cloud’, measurement data was produced in much smaller sets of information and was simpler to validate. This is because the measuring instruments (meters, springs, and dial gauges) were mechanical devices, and the recording instruments were analog devices (paper charts and totalizers). A human would collect this information (usually only 3-7 data points) at a common frequency of once per day. This information would be reported to the office where the necessary additional calculations would be performed. These small sets of data were easier to validate by the humans involved in the process.

The introduction of flow computers (electronic measurement) increased the amount of measurement data being generated by an order of magnitude! The measuring instruments were still largely mechanical, but the recording devices attached to the meters were becoming digital. Transmitters took the place of the springs and dial gauges being used to measure differential pressure, static pressure, and temperature in gas measurement. Pulse transmitters were being connected to totalizers to relay volumetric liquid data. These devices were connected to flow computers which had the ability to instantaneously calculate flow rate, correction factors, standard volumes, etc. These calculations were happening in real time and being averaged into hourly resolutions. What was once a single daily set of information with only a handful of data points has been contemporized into hourly records with over a dozen more data points being reported to the back-office.

In addition to the abundance of measurement flow data the flow computer can generate, the flow computer is also able to monitor, track, and store information other than the meter’s flow data. Configurations and characteristics used as identification details, location, or calculation information can be stored in the flow computer. The flow computer can also store events that help to track changes to the configuration and characteristic information. These events may also include when a verification and calibration is performed with the as found and as left readings. Alarms can be generated and stored based on settings from the configurations which help to identify process issues.

Even beyond the flow data, we can now understand how the quantity of measurement data has increased. What was once a human collecting a few data points is now an electronic machine (with human help) collecting thousands of data points! Validating these additional data points would be almost impossible for the next human in the process without help. This additional data is valuable, but if the data can't be easily reviewed and interpreted it is just diagnostic fodder.

VALIDATING DATA

Fundamentally, to validate data is to review and confirm the quality of the data. A measurement validation process will review all available measurement data, identify anomalies and outliers, then allow the end user to decide if, or how, to resolve the anomaly or outlier. For a measurement analyst who is responsible to review, validate, correct, balance, and report hundreds of meters every month this can be an overwhelming task.

For over 20 years measurement analysts have been aided with this task in the form of software. As flow computers grew in popularity, software to help manage this new source of data were coming to market. Validating the measurement data became a key feature in these software applications. In these measurement software applications, the validation process is based upon, and run against, a series of user-defined set points within the application. These set points can be a min/max range the data must fit into, or a condition which the data must meet to be considered valid. In either case, these set points must be determined by the measurement staff through personal understanding, experience, historical performance, or calculation of previously defined data.

Data that fits the range or condition of the set point is considered good data. Conversely, data that does not meet the validation criteria is considered suspect data, or an 'exception'. Once the measurement software runs the validation management process, the measurement analyst can perform an exception review process. This process is commonly known as managing by exception and allows the measurement analyst to efficiently focus on the review and resolution of the identified anomalies and outliers. Since data that meets the validation criteria is considered good data, the measurement analyst can more quickly identify an issue which may take more time to investigate and resolve.

In addition to increasing efficiency, validations and exceptions can also be used to monitor the equipment in the field. By tracking validations and exceptions, recurring issues can be reviewed to determine if failing equipment may be the cause for data error, mismeasurement, or imbalances. By tracking and trending the validation data, measurement teams can make decisions to repair or replace equipment which could lead to even better data over time.

VALIDATION METHODS

There are numerous ways to perform measurement data validation and numerous data points to validate against. Here are some common examples:

- 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;
- 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 the measurement data system;
- 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, N2, CO2, C6+, O2, He, H2S, 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.

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.

With the amount of measurement data being generated in the 21st century it is becoming increasingly difficult set a validation that is important while avoiding one that is not necessary. Large, unstructured data sets can become very noisy and commonly lead to one of two situations. The first is when validation ranges are too restrictive and trigger excessive and noisy exceptions. Noisy exceptions could camouflage actual suspect data by overwhelming the analyst. The second is when the validation limits are too wide and very few exceptions are triggered. This too can camouflage actual suspect data by not alerting the analyst to a potential issue. More plainly, too many validation triggers create too many exceptions which leads to a large data set to review, or false alarms. Too few validation triggers don’t create the necessary exceptions to identify true suspect data.

Fortunately, just like when software increased our access to this data, software can also help us manage this data more effectively. Data science is a process of using scientific methods, math, statistics, and business processes to help make decisions from large data sets. When applying the practice of data science to measurement data and the process of validation management, machine learning algorithms can use the data to determine dynamic validation set points that are determined on a broader range of operating conditions. This creates more efficiency for the measurement analysts and further elevates the integrity of the data. Additionally, the historical data and machine learning techniques can be used to perform predictive analytics to identify an issue before it becomes an issue!

CONCLUSION

Gas and Liquid measurement data is becoming more abundant, easier to access, cheaper to store, and increasingly complex. The integrity of the measurement data is essential to be able to accurately review, correct, and report data. Consequently, identifying suspicious data is a critical business function of any measurement department.

A good validation management process will allow a user to define the validation set points over a wide range of data points. Newer data validation tools may incorporate enhanced software solutions which employ data science techniques to further refine and adjust the validation set points. Oil and gas companies continue to rely on data to make informed decisions, and the measurement departments of these companies continue to improve their data processes.