IMPROVING FLOW MEASUREMENTS WITH IMPROVED CALIBRATION AND DATA HANDLING PROCEDURES

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Introduction

The continual flow of information from field measurement technicians to measurement analysts in the corporate office is extremely demanding and creates tremendous and constant challenges for all organizations.

Every day, measurement technicians test their knowledge and skill sets regarding:

- Electronic and pneumatic controls
- Communication system support
- Multiple technical disciplines
- Measurement and verification equipment
- Keeping current with applicable measurement standards
- Standard operating procedures
- Facility regulatory requirements
- Ongoing training

Measurement analysts require a completely different skillset to verify the flow measurement data along with interpreting the meter testing and calibration data received from the field. Analysts are tasked with absorbing large quantities of information and utilizing their extensive knowledge base to determine whether a current month adjustment or even prior month(s) adjustments are warranted.

Throughout the process, maintaining data integrity requires all parties to continually ask: “Did the technician and analyst follow the correct procedures in performing the calibration and the adjustment?”

Past to Present

In the past, most major companies staffed its own measurement training facility and provided instruction at regular intervals throughout the year. The training often took place at live gas facilities and usually included videos, classroom training sessions, and hands-on field training. Every company had a set of standard operating procedures (SOPs) and the appropriate AGA, API, and GPA documents. Each SOP had a standard form that outlined how to successfully document the gas measurement data process. All measurement technicians were taught through demonstration and execution based on those procedures. With the ability to cycling through multi-level training classes and receiving certification and sign-off upon completion of each measurement understanding level.

By the mid to late 90s, FERC order 636, deregulation, and major corporate organizational changes resulted in most company-staffed measurement training facilities being discontinued. Many companies experienced major modifications and consolidations of SOPs. This consolidation forced the “retirement” of a significant portion of the industry’s gas measurement knowledge base. Fortunately, the prior training investment was able to sustain the industry’s needs for a number of years going forward.

Today, the bar has been raised. New measurement technicians now need advanced computer skills and operations knowledge for the ever-growing list of new primary, secondary, and tertiary devices. They must also develop this proficiency in a condensed timeframe with a larger list of devices to learn than ever before. Additionally, Operator Qualification programs have significantly affected the documentation and sign-off requirements for new and existing measurement personnel seeking certification.

Equipping the Technician to Perform the Task

Measurement technicians must have access to the proper verification equipment and fully understand how to use and maintain the devices. This is critical for validating temperature, pressure, and differential transmitters while also adhering to the standards for validating linear meters as outlined in a company's SOP or measurement guidelines.

Gathering the proper equipment and ensuring that it is certified by the National Institute of Standards and Technology (NIST) is part of this process, as is the use of stain tubes and additional gas quality verification equipment. To comply with each company's SOP, tariff, and/or contractual obligations, maintaining proper documentation of the calibration and test is critical.

To ensure the measurement technician understands how to properly operate the equipment, thorough training and reviews should be conducted. This review process should include equipment operations with all RTU brands and models in operation, as well as their related components.

Training should also include the following topics to ensure that the measurement technician understands the importance and potential impact of the verification process:

- Boyle's law
- Charles's law
- Deviation from Boyle's law
- Typical standard units of measurement
- Basic electronics
- Basic math
- Volume calculation to energy
- Orifice metering and AGA 3 (2013)
- Turbine meters, positive displacement meters and AGA 7
- Ultrasonic meters and AGA 9 (2017)
- Coriolis meters and AGA 11 (2013)
- AGA 8 – Compressibility Factors of Natural Gas (2017)
- API 21.1 – Electronic Gas Measurement 2nd Edition (2013)
- Overall measurement accuracy
- API 14.1 Gas Sampling (2016)
- Chromatography
- Specific gravity determination
- Determination of moisture content
- GPA 2166 (2017)
- GPA 2172 (2014)
- Automatic control of flow and pressure
- Control valves and regulator equipment
- Odorization
- Electronic flow computers
- Supervisory Control and Data Acquisition (SCADA) and polling engines
- Corrosion control and cathodic protection in pipeline operations
- Communication techniques and equipment
- Safety issues
- Etc.

Importance of Scheduling Inspections and Calibrations

Scheduling meter test inspections and calibrations, gas sampling, and routine maintenance is crucial. Schedule frequency is typically specified in company tariffs, SOPs, and/or contracts. Some facility scheduling requirements are driven by governmental agencies such as the Bureau of Ocean Energy Management (BOEM), formerly the Mineral Management Service (MMS), and the Bureau of Land Management (BLM). When companies manage a significant number of monthly inspections, scheduling these inspections and calibrations becomes labor intensive. Organizations will typically discover whether they within compliance regarding their scheduled commitments during an audit. A number of companies today risk significant exposure in the industry due to their inability to comply with scheduled meter test and inspections dictated by their contracts, tariffs, SOPs, or regulatory requirements.

Many natural gas companies have taken advantage of computer-based tools to document required tasks and schedules. These tools provide required information in a format that makes delinquent tests easy to identify, thereby minimizing a company's potential exposure. The view in Figure 1, which highlights delinquent tests in red, demonstrates one of many ways that the schedules can be viewed, reported, and exported. These tools can also sort and prioritize the work by area, region, and possibly even throughput, allowing technicians to make more effective use of their time.

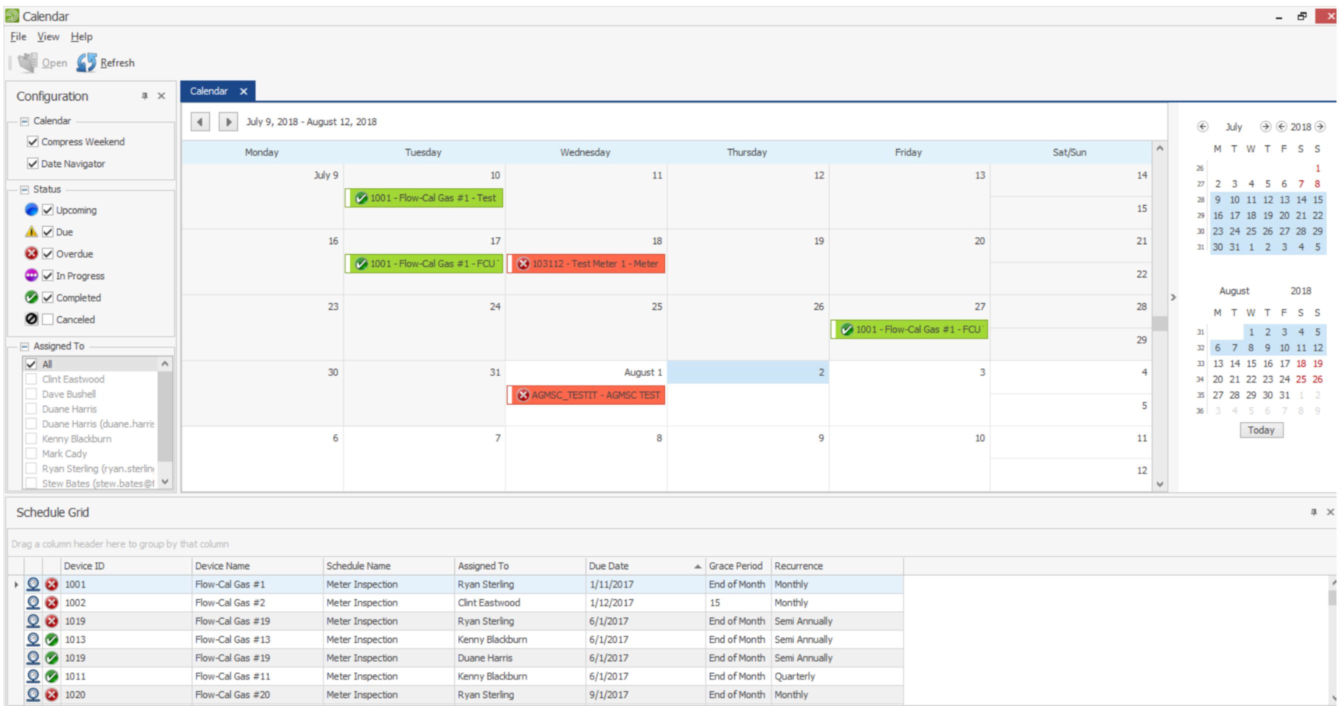


Figure 1

Understanding the Testing and Calibration Form

Standardization of inspection/calibration forms, whether paper or electronic, is essential for consistent interpretation across a corporation. It is difficult for a measurement analyst or technician to interpret data in multiple formats and determine if it is complete, conflicting, or wrong.

Standardizing forms and procedures can reduce or eliminate aspects of a test that are often confusing, such as:

- Is the working pressure zero adjusted prior to adjusting the atmospheric pressure zero?
- Is the working pressure zero adjusted prior to determining the "as found" multi-point calibration?
- When making adjustments to the multi-point calibration, are the adjustments made at each point or at the conclusion of the multi-point calibration?
- Is your calibration equipment PSIG or PSIA as compared to the transmitter?
- Should any adjustments be made to the transmitter based on the multi-point calibration, or should the transmitter be replaced and recalibrated at the factory or certified facility?

Additionally, the ability to attach pictures of key witnessed events is also critical to the documentation process (Figure 2).

Figure 2

Conducting the Test and Calibration

Typically, testing and calibration processes should follow rigid guidelines to ensure all steps are covered with the highest level of accuracy and reduced uncertainty. Following the best recommended practices of the AGA, API, and/or GPA is essential during this process. A technician should have a copy of the company's tariff, contract, or SOPs during the testing and calibration process. Procedural changes at a facility can often lead to a mistake or error on the verification/calibration report. Other events that can cause deviations include weather, additional help, equipment malfunction, and witnesses.

The SOP governing each task should note what is required on the form for the task to be considered complete. The AGA, API, and GPA have recommended "best practices", and provide a listing of the essential information needed on the form, as well as its specific purpose. Good measurement training explains the consequences of incomplete test data and emphasizes the importance of properly documenting each test. Proper training, when coupled with a company's SOP, will yield consistent measurement practices and provide an organization with measurement integrity and successful audit results.

"As found" meter values (that is, values recorded when arriving at the meter) are often critical in helping determine errors. To determine the meter error as related to the test, most companies either utilize the "as found" reading or they utilize the last month, quarter, or yearly average of the flowing parameters (depending on the testing and calibration frequency of the meter). Refer to the diagram in Figure 3 (as referenced from RANSolutions) for a recommended Transmitter Verification and Calibration process.

It is best to follow the company's recommended guidelines in determining where the threshold exists between a verification of "Yes" and "No". The threshold might be between 0 and +/-.125 inches or pounds on the differential and/or static pressure transmitters, and between 0 and +/-.5 degrees for the temperature transmitter. The company may want to replace the transmitter or recalibrate the transmitter (based on their recommended practice) if the threshold reaches +/-.250 inches or pounds on the differential and/or static pressure transmitters and 0 to +/-1 degree for the temperature transmitter.

Transmitter Verification and Calibration Process

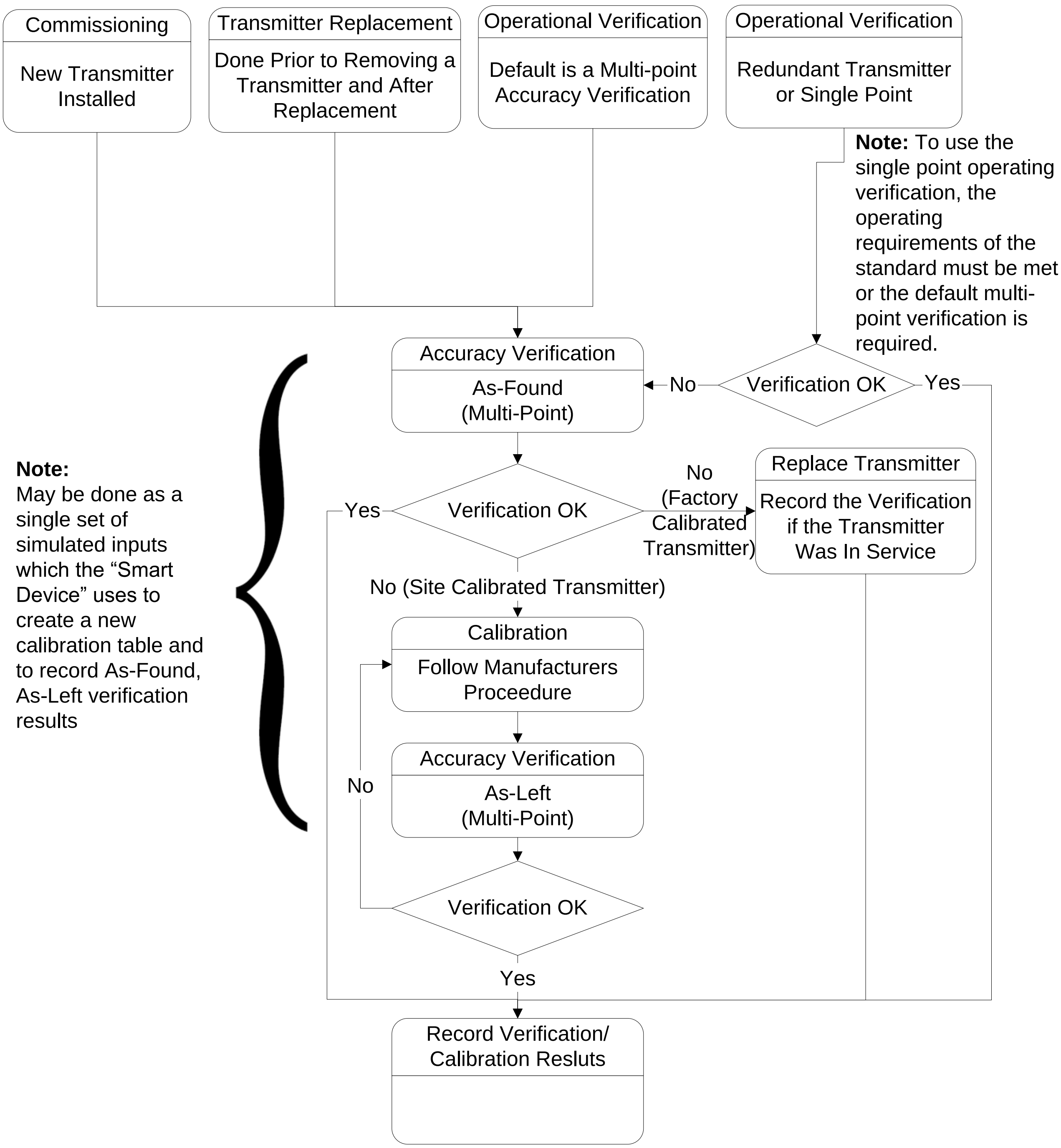


Figure 3

Extreme caution should be taken while performing the verification on all transmitters to avoid affecting the transmitter's hysteresis.[1] The main risk regarding hysteresis occurs when a technician adjusts the transmitter to bring it back into calibration. The process of adjusting the transmitter may cause a hysteresis effect during the calibration process, moving the transmitter out of calibration when it recovers from the hysteresis.

Once the technician has performed a multi-point verification and avoided any effect on hysteresis, the next step is to determine if an error exists. The error for differential pressure as seen below is a good formula for determining the "as found" error at each point in the verification process.

Differential Pressure:
As Found = 99.82
Standard (Reference) = 100.0

V(f) = Flow Rate at found conditions
V(s) = Flow Rate at standard conditions

$$Error = \frac{100 * (V(f) - V(s))}{V(s)}$$

V(f) = V(99.82) = 33.956
V(s) = V(100.0) = 33.987

$$Error = \frac{100 * (33.956 - 33.987)}{33.987} = -.0898\%$$

These calculations should be based on initial found conditions for static pressure and temperature and the effective gas quality and current meter characteristics.

This exact formula can then be followed to determine the error at each standard or reference point for differential pressure, static pressure, and temperature. See Figure 4.

[1] The lagging of a physical effect behind its cause (as behind changed forces and conditions) (Retrieved from www.merriam-webster.com/dictionary/hysteresis)

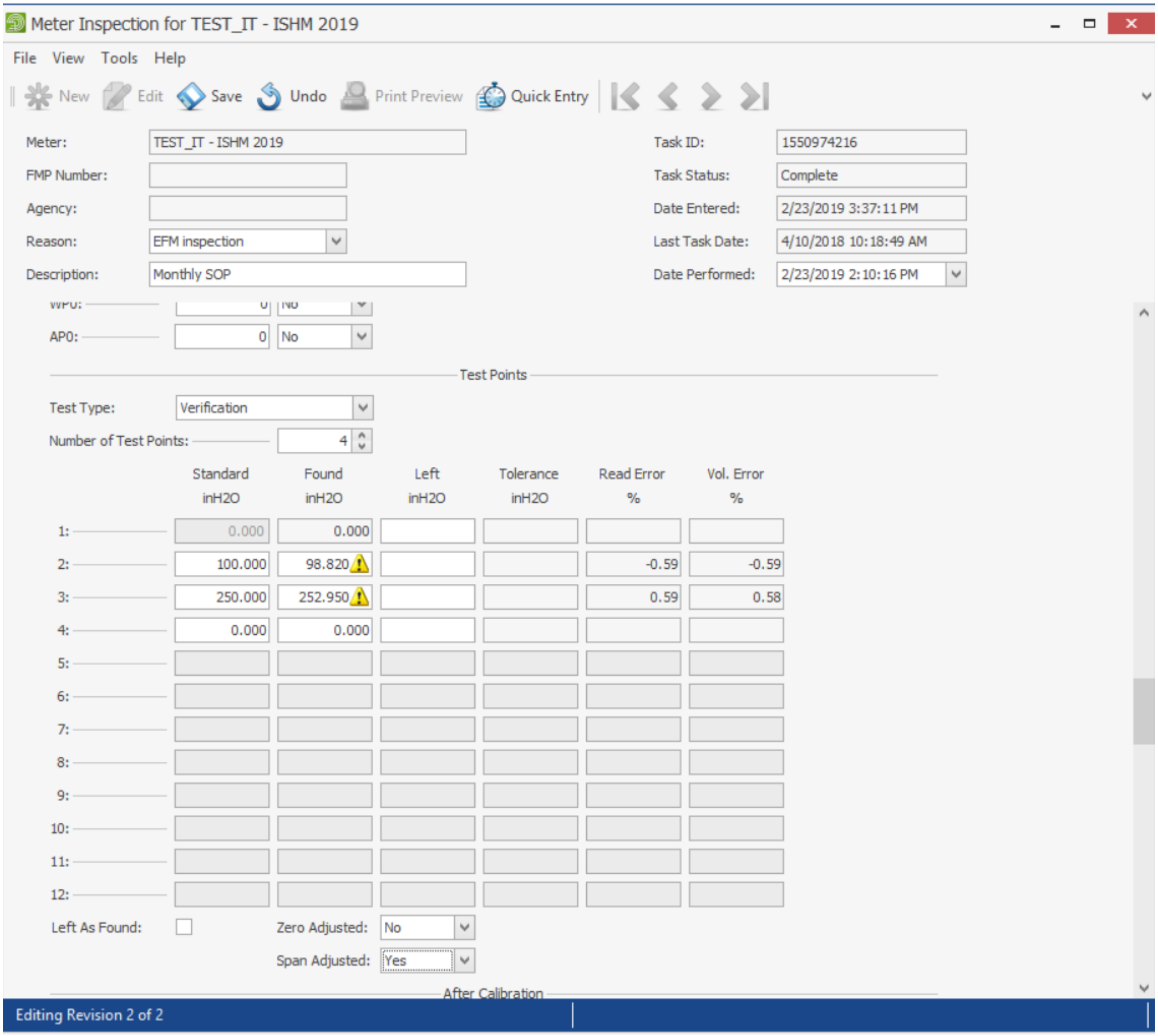


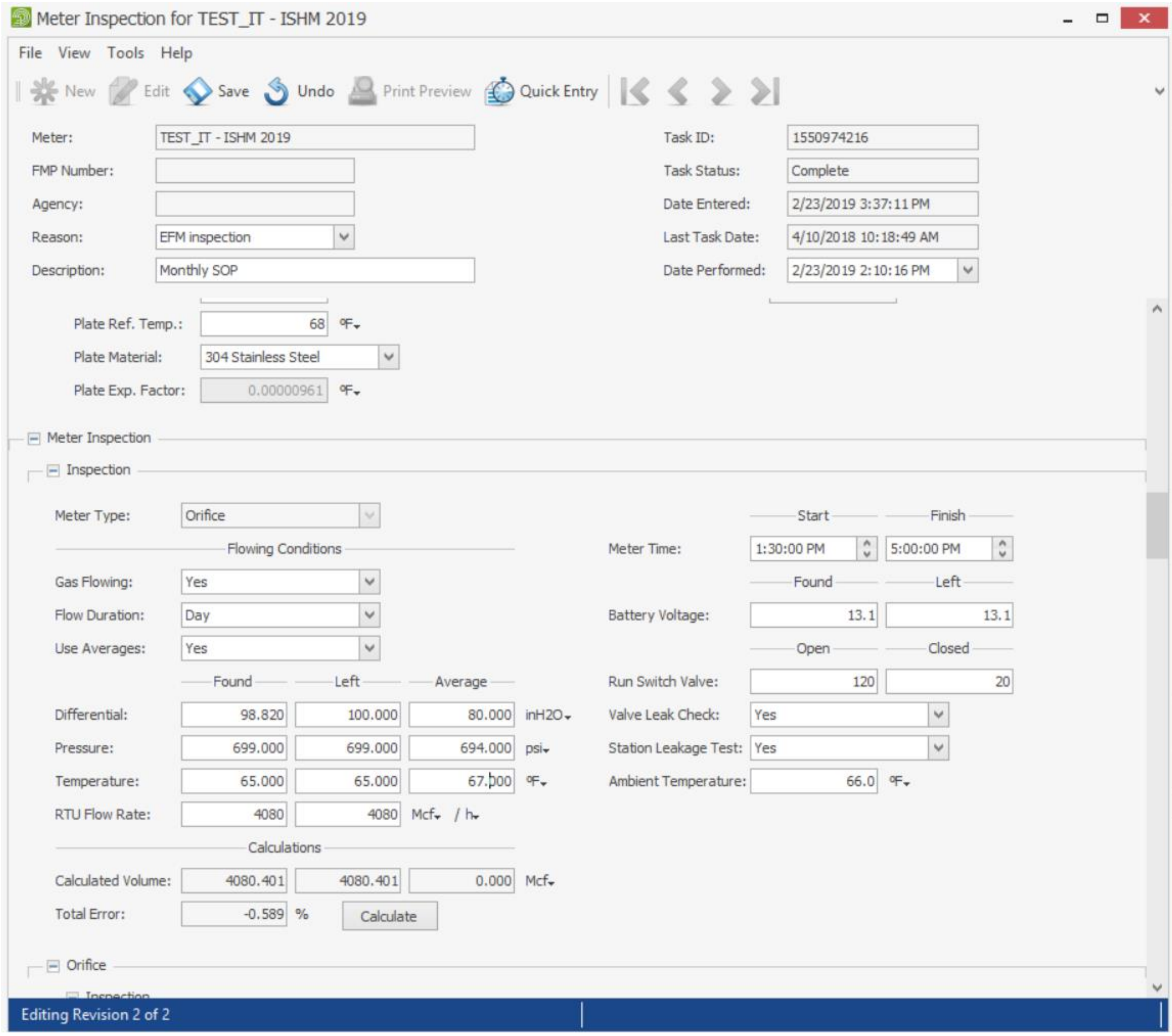
Figure 4

A similar formula can be followed to determine the Total Error of the meter as summarized below:

$V(i)$ = Flow Rate at initial found conditions
$V(a)$ = Flow Rate at adjusted conditions

$$Error = \frac{100 * (V(i) - V(a))}{V(a)}$$

See Figure 5.


Meter Inspection for TEST_IT - ISHM 2019
File View Tools Help
New Edit Save Undo Print Preview Quick Entry
Meter: TEST_IT - ISHM 2019
FMP Number:
Agency:
Reason: EFM inspection
Description: Monthly SOP
Task ID: 1550974216
Task Status: Complete
Date Entered: 2/23/2019 3:37:11 PM
Last Task Date: 4/10/2018 10:18:49 AM
Date Performed: 2/23/2019 2:10:16 PM
Plate Ref. Temp.: 68 ºF
Plate Material: 304 Stainless Steel
Plate Exp. Factor: 0.00000961 ºF
Meter Inspection
Inspection
Meter Type: Orifice
Flowing Conditions
Gas Flowing: Yes
Flow Duration: Day
Use Averages: Yes
Found Left Average
Differential: 98.820 100.000 80.000 inH2O
Pressure: 699.000 699.000 694.000 psi
Temperature: 65.000 65.000 67.000 ºF
RTU Flow Rate: 4080 4080 Mcf / h
Calculations
Calculated Volume: 4080.401 4080.401 0.000 Mcf
Total Error: -0.589 % Calculate
Start Finish
Meter Time: 1:30:00 PM 5:00:00 PM
Found Left
Battery Voltage: 13.1 13.1
Open Closed
Run Switch Valve: 120 20
Valve Leak Check: Yes
Station Leakage Test: Yes
Ambient Temperature: 66.0 ºF
Orifice
Editing Revision 2 of 2
Figure 5

Processing the Test and Calibration Form – The Challenge: "Checking" vs. "Auditing"

The final review step in the calibration and testing process often receives the least attention due to the difficulty of the task, and therefore provides sketchy end results. Time invested in this effort will directly affect the measurement bottom line. This process helps determine several items, including (but not limited to):

- When an adjustment should be made?
- What equipment is out of tolerance?
- Where suspect plate sizes and tube-IDs are in use on the system?
- Which measurement technicians may require additional training?

For years, the process of reviewing the calibration and testing forms has been a manual "checking" process. A significant amount of time has been invested in validating plate sizes, tube IDs, K-factors, meter multipliers, various transmitter/chart ranges, various transmitter/chart calibrated ranges, and RTU gas quality, not to mention the endless list of user-defined fields that every company requires and views as critical. The ability to identify any substantial variances in a manual environment depends upon the education and training of a measurement analyst. Most companies also provide a plus/minus tolerance for static pressure, temperature, and differential pressure based on certain ranges, requiring analysts to perform additional analyses to determine if the adjustment made a 1% or 2% volume difference.

Today, the processes for identifying variances can be automated and flagged to automatically direct the analyst to problem areas, eliminating the need to review every calibration and test report. The validation process can now be configured to create exceptions when warranted for all calibration and test reports received. Automatically flagged data includes:

- Differences in plate sizes and tube IDs
- Discrepancies in K-factors, meter multipliers, various transmitter/chart ranges, and various transmitter/chart calibrated ranges
- Calibration and test error anomalies
- Unique company-required fields

All meter adjustments can be processed automatically, or "audited", to determine if an adjustment is required based on the calibration and testing results for each reference point. Any auditor in the industry will strongly urge companies to review each calibration and test report, either through a manual or automated exception-based process, to make certain all reported discrepancies are identified and resolved.

Conclusion

Taking the right steps to review existing measurement processes can provide insightful direction and help improve the overall measurement accuracy.

1. Existing SOPs, contracts, updated standards, and/or tariffs that dictate the scheduling of meter test inspection/calibration process should be reviewed. The following questions should be addressed:

    - Are all processes documented?
    - Are all measurement personnel trained in the complete process as described in the documentation?
    - Are all measurement personnel trained in completing the form properly?

2. Review the scheduling tools for meter inspection and calibration by asking the following questions:

    - Can compliance with testing and calibrating meters be determined on a routine basis?
    - Can a report be generated easily in the instance of an audit?
    - If needed, can a meter test inspection be provided for the last two or more inspections?
    - Over a year's time, can the variance in the data be reviewed and analyzed easily?

- Where is the test meter data kept, and how easily can it be accessed?

3. Review the procedures for processing test meter data from the field. All processes should be documented for this “checking” procedure. Identify the company’s “plus/minus” adjustment tolerance.

Reviewing the calibration and data handling procedures will improve measurement accuracy and continue to improve measurement uncertainty. This will not only improve customer relations, but it can also help manage unaccounted-for gas loss.

The calibration and testing procedures continue to change and improve just about as frequently as the equipment and training requirements. It is imperative for every company to keep up with industry standards and gas measurement best-practices. By participating in measurement schools and standards committies, companies will be able to stay current with the latest industry trends and policies. Time spent wisely on this endeavor will benefit every company.