Understanding Your Choices In Flowmeter Calibration

Mubeen Almoustafa, Calibration Application Engineer
Flow Dynamics. Inc.

Across various industries, the performance of a flow measurement device is ultimately dependent upon the proper functioning of its sensors or other signal-producing elements, which have an active relationship with the flowing fluid. In order to be confident that a meter is accurately measuring the flow volume or mass, it must be recalibrated on a periodic basis.

Flowmeter users have several options when deciding upon a calibration solution. Their choices include: 1) Contract with an established flow laboratory offering primary standard flowmeter calibration services, 2) Utilize a staffed, onsite calibration service employing either a Primary Standard Flow Calibrator or Flow Transfer Standard (FTS), 3) Purchase their own Primary Standard Calibration System for in-house use, or 4) Acquire a secondary standard FTS to perform their own field calibrations.

Background

When it comes to accurately measuring the flow of liquid or gas, your flowmeter is only as accurate as the equipment it is calibrated on. And in the age of ISO 9001, ISO/IEC 17025, ANSI Z540 and other strict quality standards, this fact is becoming increasingly important (See Fig. 1).

Figure 1. Primary Standard Calibrators provide the best calibration uncertainty for both gas and liquid flowmeters.

Test and measurement applications depend on repeatable flow measurements, which provide performance criteria of the instrument being tested. These devices
often play a critical role on aircraft, placing greater demand on accurate flow test measurement for fuel consumption or hydraulic actuator controls.

Industrial operations live and die by the repeatability of process conditions. It is not enough for an individual flow-metering instrument to perform in a consistent manner, day in and day out; measurements must also be replicated. Multiple devices running on the same process—in different physical locations—must perform the same under identical conditions. Most calibrators achieve acceptable repeatability and traceability to government metrology laboratories, such as NIST. However, only those labs participating in the NIST Round Robin will know their potential bias from the NIST standard.

For industrial operations, inaccurate flowmeter calibrations can have a serious impact on plant performance, ultimately resulting in poor yields or compromised quality. Therefore, periodic flowmeter calibration must be part of the user’s quality process.

With local/domestic markets becoming a global/international arena, flowmeter users in all types of industries need precision measurements, which, in turn, require credible measurement connections to accepted reference standards in order to satisfy sellers and buyers.

The extent to which a flowmeter calibration is traceable to recognized standards, such as those established by the National Institute of Standards and Technology (NIST), depends on whether the calibration system used is a “Primary Standard” or “Secondary Standard.” A Primary Standard calibrator is based on the measurable standards of time, weight, pressure, temperature and distance, while a Secondary Standard or Flow Transfer Standard is a reproduction of the flow rate produced on a Primary Standard. Therefore, it is not based on the primary measurement standards of a government metrology laboratory. Calibration performance will be only as good as the repeatability of the Secondary Standard flowmeter combined with the uncertainty of the Primary Standard calibrator.

**Latest Technology**

The process of automation in flow calibration technology is one of the most important technological advancements revolutionizing service delivery mechanisms and processes. It offers calibration service providers, especially those calibrating sophisticated metering equipment, the option to eliminate assembly and calibration error, as well as meet customers’ expectations of reduced turnaround time and enhanced service quality.

*Positive Displacement Calibrators:*

Some of the most dramatic improvements in flow calibrator technology involve the evolution of Positive Displacement calibrators. PD systems are Primary Standard calibrators, which take into account the varying conditions under which flowmeters operate. These calibrators are able to compensate for temperature, density, viscosity and other variables that can shift a meter’s output. As such, they can
typically achieve uncertainties in liquid of +/-0.05\% of volumetric flow rate measurement (95 percent CF) (See Fig. 2). Gas bell and piston provers achieve uncertainties of ±0.2\% (95 percent CF).

Fig. 2. Primary Standard Calibrators provide the best uncertainty and develop diagnostic history of flowmeter performance. Pictured is the Flow Dynamics PDCI-400 providing ±0.05\% uncertainty with ±0.01\% repeatability.

An important feature of modern PD calibrators is their user interface, which must have easy to understand user screens defining the setup and results of the calibration. Ideally, calibrator operators should be able to overlay the current calibration with previous calibrations to evaluate any differences in meter performance.

There is an advantage to having calibrators utilize Windows™ based software, which allows for the creation of graphs in Excel™ or data sheets in Word™. This platform enables digital file sharing, which the end user can store and overlay with previous cals for historical comparison.

Flow Transfer Standards:

Unlike primary flow standards, whose most important characteristics are their traceability to primary physical measurements (resulting in the minimization of absolute uncertainties, with less concern for usability or cost issues), the key criteria for secondary Flow Transfer Standards are portability, low cost and the ability to calibrate the flowmeter in the physical piping configuration it lives in.

Instead of removing flowmeters from service for recalibration, FTS devices allow users to “bring the calibrator to the flowmeter.” These portable, documenting field flow calibrators are intended for in-line calibration and validation of meters using the actual process conditions for gas or liquid. Advanced FTS systems incorporate hand-held electronics with built-in signal conditioners, thus eliminating bulky interface boxes and the need to carry a laptop computer into the field. High-quality
Flow Transfer Standards also have the capability of measuring and correcting the influences of line pressure and temperature effects on flow.

Operation of a portable Flow Transfer Standard requires that a master meter be installed in series with the flowmeter under test. The readings from these instruments are compared at various flow rates or flow totals. A technician can install the master meter in the same system as the test meter, perform the calibration, and note any changes in performance. New calibration data might cause rescaling or new data points to be programmed into a flowmeter’s computer to align the measurement with the current flow calibration data.

Optional Approaches

The choice of a flowmeter calibration solution is not always an easy one. Thankfully, end-users have numerous options when seeking assistance from an outside calibration service center, or considering the purchase of their own in-house calibration equipment. Their alternatives can include:

1.) Contract with an established flow laboratory offering Primary Standard flowmeter calibration services

Leading flow laboratories provide highly documented, NIST-traceable calibration services for every type of modern flow measurement device. Government, aerospace, industrial, OEM and test & measurement users worldwide utilize these services with confidence (See Fig. 3).

Fig. 3. Leading flow laboratories provide highly documented, NIST-traceable calibration services for every type of modern flow measurement device.
Your calibration-lab-of-choice should have a good working knowledge of the types of meters being tested, familiarity with the appropriate meter inspection procedures, the ability to quickly diagnose meter or test facility problems, and the expertise to properly assess meter performance. An experienced lab will know the best way to calibrate a particular type of meter.

In addition, a good calibration service will maintain your calibration data, by serial number, forever. This approach provides two benefits: 1) The Calibration service lab will have knowledge of your previous flowmeter calibration parameters, saving upfront administration time. 2) Having the history of the previous calibration data allows the lab to alert you to any significant calibration shifts.

While most major flow calibration labs are NIST traceable, a U.S. National Voluntary Laboratory Accreditation Program (NVLAP) accredited facility encompasses much more. First of all, the lab must be audited annually to maintain its NVLAP accreditation. This audit is not only based on the calibrator documentation traceability, but also the process used to maintain the reported uncertainty. This requires that the facility meet the requirements of ISO/IEC 17025, ANSI Z540 and ISO 9001:2000.

NVLAP accreditation is based on evaluation of a laboratory’s management and technical qualifications and competence for conducting specific test methods, measurements, and services in specified fields of testing or calibration. Accreditation is granted only after thorough evaluation of an applicant has demonstrated that all NVLAP requirements have been fulfilled, and is acknowledged by the issuance of a Certificate of Accreditation and a Scope of Accreditation, which details the specific test methods, measurements and services for which a laboratory has been accredited. NVLAP operates a management system compliant with ISO/IEC 17011:2004.

In addition, NVLAP accredited calibration labs must conduct periodic correlation meter testing to ensure their calibrators are repeating from the time of their previous system calibration. This is critical to ensuring a calibrator not only produces repeatable results, but also providing factual data as evidence that flowmeters were calibrated within the stated uncertainty of the calibrator. Plus, it ensures that the calibration uncertainties, as documented on the NVLAP Certificate of Accreditation, are maintained.

Because of the intensive auditing by NVLAP, the flow calibration customer does not have to do independent audits. This saves time along with all the associated expenses to perform an onsite audit.

2.) Utilize a staffed, onsite calibration service employing either a Primary Standard Flow Calibrator or Flow Transfer Standard

Some calibration providers offer on-site calibration of flow measurement instrumentation for customers unable to shut down process lines for extended periods of time. Calibration of in-line flowmeters can often be accomplished in one day or less.
Larger flow calibration labs offer onsite primary Standard Calibration services staffed with a calibration technician who works at the customer location handling high-volume calibration needs.

For some flowmeter installations, portable Flow Transfer Standards are used when it is difficult to remove flowmeters from system piping. A calibration service provider will have the proper master meters to perform the calibration online.

The efficiency of the calibration is guaranteed with an experienced calibration technician or engineer to provide quality results.

3.) *Purchase a Primary Standard Calibration System for in-house use*

Military calibration labs, aerospace testing facilities and other large operations frequently purchase their own in-house Primary Standard Calibration System in order to minimize the time and cost required to keep meters in optimal working order. Primary Standard Calibrators represent a significant investment, but for users with critical flow accuracy requirements, they are the “gold standard” by which all flow calibrations are measured.

Sophisticated Primary Standard systems offer enhanced features enabling the most precise liquid calibrations available. Their flow capabilities range from 0.01 GPM (0.04 LPM) to 400 GPM (1514 LPM) with an uncertainty of ±0.02% and a repeatability of 0.01% of reading.

4.) *Acquire a Secondary Standard FTS to perform your own field calibrations.*

For some flowmeter installations, portable Flow Transfer Standards are an economical, user-friendly tool for an ongoing calibration program when it is difficult to remove flowmeters from system piping. An FTS system allows users to either set up a flow loop with master meters in a manifold configuration and perform their own calibrations, or install a master meter inline in their existing piping and calibrate meters under test based on actual process conditions (See Fig. 4).
Flow Transfer Standards are designed to be used in the field and vary from handheld data acquisition systems with inline master meters to a master meter visual model with fluid selection capability.

The current generation of FTS systems are designed for exceptionally wide flow ranges, and can be used with a manifold control involving multiple flowmeters. The calibrator reads signals from the master meter, the flow meter under test, and a fluid temperature sensor. It automatically selects the appropriate master meter based on the current flow rate. Flow conditioners are part of the manifold system, which includes a temperature sensor (See Fig. 5).

Automated FTS equipment utilizes advanced calibration software to compile flow data and save all the parameters of the calibration set-up. Users can download reports showing data points for the meter under test and compare that information with output from a master meter. They can also generate calibration data sheets in volumetric or mass units, which can be stored for future reference. This capability enhances calibration management programs by providing a record of traceability to recognized calibration standards (See Fig. 6).
Conclusion

If you chose a calibration lab to perform all your flowmeter calibrations, they will keep a serial number record of the flowmeter data and calibration parameters. This will make it easier for the next calibration, as all the information exists. Flow calibration labs are generally very repeatable, but there may be a bias between labs and between NIST. Select a cal lab that signs up for the NIST Round Robin to check for calibration bias.

Think out of the box and partner with a calibration lab that might be willing to install a primary standard calibrator onsite and provide an experienced operator to perform your flowmeter calibrations.

Keep in mind that even though a Flow Transfer Standard is not a primary standard, it will allow you to calibrate your meter in the same conditions it operates in. Pumps, pipe elbows and fluid viscosity are but a few of the variables the FTS will take into consideration, which is not practical to duplicate in a flow laboratory.

Lastly, remember that flowmeters shift their calibration due to particulates in bearings, build up on the walls of the meter, natural metallic wear (most liquids are abrasive), metal fatigue, electronic drift and signal isolation deterioration, which are among a few reasons why flowmeters need calibration attention. Good results depend on flowmeter calibration data developed over a period of time, which provides factual performance history.