by Jesse Yoder, Ph.D.

Accuracy Matters

The Where & Why of Flowmeter Calibration

Almost anyone who owns a flowmeter has dealt with the topic of flowmeter calibration at one time or another. Even though a flowmeter performs well "out of the box," it is an electronic and mechanical device, and as such, it is subject to performance variations over time. Like a car that needs a periodic tuneup, flowmeters need to be calibrated periodically to make sure that they are performing at a satisfactory optimal level.

Calibrations can take many forms. For some calibrations, the performance of a flowmeter is compared to that of a "master meter." A master meter is a highly accurate flowmeter whose performance has been checked against a reference standard. When a calibration is performed, the performance of the flowmeter being calibrated is compared to that of the master meter. If there is a variation between the two, an adjustment is made to the calibrated flowmeter to correct its performance.

Another calibration method uses a weigh scale to measure liquid volume. This method, called proving, is an especially accurate method of calibration. This volumetric method requires accurate timing. As is the case with the master meter method, the performance of the meter being calibrated is compared to that of the prover. The flowmeter being calibrated is adjusted to bring its performance in line with that of the prover. This is often done with a meter factor.

Why Flowmeter Performance Changes Over Time

There are many reasons why flowmeter performance varies over time. Deposits on the inside wall of a flowmeter can have an impact on performance. Water contamination in fuel or hydrocarbon-based liquids can cause corrosion and component wear. Flowmeters with moving parts, such as turbine meters, are subject to wear, and performance can degrade over time. In some cases, bearings may need to be replaced.

Changes in the type of fluid being measured can affect the performance of a flowmeter. A flowmeter that is calibrated on one type of fluid can perform differently when a different type of fluid is being measured. In many cases, corrections can be made to compensate for the fluid change. Another factor is improper installation. This involves factors such as the amount of upstream or downstream piping, the proper position of a sensing element, or allowing protrusions in the line.

Other factors that affect flowmeter performance include outside influences such as variations in pressure or temperature, vibration, and electromagnetic interference. Pressure and temperature are especially important when gas flow is being measured. For steam flow, steam flow quality has an important impact on correct flow measurement.

Table 1: Reasons for Calibrating New-Technology Flowmeters

Flowmeter Type	Technology	Reasons for Calibrating
Coriolis	Fluid passes through a vibrating tube. The degree of twisting motion is directly proportional to mass flow	Coating and wear of the flow tubes; electronic failure
Magnetic	The voltage generated by electrically conductive fluid passing through a pipe is measured to compute flowrate.	Liner damage; electrode coating; electronic failure
Ultrasonic	An ultrasonic signal is sent across a pipe and back. The difference between the two transit times in either direction is proportional to flowrate.	Changes in the sonic properties of the fluid; transducer failure; lack of contact between transducer and pipe wall; electronic failure
Vortex	A bluff body in the flowstream generates vortices. Flowrate is proportional to the frequency of the vortices.	Flowmeter mounted improperly in pipe; vibration; sensor failure; shedder wear
Thermal	Heat is introduced into the flowstream. The amount of heat that dissipates is measured using temperature sensors. This value is used in calculating mass flow.	Sensor wear; sensor failure; contamination of thermally conductive surfaces; electronic failure

Some Options for Calibration

Many flowmeters today have expanded diagnostic capability. While self-diagnostics are not a substitute for calibration, they can serve to identify flowmeter parameters that have shifted over time. Often the self-diagnostics compare current measurement parameters with those made at the factory to identify any changes. Expanded diagnostic capabilities are an important step towards maintaining the integrity of flowmeters in the field.

One option that companies have for flowmeter calibration is to have the calibration done on-site. Equipment is available, both in the form of master meters and flowmeter provers, to perform on-site calibration. There are companies that offer on-site calibration as a service, and some companies may choose to buy this equipment to have it available so they can perform on-site calibrations on their own.

Another option for calibration is to have the flowmeter sent to an outside flowmeter laboratory. There are a number of excellent facilities available,

Table 2: Reasons for Calibrating Traditional Technology Flowmeters

Flowmeter Type	Technology	Reasons for Calibrating
Differential Pressure	A constriction called a primary element is placed in the flow-stream. The difference in upstream vs. downstream pressure is used to compute flowrate.	Orifice plates, nozzles, and Venturis are subject to wear; Orifice place get knocked out of position; Pitot tubes become clogged; transmitter failure
Positive Displacement	Fluid is captured in a container of known volume and released. Flowrate is determined based on how many times this is done.	Dirty liquids, corrosion, and abrasion change the volume; bearing wear degrades accuracy; gear service affects calibration; solids can cause plugging
Turbine	Fluid passes over a spinning rotor. Flowrate is proportional to the speed of the rotor.	Bearings affected by chemicals or dirty; bearing service affects calibration; rotors wear; electronic failure
Open Channel	Some use liquid levels at weirs or flumes; others compute flow from velocity, level, depth, and/or diameter data.	Level transmitter calibration; accumulation of debris; electronic failure of transmitter
Variable Area	Fluid passes through a tapered tube containing a float. Flowrate is indicated by the height of the float in the tube.	Material buildup; plugging; meter tube failure

although most of them are located in the United States, Canada, and Europe. While these are relatively convenient for end-users in those regions, they are less convenient for end-users in the Middle East, Africa, and Asia.

There are a number of issues to be considered in selecting a flow laboratory. To send a flowmeter to an outside laboratory, it has to be pulled out of service and shipped to the calibration facility. So one issue to consider is how long the end-user will be without the use of the meter. Some companies have spare flowmeters they can put into service while a flowmeter is being calibrated. Having a spare meter is a good idea, but it can be expensive, depending on the cost of the meter. Some companies run two flowmeters in series as a check so that while one meter is out for calibration, the company can make do with a single meter. This is sometimes the case for custody-transfer applications.

A second issue is the cost of shipping the flowmeter to the calibration facility and back. Here, there is a choice between ground and air methods, depending on the location. The decision about the mode of transportation and cost is determined in part by the location of the calibra-

tion facility and the importance of a quick turnaround.

It is important to consider the capabilities of the flowmeter laboratory when deciding where to send a meter for calibration. Some flowmeters, such as multi-path ultrasonic flowmeters for custody-transfer applications, have to be tested under high-pressure conditions. Not all calibration facilities have this capability. Other facilities specialize more in measuring liquid rather than gas flows. It is also important to be sure that the calibration facility is properly certified and meets industry standards for testing.

Some Calibration Options

There are a number of calibration facilities to choose from. Several of them are described here.

Some of the turbine flowmeters that serve as the transfer standard at CEESI Iowa.

CEESI: The origins of Colorado Engineering Experiment Station Inc. (CEESI, *www.ceesi.com*) go back to 1951, when it was a program for the College of Engineering at the University of Colorado at Boulder for the research and testing of small rockets. In 1966, the program separated from the university and moved to its current location, a surplus Atlas missile site near Nunn, Colorado. At that time, the facility was non-profit. It remained non-profit until 1986, when it was purchased by Steve Caldwell and Walt Seidl.

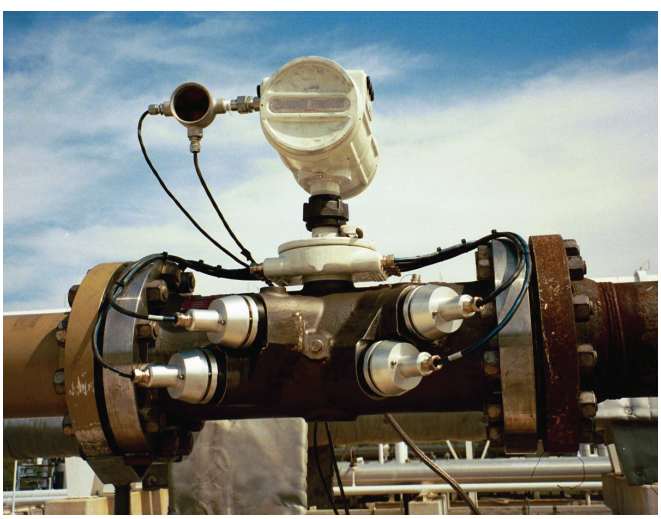
CEESI can calibrate a wide range of flowmeter types, including orifice meters, Venturis, turbine meters, ultrasonic, vortex, and many other types. In addition to its facilities near Nunn, Colorado, CEESI maintains a High Flow Natural Gas Calibration Facility in Garner, Iowa. This facility is used to calibrate and test ultrasonic and turbine flowmeters for custody transfer of natural gas.

Trans Canada Calibrations: TransCanada Calibrations (*www.tccalibrations.com*) is located along TransCanada

A 42-inch natural gas supply pipeline at CEESI's natural gas custody transfer station in Iowa.

pipelines near Winnipeg in Manitoba, Canada. TransCanada specializes in calibration of turbine and ultrasonic flowmeters for custody transfer of natural gas. The facility began operation in 1999, and performed its first calibrations of ultrasonic and turbine flowmeters in 2001. TransCanada offers door-to-door service, including transportation management, as support for its calibration services. In addition to its calibration services, the facility offers flowmeter repair, technical services, and training.

GL Noble Denton: GL Noble Denton (*www.gl-nobledenton.com*), based in London, is a technical service provider for the oil & gas industry. The company designs, builds, and operates oil and gas assets, such as pipelines, subsea systems, import terminals, and drilling units. In 2007, Germanischer Lloyd (GL) and Advantica combined their operations. Advantica was a flowmeter calibration facility in the United Kingdom. In 2009, Advantica changed its name to GL Industrial Services. In January 2010, GL's oil & gas division combined with Noble Denton to form GL



A Daniel ultrasonic natural gas flowmeter mounted inline for calibration at Southwest Research Institute in San Antonio, Texas.

Noble Denton. GL's Flow Centre performs a wide variety of calibrations, including calibrations of ultrasonic, turbine, and Venturi flowmeters. The Centre can undertake natural gas calibrations of whole metering packages. Most of the flowmeters tested and calibrated are between two inches and 24 inches.

Netherlands Metrology Institute (NMi): NMi (*www.nmi.nl*) is based in Dordrecht, the Netherlands, but has agencies in Belgium, Turkey and Japan. It also has additional offices elsewhere in the Netherlands, Italy and the United Kingdom. NMi can calibrate both liquid and gas flowmeters. It is currently working on a new facility in Rotterdam, the Netherlands, called Euroloop. NMi calls Euroloop "the world's largest test site for flow and quantity measurement of natural gas and petroleum." Euroloop is being developed together with KROHNE, a major flowmeter supplier with offices in Dordrecht.

Other Facilities

While the above are some of the main calibration facilities globally, other laboratories are available. One is the Metering Research Facility at Southwest Research Institute (*www.mrf.swri.org*) in San Antonio, Texas. The Metering Research Facility has both a high-pressure loop and a low-pressure loop for handing flowmeters of different sizes and pressures. Other calibration facilities are Alden Research Laboratory (*www.aldenlab.com*) in Holden, Mass., and Flow Dynamics (*www.flow-dynamics.com*) in Scottsdale, Arizona. Many flowmeter technology suppliers also offer calibration services, not only for their own flowmeters, but also for a range of flowmeter types and manufactures. At some point, some facilities figure to come online that are more convenient for end-users in the Middle East, Africa and Asia. FC

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***EDITOR'S NOTE:** To expand upon the topic of Flow Calibration, Flow Control magazine will be publishing a two-part series on flowmeter calibration best practices for liquid and gas applications. Look for the first part of this series to appear in the August issue.*