

APPLICABILITY OF WATER CALIBRATIONS FOR GAS SERVICE

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Introduction

In the late 1970's, the first Coriolis mass flow meter was introduced. By the early 1980's, the use of Coriolis meters gained popularity for liquid applications, but few were used for gas applications. In the 1990's major design enhancements were made to the technology improving its usability in gas applications. Driven by the need for a standard industry practice to guide its use in gas applications, the American Gas Association (AGA) published the first edition of AGA Report Number 11, *Measurement of Natural Gas by Coriolis Meter* in 2003. Today, with an installed population of over 100,000 Coriolis meters in gas applications and the 2013 publication of the second edition of AGA Report No. 11 (see Figure 1), many users are applying Coriolis meters in gas custody transfer applications.

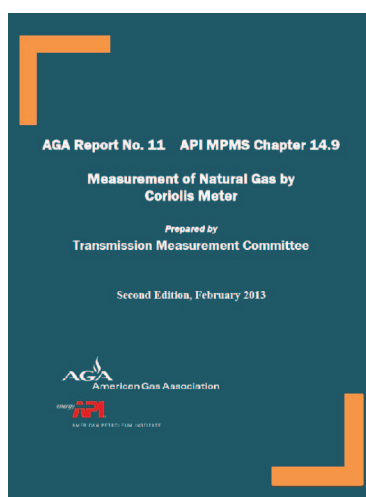


Figure 1. AGA Report No. 11 Second Edition

There are many advantages users have found to using Coriolis meters over other technologies including:

- Very high accuracy measurement
- No moving parts to wear over time
- Bi-directional flow capabilities
- No flow profile or straight run requirements (design specific – check with manufacturer)
- Water calibration valid for gas applications (design specific – check with manufacturer)
- Direct mass measurement eliminates the need for pressure and temperature compensation in most cases
- No damage to flow tubes with over range of flow (unlike most mechanical meters)
- Tolerant of wet gases and dirty gases
- Insensitive to flow pulsations (design specific – check with manufacturer)
- Multiple health diagnostics available (check with manufacturer for details)

An age old question has been around the transferability of the water calibration on a Coriolis meter for use on other fluids (especially gases). In 2003, the first edition of AGA Report No. 11 (AGA11) recognized the potential for a Coriolis meter calibration with an alternative calibration fluid (e.g. water, CO₂, etc.) to transfer to gas applications. This recognition was based on test data collected from water calibrated Coriolis meters up to 4 inches in flow diameter from gas laboratories around the world. The second edition of AGA Report No. 11 expanded upon the practice of using alternate calibration fluids to include on-site calibrations with portable water calibration systems. In expanding the practice of Coriolis calibrations with alternate fluids, the second edition of AGA11 emphasizes that this practice is only valid when *“transferability with the alternate calibration fluid has been demonstrated by the meter manufacturer through tests conducted by an independent flow calibration laboratory.”* The answer to the alternate fluids transferability question is even more important as users begin to use larger, more difficult to calibrate Coriolis meters for gas applications. This paper will address the applicability of water calibrations for gas service, especially on large Coriolis meters.

Calibration

Due to the variability of manufacturing processes, all Coriolis meters require a flow calibration to adjust their performance to the accuracy limits inherent to their particular design. As a common practice most Coriolis manufacturers capitalize on the economics and high stability of a water calibration to perform these calibrations. Some advanced Coriolis meter designs are immune to fluid phase, density, and viscosity; enabling water calibrations to transfer to all other fluids; i.e. gas, liquid, and slurries.

Testing by numerous European and North American flow labs has confirmed the transferability of water calibration data on Micro Motion Coriolis meters to gas applications. Most notably testing sponsored by the Gas Research Institute in 2004 and documented in report GRI-04/172 (see Figure 2), which covers water to gas transferability and wet gas performance of Coriolis meters. Conclusions in the report state, *“The single fluid calibration tests show that a water calibration of a Coriolis mass flow meter can be used for natural gas applications without loss of accuracy”*.

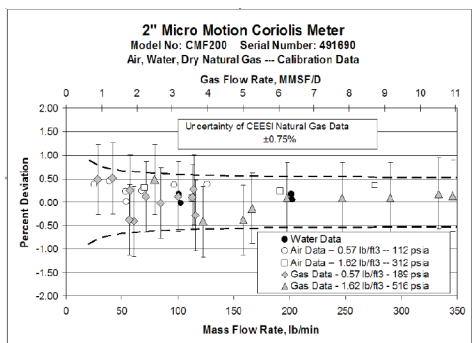


Figure 2. GRI 04/0172 Water, Air and Gas Transferability Data

Industry testing has shown there is minimal benefit, from a calibration uncertainty perspective, in performing a gas calibration over a water calibration on Coriolis meters intended for gas measurement. Although this is the case, the user should review industry recommended practices, standards, and regulatory requirements when establishing calibration policy for Coriolis.

Coriolis meters are an attractive technology when the availability, capability, or economic viability of gas calibrations is limited. Highly accurate water calibrations and the construction of water calibration facilities are achieved at a fraction the cost of their gas counterparts.

However, in 2004, Coriolis meters larger than 4 inches were not commonly available, so the testing in the GRI report was limited to smaller sensors. Similarly, by 2004 Micro Motion’s commissioning of water to gas calibration transferability testing with NMI Certin B.V. in the Netherlands only encompassed the Coriolis meter sizes of ½ to 4 inches in flow diameter (see Figure 3).

With the design of Micro Motion Coriolis meters up to 10 inch in flow diameter, there has been renewed interest in validating the transferability of a water calibration to gas applications on these larger meters by an independent flow testing laboratory.

Testing of Large Meters for Water Calibration Applicability for Gas Applications

Micro Motion, Inc. commissioned NMI Certin B.V. in the Netherlands to investigate the transferability of a water calibration to gas applications with the three largest flow meters they manufacture. NMI conducted a series of tests on these meters at the Pigsar laboratory in Germany and the Euroloop in Rotterdam, Netherlands on natural gas using a pre-established calibration factor that was determined on water at the Micro Motion factory.

The first size was a 6-8” nominal meter size (Micro Motion Elite CMFHC2). The testing was completed at three pressures; 31.3 bar-a, 41.2 bar-a, and 51.1 bar-a. at the Pigsar Germany laboratory. After the tests, the known pressure effect of 0.023% per bar was applied to the test results as per the equation below.

Both the raw test results and pressure corrected test results are shown (see Figure 4). The pressure corrected results are shown in green and the maximum deviation of the Coriolis meter pressure corrected reading versus the lab was less than 0.4%.



Figure 3. NMI Water Calibration Transferability to Gas Applications Declaration May 2003

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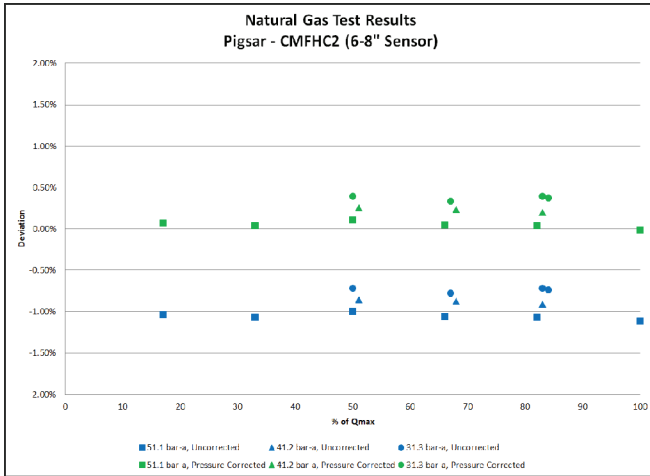


Figure 4. Natural Gas Test Results for Micro Motion CMFHC2 Sensor at Pigsar

An 8-10" nominal size Coriolis meter (Micro Motion Elite CMFHC3) was also tested by a third party lab, NMI Euroloop in the Netherlands (see Figure 5). This sensor size was tested on water and natural gas at 35 bar-a and 50 bar-a. The pressure corrected readings from the flow meter are shown in the graph below. Both the observed errors and the weighted mean errors of this sensor on water and the natural gas tests fell within permissible errors. The weighted mean errors for the 50 bar-a natural gas, 35 bar-a natural gas and water test were 0.25%, 0.12%, and -0.04% respectively (see Figure 6).

Finally, a 10-16" nominal size Coriolis meter (Micro Motion Elite CMFHC4) was also tested at the NMI Euroloop facility. This sensor size was tested on water and natural gas at 35 bar-a and 60 bar-a. The pressure corrected readings from the flow meter are shown in the graph below. Both the observed errors and the weighted mean errors of this sensor on water and the natural gas tests fell within permissible errors. The weighted mean errors for the 60 bar-a natural gas, 35 bar-a natural gas and water test were 0.21%, -0.02%, and 0.04% respectively (see Figure 9).



Figure 5. NMI Euroloop Test Setup for Large Coriolis Sensor

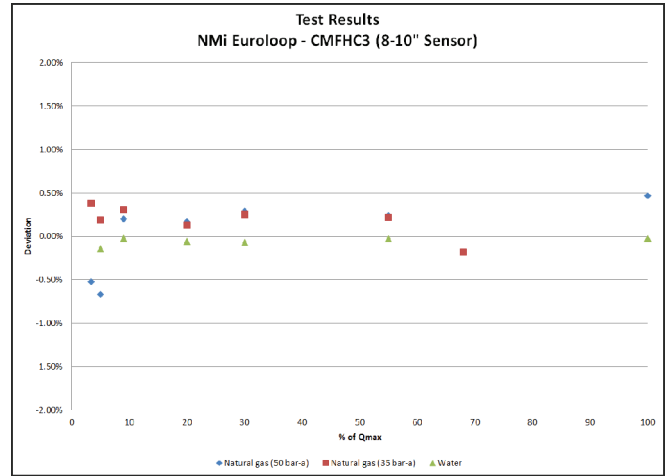


Figure 6. Natural Gas Test Results for Micro Motion CMFHC3 Sensor at Euroloop

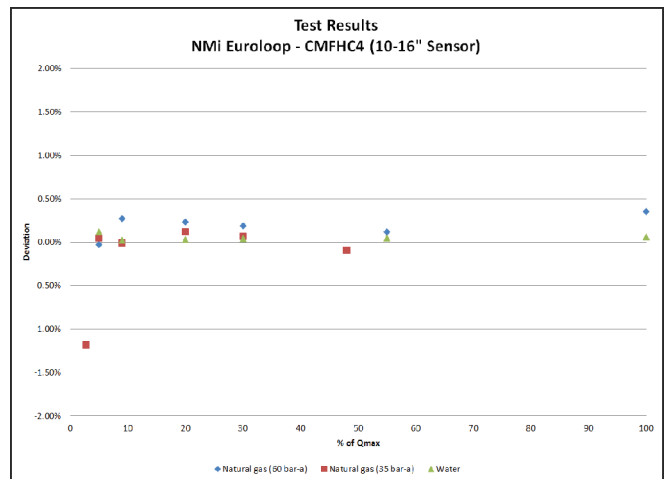


Figure 7. Natural Gas Test Results for Micro Motion CMFHC4 Sensor at Euroloop

The large meters tested were found to be in conformity with the class 1 requirements of the OIML R137-1&2:2012 for the performed tests. All tests were performed using the water calibration parameters and tested on gas. Full details of the testing and results can be found in the NMI Test Report Number NMI-12200340-03.

As a result of these tests and previous tests that have been performed by NMI on Emerson's Micro Motion Coriolis meters, they have been approved for use as custody transfer meters meeting Class 1 accuracy under the requirements of Directive 2004/22/EC without requiring a field calibration or gas calibration. For more details, refer to EC type examination Certificate Number T10020 revision 4 or later (see Figure 8 for excerpt).

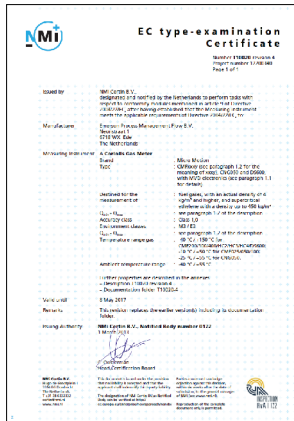


Figure 8. Page 1 of the NMI EC type-examination certificate

Conclusion

Although a relatively new technology for the natural gas industry, Coriolis meters have gained worldwide acceptance as the ideal meter for measurement of many fluids in other industries. With a worldwide installed base of over one million units, Coriolis technology is seeing expanded use for both liquid petroleum and natural gas. Coriolis technology facilitates high accuracy measurement with no moving parts, bi-directional flow capabilities, no straight run requirements and a high tolerance to dirty processes; e.g. dirty gas and crude oils. Micro Motion Coriolis meters have shown to be insensitive to flow pulsation error and have performance and process diagnostics that not only confirm the health of the meter, but also the process conditions for optimum flow accuracy. In addition, unlike most mechanical meters, they are immune to damage caused by gas flow surges through the sensor.

Most countries and measurement organizations have approved or published standards for the use of the technology. Most notably is AGA and API who have jointly published AGA Report No. 11 / API MPMS Chapter 14.9, *Measurement of Natural Gas by Coriolis Meter*.

Third-party data from CEESI, Pigsar, SwRI, Euroloop and others show little, if any, effect of flow profile and the transferability of a factory water calibration to natural gas measurement applications. Recent testing has shown these attributes hold true for the larger Coriolis meters (6" and above), as well. The applicability of water calibrations for gas service may vary by design and manufacturer, but testing on Micro Motion ELITE meters has shown this attribute holds true.

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About Micro Motion

For over 35 years, Emerson's Micro Motion has been a technology leader delivering the most precise flow, density and concentration measurement devices for fiscal applications, process control and process monitoring. Our passion for solving flow and density measurement challenges is proven through the highly accurate and unbeatable performance of our devices.

References:

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4. **Test Report Number NMi-12200340-03**, Project Number 12200340, NMi Certin B.V., Hugo de Grootplein 1, 3314 EG Dordrecht, The Netherlands

This paper was presented at the AGA Operations Conference & Biennial Exhibition, held May 21-24, 2013, Orlando, FL

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