AGA Report No. 9

Measurement of Gas by Multipath Ultrasonic Meters

Second Edition
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American Gas Association

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Transmission Measurement Committee

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FOREWORD

This report is published in the form of a performance-based specification for multipath ultrasonic meters for gas flow measurement. It is the result of a collaborative effort of users, meter manufacturers, flow measurement research organizations and independent consultants forming Task Group R-9 of AGA's Transmission Measurement Committee (TMC). In addition, comments to this report were made by the Committee on Gas Flow Measurement (COGFM) of the American Petroleum Institute (API), Gas Processor's Association (GPA), International Standard Organization's ISO/TC 30/SC 5/WG 1, Pipeline Research Council International (PRCI) and the committee members of International School of Hydrocarbon Measurement (ISHM).

This version of AGA Report No. 9 is intended to supersede all prior versions of this document. However, this document does not reference existing multipath ultrasonic meter installations. The decision to apply this document to existing installations shall be at the discretion of the parties involved.

Research conducted in support of this report and cited herein has demonstrated that multipath ultrasonic meters can accurately measure gas flow and, therefore, should be able to meet or exceed the requirements specified in this report when calibrated and installed according to the recommendations contained herein. Users should follow appropriate installation, use and maintenance of an ultrasonic meter as applicable in each case.

Various combinations of upstream fittings, valves and lengths of straight pipe can produce profile disturbances at the meter inlet that may result in flow-rate measurement errors. The amount of meter error will depend on the magnitude of the inlet velocity profile distortion produced by the upstream piping configuration and the meter's ability to compensate for this distortion. Research results and flow-meter calibration data have indicated that multipath ultrasonic flow meters can accurately measure gas flow rate when installed with upstream piping lengths and/or flow conditioning systems sufficient to maintain the integrity of the flow calibration. Other effects that may also result in flow-rate measurement errors for a given installation include levels of pulsation, range of operating pressures and ambient temperature conditions.

Flow-calibration guidelines are provided for circumstances when a flow calibration is requested or required to verify the meter's accuracy or to apply a calibration factor to minimize the measurement uncertainty. (See Report text and Appendix A)

Unlike most traditional gas meters, multipath ultrasonic meters inherently have an embedded microprocessor system. Therefore, this report includes, by reference, a standardized set of international testing specifications applicable to electronic gas meters. These tests, summarized in Appendix B, are used to demonstrate the acceptable performance of the multipath ultrasonic meter's electronic system design under different influences and disturbances.

AGA Engineering Technical Note M-96-2-3, Ultrasonic Flow Measurement for Natural Gas Applications, is included in Appendix C, as a source of background information on ultrasonic gas metering. Contents of this technical note were based on the information available when the note was written in March 1996. Therefore, in case of any conflict between the information in the main report and the technical note (Appendix C), the content in the main report prevails.

The flow meter and/or flow conditioner performance verification test found in Appendix D is intended to provide a method by which an ultrasonic flow metering system can be shown to perform acceptably (i.e., within the performance specifications described in Sections 5.1, 5.1.1 and 5.1.2 of this document) under varying test flow conditions.

An example of overall measurement uncertainty calculations is provided in Appendix E with assumed numerical values for estimating measurement uncertainty for sites using ultrasonic gas flow meters.

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AGA Report No. 9, *Measurement of Gas by Multipath Ultrasonic Meters,* was revised by a Task Group of the American Gas Association's Transmission Measurement Committee under the joint chairmanship of **Paul LaNasa** of CPL & Associates and **Warren Peterson** of TransCanada Corporation. Individuals who made substantial contributions to the revision of this document are:

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1. Introduction

1.1 Scope

This report was developed for multipath ultrasonic transit-time flow meters used for the measurement of natural gas. Multipath ultrasonic meters have at least two independent pairs of measuring transducers (acoustic paths). Typical applications include measuring the flow of gas through production facilities, transmission pipelines, storage facilities, distribution systems and large end-use customer meter sets.

1.2 Principle of Measurement

Multipath ultrasonic meters are inferential meters that derive the gas flow rate by measuring the transit times of high-frequency sound pulses. Transit times are measured for sound pulses transmitted and received between pairs of transducers positioned on or in the pipe. Pulses transmitted downstream with the gas flow are accelerated by the flow and pulses transmitted upstream against the gas flow along the identical acoustic path are decelerated. The difference in these transit times along the acoustic paths is related to the average gas flow velocity. Numerical calculation techniques are then used to compute the average axial gas flow velocity and the gas volume flow rate at line conditions through the meter.

The accuracy of an ultrasonic gas meter depends on several factors, such as:

- Precisely measured dimensions of the meter body and ultrasonic transducer locations
- The velocity integration technique inherent in the design of the meter
- The shape of the velocity profile at the meter
- Levels of pulsation that may exist in the flowing gas stream
- The accuracy of the transit-time measurements
- Flow calibrations.

The accuracy of the transit-time measurement depends on:

- The electronic clock accuracy and stability
- Accurate, consistent detection of sound pulse transmit and receive times
- Proper compensation for signal delays of electronic components and transducers
- Dimensional integrity of the meter body.

Ultrasonic meter (UM) accuracy is dependent on these fundamental characterizations and their continued integrity over time. These accuracy dependencies may be adversely influenced by operational degradation of the UM over time (e.g., dirt build up on the internal surfaces of the meter, electronics drift, etc.). Emphasis on UM diagnostic data collection and interpretation in this document is made to impress upon users the need to continuously monitor UM integrity so that accuracy is maintained.