

AGA Report No. 11

API MPMS 14.9

**Measurement of Natural Gas
by Coriolis Meter**

Prepared by

Transmission Measurement Committee

Copyright © 2003 American Gas Association

All Rights Reserved

Catalog # XQ0311

Currently in preview, click buy full version

DISCLAIMERS AND COPYRIGHT

Nothing contained in this publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use in connection with any method, apparatus, or product covered by letters patent, or as insuring anyone against liability for infringement of letters patent.

The American Gas Association's Transmission Measurement Committee developed this publication as a service to the natural gas industry and to the public. Use of this publication is voluntary and should be taken after an independent review of the applicable facts and circumstances.

Efforts have been made to ensure the accuracy and reliability of the data contained in this publication; however, the American Gas Association (AGA) makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or from the use of any product or methodology described herein; for any violation of any federal, state, or municipal regulation with which this publication may conflict; or for the infringement of any patent from the use of this publication. Nothing contained in this publication should be viewed as an endorsement by AGA of any particular manufacturer's products.

Permission is granted to republish material herein in laws or ordinance, and in regulations, administrative orders, or similar documents issued by public authorities. Those desiring permission for other publications should consult the Operating and Engineering Section, American Gas Association, 400 North Capitol Street, NW, 4th Floor, Washington, DC 20001, USA.

Copyright © 2003 American Gas Association, All Rights Reserved.

FOREWORD

This report is published in the form of a performance-based specification for Coriolis meter for natural gas flow measurement. It is the result of collaborative effort of natural gas users, Coriolis meter manufacturers, flow measurement research organizations and independent consultants forming Task Group 11 of AGA's Transmission Measurement Committee (TMC). In addition, comments to this report were made by the Alternative Meter Task Group under the Committee on Gas Flow Measurement (COGFM) of the American Petroleum Institute (API). Throughout the process, AGA Task Group 11 met several times and developed drafts reflective of comments received.

This report contains general guidance and information for consideration. The material may not be adequate under all conditions and does not restrict the use of other methods. Use of this publication is entirely within the control and discretion of the user and is wholly voluntary. Any use should be taken after an independent review of the applicable facts and circumstances.

At the time the writing of this report was initiated, all the known manufacturers of Coriolis meter for natural gas flow measurement were invited to join Task Group 11 and participate in the process of developing this report. Changes to this report may become necessary from time to time. If changes in this report are believed appropriate by any manufacturer, individual or organization, such suggested changes should be communicated to AGA by completing the last page of this report titled "**FORM FOR SUGGESTION TO CHANGE IN THE AGA REPORT NO. 11**" and sending it to: **Operating Section, American Gas Association, 400 North Capitol Street, NW, 4th Floor, Washington, DC 20001, U.S.A.**

Methods for verifying a meter's accuracy and/or applying a flow Weighted Mean Error (FWME) correction factor to minimize the measurement uncertainty are contained in Appendix A - *Coriolis Gas Flow Meter Calibration Issues*. Depending on the design, a flow calibration of each meter on a gas similar to that which it will be applied may be necessary. In order to guide the designers and users in the specification of a Coriolis meter, Appendix B - *Coriolis Meter Data Sheet*, has been provided.

As a reference for background information on Coriolis natural gas metering, Appendix C - AGA Engineering Technical Note XQ0112 - *Coriolis Flow Measurement for Natural Gas Applications*, is provided. Due to the unique principle of operation and atypical performance characteristics of Coriolis mass flow meters, in comparison to volumetric flow meters, readers who are not familiar with the technology are encouraged to read this document prior to applying the general concepts and guidelines of this report.

As a reference for assessing the applicability of Coriolis meter technology to natural gas flow measurement, Appendix D - Gas Research Institute Topical Report GRI-01/0222 - *Metering Research Facility Program, Coriolis Mass Flow Meter Performance with Natural Gas*, is provided. This report outlines methods for baseline and installation effects testing of Coriolis meters for natural gas applications. The test data presented are an indicator of the state of Coriolis technology at the time of the tests. This report is intended as a general guide of testing methods to be used for the qualification of Coriolis meters as meeting the performance specifications of this report and the identification of the flow conditioning requirements of a particular meter design.

ACKNOWLEDGEMENTS

Report No. 11, Measurement of Gas by Coriolis Meters, was developed by a Transmission Measurement Committee (TMC) task group, **chaired by Stephen Baldwin, Unocal Corp.** Subsequently, a special subcommittee of the task group was formed to assemble technical information, compose drafts of the report, evaluate and resolve comments received through balloting, and prepare a final report.

The members of the special subcommittee, who devoted an extensive amount of their time, deserve special thanks:

Stephen Baldwin, Unocal Corp.
Ed Bowles, Southwest Research Institute (SwRI)
Terry L. Fredlund, Solar Turbines, Inc.
Dave Mesnard, FMC Measurement Solutions
Tom O'Banion, Micro Motion, Inc.
Tim Patten, Micro Motion, Inc.
Karl Stappert, Daniel Measurement and Control, Inc.

Other persons, who helped the subcommittee and made substantial contributions, should also be thanked. They are:

Steve Caldwell, Colorado Engineering Experimental Station, Inc. (CEESI)
Robert DeBoom, Daniel Measurement and Control, Inc.
Angela Floyd, Daniel Measurement and Control, Inc.
Larry Fraser, L. Fraser & Associate Consulting
Dr. Zaki Husain, Chevron Texaco, Inc.
Michael Keilty, Endress + Hauser Flowtec AG
Wade Mattar, Coxboro
Dan Rebman, Williams
Stephen T. Stark, Starling & Associates, Inc.
William Stephens, Kinder Morgan, Inc.
Dr. Klaus Zanker, Daniel Measurement and Control, Inc.

This project was possible due to the support of the American Petroleum Institute (API) – GOGFM Alternative Meter Task Group under the chairmanship of **Steve Caldwell**, Colorado Engineering Experimental Station, Inc. (CEESI) and the American Gas Association, Transmission Measurement Committee. Special thanks are extended to the Gas Technology Institute (GTI), Endress + Hauser, Inc., Emerson Process Management, and FMC Measurement Solutions for funding and the contribution of Coriolis meters for the data collection at the GTI-Metering Research Facility at Southwest Research Institute (SwRI).

Task Group Members of the TMC (in addition to those mentioned above), who deserve thanks for contribution in the development and finalization of the report are:

Dr. Darin George, Southwest Research Institute (SwRI)
Terry Grimley, Southwest Research Institute (SwRI)
John Lansing, Daniel Measurement and Control, Inc.
Kenneth E. Starling, Starling Associates, Inc.
Ed Otto, FMC Measurement Solutions
John Stuart, Stuart Gas Measurement Consulting
Fred VanOrsdol, SPL
James Walker, Consultant

TABLE OF CONTENTS

DISCLAIMERS AND COPYRIGHT	iii
FOREWORD	iv
ACKNOWLEDGMENTS	v
1. INTRODUCTION	1
1.1. SCOPE	1
1.2. PRINCIPLE OF MEASUREMENT	1
2. SYMBOLS	2
3. TERMINOLOGY	3
4. OPERATING CONDITIONS	7
4.1. GAS QUALITY	7
4.2. OPERATING PRESSURES	7
4.3. TEMPERATURE; GAS AND AMBIENT	7
4.4. GAS FLOW CONSIDERATIONS	7
4.5. UPSTREAM PIPING AND FLOW PROFILES	8
5. METER REQUIREMENTS	9
5.1. CODES AND REGULATIONS	9
5.2. METER BODY	9
5.2.1. <i>Maximum Operating Conditions</i>	9
5.2.2. <i>Corrosion Resistance</i>	9
5.2.3. <i>Meter Lengths</i>	9
5.2.4. <i>Pressure Tap</i>	9
5.2.5. <i>Miscellaneous</i>	10
5.2.6. <i>Meter Body Markings</i>	10
5.3. ELECTRONICS	10
5.3.1. <i>General Requirements</i>	10
5.3.2. <i>Electrical Safety Design Requirements</i>	10
5.3.3. <i>Output Signal Specifications</i>	11
5.3.4. <i>Cable Jacket and Insulation</i>	11
5.4. SOFTWARE	11
5.4.1. <i>Signal Processing Software</i>	11
5.4.2. <i>Configuration and Maintenance Software</i>	12
5.4.3. <i>Inspection and Training Functions</i>	12
5.4.4. <i>Alarms</i>	12
5.4.5. <i>Diagnostic Measurements</i>	12
5.4.6. <i>Engineering Units</i>	13
5.4.7. <i>Documentation</i>	13
5.5. MANUFACTURER TESTING REQUIREMENTS	14
5.5.1. <i>Calibration Requirements</i>	14
5.5.2. <i>Alternative Calibration Fluids</i>	14
5.5.3. <i>Calibration Test Reports</i>	14
5.5.4. <i>Static Pressure Testing</i>	15
5.6. METER RECEIPT OF ORDER	15
6. METER SELECTION CONSIDERATIONS	16
6.1. MINIMUM FLOW RATE (Q_{\min})	16
6.2. TRANSITIONAL FLOW RATE (Q_t)	16
6.3. MAXIMUM FLOW RATE (Q_{\max})	16
6.3.1. <i>Meter Pressure Loss (ΔP)</i>	17

6.4	METER TURNDOWN RATIO	19
6.5	METER SIZING METHODOLOGY	19
7.	PERFORMANCE REQUIREMENTS	21
7.1.	MINIMUM PERFORMANCE REQUIREMENTS	21
7.2.	PERFORMANCE ENHANCEMENTS	22
8.	INSTALLATION REQUIREMENTS	23
8.1.	GENERAL REQUIREMENTS	23
8.1.1.	Temperature	23
8.1.2.	Vibration	23
8.1.3.	Electrical Noise	23
8.2.	METER MODULE DESIGN	23
8.2.1.	Piping Configuration	24
8.2.2.	Flow Direction	24
8.2.3.	Protrusions	24
8.2.4.	Meter Mounting	24
8.2.5.	Orientation	25
8.2.6.	Filtration	25
9.	FIELD MAINTENANCE AND PERFORMANCE TESTING	26
9.1.	FIELD MAINTENANCE	26
9.2.	FIELD PERFORMANCE TESTING	27
9.3.	RECALIBRATION	28
10.	REFERENCE LIST	29
APPENDIX A:	CORIOLIS GAS FLOW METER CALIBRATION ISSUES	A-1
A.1.	GENERAL	A-1
A.2.	FLOW CALIBRATION DATA EXAMPLE	A-1
A.3.	METHODS FOR CORRECTING CORIOLIS FLOW MEASUREMENT ERRORS	A-3
A.4.	FLOW-WEIGHTED MEAN ERROR (FWME) CALCULATIONS	A-3
APPENDIX B:	CORIOLIS METER DATA SHEET	B-1
APPENDIX C:	AGA ENGINEERING TECHNICAL NOTE ON CORIOLIS FLOW MEASUREMENT FOR NATURAL GAS APPLICATIONS	C-i
APPENDIX D:	GTI TOPICAL REPORT GRI-01/0222 CORIOLIS MASS FLOW METER PERFORMANCE WITH NATURAL GAS	D-1

FIGURES AND TABLES

Figure 6.1:	Example Flow Rate vs. Measurement Error and Pressure Drop at 1000 psig Static Pressure	17
Figure 6.2:	Example Flow Rate vs. Meter Error and Pressure Loss at 500 psig Static Pressure	18
Figure 6.3:	Sizing Methodology Flow Chart	20
Figure 7.1:	Performance Specification Summary	22
Figure 8.1:	Installation Example	24
Figure 9.1:	Example Configuration for Field Performance Testing	27
Figure A.1:	Flow Calibration Data for 3-inch Diameter Coriolis Flow Meter	A-2
Figure A.2:	FWME-Corrected Flow Calibration Data for 3-inch Diameter Coriolis Flow Meter	A-7
Table 6.1:	Meter Sizing Examples	19
Table A.1:	Flow Calibration Data for 3-inch Diameter Coriolis Flow Meter	A-2
Table A.2:	FWME Calculation Summary for 3-inch Diameter Coriolis Flow Meter	A-5
Table A.3:	Correction Factor Adjusted FWME Calculation Summary for 3-inch Diameter Coriolis Flow Meter	A-6

Currently in preview, click buy full version

1. Introduction

1.1. Scope

This report was developed to assist designers and users in operating, calibrating, installing, maintaining and verifying Coriolis flow meters used for natural gas flow measurement. Coriolis meters infer mass flow rate by measuring tube displacement resulting from the Coriolis effect. The scope of this document is limited to the measurement of natural gas and associated hydrocarbon gases either as pure hydrocarbons, as a mixture of pure hydrocarbons, and diluents. Although not within the scope of this document, Coriolis meters are used to measure a broad range of compressible fluids (gases), other than natural gas.

This report is applies to Coriolis meters used in medium to high-pressure natural gas applications. Typical applications include measuring single-phase gas flow found in production, process, transmission, storage, distribution, and end-use fuel measurement systems.

1.2. Principle of Measurement

Coriolis meters operate on the principle of the apparent bending force known as the Coriolis force (named after the French mathematician Gustave-Gabriel de Coriolis). When a fluid particle inside a rotating body moves in a direction toward or away from a center of rotation, that particle generates an inertial force (known as the Coriolis force) that acts on the body. In the case of a Coriolis flow meter, the body is a tube through which fluid flows. Coriolis meters create a rotating motion by vibrating the tube or tubes through which the fluid flows. Coriolis meters have the inherent ability to measure flow in either direction with comparable measurement accuracy in either flow direction. The inertial force that results is proportional to the mass flow rate. Numerical calculation techniques utilizing the calculated base density of the gas are used to convert the measured mass flow rate into standard volumetric flow rate. At the date of publication of this report, the flowing density of a gas as indicated by a Coriolis meter is not of sufficient accuracy to be used to infer the flowing volume of gas and shall not be used for this purpose. Appendix C (Engineering Technical Note), Section 2.1, 3.2, and Appendix D of the Engineering Technical Note discusses in detail the conversion of mass flow rate to standard volume. For more information on the theory and physical dynamics that govern the operation of Coriolis meters, refer to Appendix C, Section 2.1.