AGA Report No. 3

ORIFICE METERING OF NATURAL GAS AND OTHER RELATED HYDROCARBON FLUIDS

PART 2

Specification and Installation Requirements

American Gas Association
400 North Capitol Street, N.W., 4th Floor
Washington, DC 20001
U.S.A.

Fourth Edition, April 2000
2nd Printing, June 2003

Catalog No. XQ0002

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.

This publication was developed 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 ordinances, and in regulations, administrative orders, or similar documents issued by public authorities. Those desiring permission for other publications should consult the Operations and Engineering Section, American Gas Association, 400 North Capitol Street, NW, 4th Floor, Washington, DC 20001, USA.

FOREWORD

AGA Report No. 3, *Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids,* consists of four parts. **This one is Part 2 – *Specification and Installation Requirements.*** Other parts are:

Part 1 – *General Equations and Uncertainty Guidelines*

Part 3 – *Natural Gas Applications*

Part 4 – *Background, Development, Implementation Procedure, and Subroutine Documentation for Empirical Flange-Tapped Discharge Coefficient Equation*

Each of the four parts is published separately to facilitate future changes, allow immediate use, and reduce the size of the applicable part needed by most users. Although for many applications each part can be used independently, users with natural gas applications are advised to obtain Parts 1, 3 and 4.

This report applies to fluids that, for all practical purposes, are considered to be clean, single phase, homogeneous, and Newtonian, measured using concentric, square-edged, flange-tapped orifice meters; and the Part 2 of the report furnishes specifications and installation requirements, and provides specifications for the construction and installation of orifice plates, meter tubes, and associated fittings. Users of pipe tap orifice meters are referred to AGA Report No. 3, Part 3, for specifications relevant to those meters.

This report has been developed through the cooperative efforts of many individuals from industry under the sponsorship of the American Gas Association, the American Petroleum Institute, and the Gas Processors Association, with contributions from the Gas Research Institute, the Chemical Manufacturers Association, the Canadian Gas Association, and the Commission of the European Communities, Norway, Japan, and others.

The methods and criteria used to analyze data applied for April 2000 revision are described in the relevant white papers and in the Gas Research Institute research reports (see references in Appendix 2-A)

Further revisions to this report may become necessary from time to time. Whenever any revisions are deemed advisable, recommendations should be forwarded to the Operations and Engineering Section, **American Gas Association**, 400 N. Capitol Street, NW, 4th Floor, Washington, DC 20001, U.S.A. A form is included for that purpose at the end of this report.

ACKNOWLEDGMENTS

Over the duration of the revision process, several individuals have devoted time and technical expertise, however, special acknowledgments are due to a small group of people who have played a vital role in the completion of the document. This group includes:

Mr. Ronald Beaty (Chairman), Premier Measurement Services, Houston, Texas, USA
Dr. Wojciech Studzinski, NOVA Research & Technology Centre, Calgary, Alberta, Canada
Dr. Tom Morrow, Southwest Research Institute, San Antonio, Texas, USA
Mr. Paul La Nasa, CPL & Associates, Houston, Texas, USA
Dr. Umesh Karnik, NOVA Research & Technology Centre, Calgary, Alberta, Canada
Dr. Zaki Husain, Texaco, Inc., Bellaire, Texas, USA
Mr. Klaus Zanker, Daniel Flow Products, Inc., Houston, Texas, USA
Mr. Jim Gallagher, Savant Measurement Corporation, Kingwood, Texas, USA
Mr. Dale Goodson, Daniel Flow Products, Inc., Houston, Texas, USA
Mr. Paul Johnson, Savant Measurement Corporation, Kingwood, Texas, USA
Mr. Fred Van Orsdol, Williams Energy Group, Tulsa, Oklahoma, USA and
Mr. Stephen Stark, Stark & Associates Inc., Tulsa, Oklahoma, USA

During much of the corresponding time period, a similar effort occurred in Europe. Valuable liaison between the two efforts was provided by Dr. Michael Reader-Harris, NEL, Glasgow, UK, Mr. Jan Bosio, K-Lab, Haugesund, Norway, Dr. Bob Peters, Daniel Industries, UK, Dr. Berndt Harbrink, Ruhrgas, Dorsten, Germany and Mr. Geoff Robson, British Standards Institution, London, UK.

This project was possible due to the support of the American Petroleum Institute, Gas Processors Association and American Gas Association. Special thanks to the Gas Research Institute and NOVA Gas Transmission for funding the data collection at the GRI-MRF at SwRI, Daniel Industries and the Didsbury Test Facility operated by NOVA Research and Technology Centre.

This standard has benefited from the contributions from several White Paper Writing Groups, task forces and the editing and comments of various individuals. A list (by no means complete) of the individuals who participated in the revision process is listed below.

Mr. Ron Beaty, Premier Measurement Services, Houston, Texas, USA
Mr. Manny Garcia, American Petroleum Institute, Washington, D.C., USA
Mr. Brent Berry, Applied Automation Inc., Bartlesville, Oklahoma, USA
Mr. James Bowen, Instromet, Inc., Houston, Texas, USA
Mr. R. G. Brunner, Gas Processors Association, Tulsa, Oklahoma, USA
Ms. Sharon Buffington, Minerals Management, Herndon, Virginia, USA
Mr. Stan Canfield, Dynegy Midstream Services, L.P., Tulsa, Oklahoma, USA
Mr. David Crane, Crane Manufacturing, Inc., Tulsa, Oklahoma, USA
Mr. Ronald Dunegan, Perry Equipment Corp., Mineral Wells, Texas, USA
Mr. Wayne Fling, Jr., Flow Metrology, Tulsa, Oklahoma, USA
Mr. Chuck French, Gas Research Institute, Chicago, Illinois, USA
Mr. Steve Gage, Arkansas Wester Gas Company, Ozark, Arizona, USA
Mr. Jim Gallagher, Savant Measurement Corporation, Kingwood, Texas, USA
Mr. Dale Goodson, Daniel Flow Products, Inc., Houston, Texas, USA
Mr. John Gregor, AMETEK, Largo, Florida, USA
Mr. Ed Hickl, Union Carbide Corp., Houston, Texas, USA
Mr. Jim Hollingsworth, Shell Oil Products Co., Houston, Texas, USA
Dr. Zaki Husain, Texaco, Inc., Bellaire, Texas, USA
Dr. Emrys Jones, Chevron Petroleum Tech. Co., La Habra, California, USA
Dr. Umesh Karnik, NOVA Research & Technology Centre, Calgary, Alberta, Canada
Mr. Paul LaNasa, CPL & Associates, Houston, Texas, USA
Mr. Joe Landes, SPL, Houston, Texas, USA

Dr. George Mattingly, National Institute of Standards and Technology, Gaithersburg, USA
Mr. Günter Maurer, Barton Instrument Systems, City of Industry, California, USA
Mr. Kevin Moir, Michigan Consolidated Gas Company, Detroit, Michigan, USA
Mr. Don Morley, CIG Exploration, Inc., Houston, Texas, USA
Dr. Gerald Morrison, Texas A & M University, College Station, Texas, USA
Dr. Tom Morrow, Southwest Research Institute, San Antonio, Texas, USA
Mr. Henry Poelnitz, Southern Natural Gas Co., Birmingham, Alabama, USA
Mr. King Poon, GH Flow Automation, Houston, Texas, USA
Mr. Ali Quraishi, American Gas Association, Washington, D.C., USA
Mr. Rick Rans, Trans Canada Pipelines Ltd., Calgary, Alberta, Canada
Mr. Robert Rayburn, Texas Gas, Lafayette, Louisiana, USA
Mr. Bill Ryan, El Paso Natural Gas Co., Midland, Texas, USA
Mr. Lee Smith, Micro Motion, Boulder, Colorado, USA
Mr. Steve Stark, Stark & Associates Inc., Tulsa, Oklahoma, USA
Mr. Jean Stolz, Consultant, Marly, France
Mr. John Stuart, Pacific Gas and Electric Co., Walnut Creek, California, USA
Dr. Wojciech Studzinski, NOVA research & Technology Centre, Calgary, Alberta, Canada
Late Dr. Ray Teyssandier, Texaco, Inc., Bellaire, Texas, USA
Mr. Fred Van Orsdol, Williams Energy Group, Tulsa, Oklahoma, USA
Dr. Noriyuki Watanabe, Weights and Measures Training Institute, Tokyo, Japan
Mr. Wayne Wenger, Natural Gas Pipeline Co. of America, Joliet, Illinois, USA
Ms. Jane Williams, Oryx Energy Co., Dallas, Texas, USA
Mr. Rusty Woomer, Tennessee Gas Pipeline Co., Houston, Texas, USA
Mr. Harry Bean, Consultant, El Paso, Texas, USA
Mr. Jan Bosio, STATOIL, Haugesund, Norway
Mr. Steve Caldwell, CEESI, Nunn, Colorado, USA
Mr. Richard Estabrook, Bureau of Land Management, Ukiah, California, USA
Mr. Lee Hillburn, Turnbow Engineering, Bartlesville, Oklahoma, USA
Mr. Doug Morris, American Petroleum Institute, Washington, D.C., USA
Mr. Dan Acosta, Perry Equipment Corporation, Mineral Well, Texas, USA
Mr. Randy Austerman, Phillips Petroleum Co., Bartlesville, Oklahoma, USA
Mr. Ed Bowles, Southwest Research Institute, San Antonio, Texas, USA
Mr. Michael Cushing, Honeywell IAC, Fort Washington, Pennsylvania, USA
Mr. Robert Deboom, Micro Motion, Inc., Boulder, Colorado, USA
Mr. Terry Doucet, Ing, Foxboro Canada Inc., Dollard-des-Ormeaux, Quebec, Canada
Mr. R. D. Jones, Chevron USA Production Co., Lafayette, Louisiana, USA
Mr. Jim Keating, Duke Energy, Houston, Texas, USA
Mr. Eric Kelner, Southwest Research Institute, San Antonio, Texas, USA
Mr. Gil Kraemer, Precision Combustion, Inc., New Haven, Connecticut, USA
Ms. Angie Law, Kelly Instrument Machine, Inc., Texarkana, Texas, USA
Mr. Rick Ledesma, ANR Pipeline Co., Bourbonnais, Illinois, USA
Mr. Charles McNamara, Flow Measurement Co., Inc., Tulsa, Oklahoma, US
Mr. Leonard Meaux, Mobil Oil, The Woodlands, Texas, USA
Mr. James Milling, Control-Soft Enterprises, Katy, Texas, USA
Mr. Greg Milster, Thurmond-McGlothlin Co., Inc., Owasso, Oklahoma, USA
Mr. John Naber, Daniel Industries, Inc., Houston, Texas, USA
Mr. Warren Peterson, Kenonic Controls, Calgary, Canada.
Mr. John Phipps, Institute of Petroleum, London, England
Mr. John Roussel, Texaco Natural Gas, St. Rose, Louisiana, USA
Mr. Irvin Schwartzenburg, Fisher Controls, FAS Group, Marshalltown, Iowa
Mr. Steve Scott, Scott Equipment Co., Wheatridge, Colorado, USA
Mr. Walt Seidl, CEESI, Nunn, Colorado, USA
Mr. Pat Skweres, Dow Chemical Company, Freeport Texas, USA
Mr. Jerry Paul Smith, Williams Gas Pipeline—Transco, Houston, Texas, USA

Dr. Frank Ting, Chevron Petroleum Tech. Co., La Habra, California, USA
Ms. Lori. Traweek, American Gas Association, Washington, D.C., USA
Mr. Eric Ward, BP Exploration (Alaska) Inc., Anchorage, Alaska, USA
Mr. James N. Witte, Tennessee Gas Pipeline Company, Houston, Texas, USA
Mr. Ian Wood, Halliburton (U.K.) Ltd., Dyce, Aberdeen, Scotland
Mr. James P. Avioli, Williams Gas Pipeline—Transco, Houston, Texas, USA
Mr. Frank Brown, CMS Energy Corporation, Houston, Texas, USA
Mr. Jeryl M. Mohn, CMS Energy Corporation, Houston, Texas, USA
Mr. William R. Mazotti, Pacific Gas and Electric Company, San Francisco, California, USA
Mr. Daniel G. Harris, Columbia Gas Transmission, Charleston, West Virginia, USA
Mr. Jeffrey M. Dowdell, CNG Transmission Corporation, Clarksburg, West Virginia, USA
Mr. Robert D. MacLean, ANR Pipeline Company, Detroit, Michigan, USA
Mr. Michael T. Brown, TransCanada Transmission, Calgary, Alberta, Canada
Ms. Claire L. Becker-Castle, Southern California Gas Company, Los Angeles, California, USA
Mr. Donal H. Tucker, TXU Electric and Gas, Dallas Texas, USA
Mr. John A. Vassaux, Columbia Gas of Ohio, Inc., Columbus, Ohio, USA
Mr. Dannie R. Mercer, TXU Pipeline Services, Dallas, Texas, USA

CONTENTS

CONTENTS

PART 2—SPECIFICATION AND INSTALLATION REQUIREMENTS

2.1 Construction and Installation Requirements

This document outlines the various design parameters that must be considered when designing metering facilities using orifice meters. The mechanical tolerances found in this document encompass a wide range of orifice diameter ratios for which experimental results are available. In several sections of this document, tolerances for the mechanical specifications have been changed relative to previous editions. In particular, this revision includes a change to the installation requirements (meter tube lengths). This change reduces the uncertainty attributable to installation effects to a magnitude smaller than the uncertainty of the database supporting the Reader-Harris/Gallagher (RG) equation and, therefore, should not affect the uncertainty previously defined for that equation.

This document does not require upgrading existing installations. If the meter installations are not upgraded to meet this current standard, however, measurement bias errors may exist due to inadequate flow conditioning and upstream straight pipe lengths. The decision to upgrade an existing installation shall be at the discretion of the parties involved.

Use of the calculation procedures and techniques shown in the AGA Report No.3, Parts 1 and 3, with existing equipment is recommended, since these represent significant improvements over the previous methods. However, the uncertainty levels for flow measurement using existing equipment may be different from those quoted in Part 1.

Use of orifice meters at the extremes of their diameter ratio (β_r) ranges should be avoided whenever possible. Good metering design and practice tend to be somewhat conservative. This means that the use of the tightest tolerances in the mid-diameter ratio (β_r) ranges would have the highest probability of producing the best measurement. An indication of this is found in the section on uncertainty in Part 1.

This standard is based on β_r between 0.10 and 0.75. Minimum uncertainty of the orifice plate coefficient of discharge (C_d) is achieved with β_r between 0.2 and 0.6 and orifice bore diameters greater than or equal to 0.45 inch. Diameter ratios and orifice bore diameters outside of this range may be used; however, the user should consult the uncertainty section in Part 1 for limitations.

Achieving the best level of measurement uncertainty begins with, but is not limited to, proper design. Two other aspects of the measurement process must accompany the design effort; otherwise it is of little value. These aspects are the application of the metering system and the maintenance of the meters, neither of which is considered directly in this standard. These aspects cannot be governed by a single standard as they cover metering applications that can differ widely in flow rate, fluid type, and operational requirements. Therefore, the user must determine the best meter selection for the application and the level of maintenance for the measurement system under consideration.

2.2 Symbols/Nomenclature

This standard reflects orifice meter application to fluid flow measurement with symbols in general technical use.

Symbol	Represented Quantity
a	Speed of sound
Cd	Orifice plate coefficient of discharge
Cd(*FT*)	Flange tap orifice plate coefficient of discharge
□*Cd*(*FT*)/*Cd*	Percent difference between baseline *Cd* and installation effect *Cd*
d	Orifice plate bore diameter calculated at flowing temperature, *Tf*
dm	Orifice plate bore diameter measured at temperature, *Tm*
dr	Orifice plate bore diameter calculated at reference temperature, *Tr*
D	Meter tube internal diameter calculated at flowing temperature, *Tf*
Di	Published meter tube internal pipe diameter
DL	Meter tube length downstream of orifice plate in multiples of published internal pipe diameters (see Figure 2-6)
Dm	Meter tube internal diameter measured at *Tm*
Dn	Nominal pipe diameter