
# AGA Report No. 3

# ORIFICE METERING OF NATURAL GAS AND OTHER RELATED HYDROCARBON FLUIDS

## PART 1

## General Equations and Uncertainty Guidelines



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

**Third Edition, October 1990**
**2nd Printing, June 2003**

**Catalog No. XQ9017**

# 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 1 – *General Equations and Uncertainty Guidelines.*** Other parts are:

Part 2 – *Specification and Installation Requirements*

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 should obtain Parts 2, 3 and 4 before implementing Part 1.

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 1 of the report provides equations for computing the flow through orifice meters and offers guidelines for uncertainty determination. Users of pipe tap orifice meters are referred to AGA Report No. 3, Part 3, for some equations and guidelines 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 Chemical Manufacturers Association, the Canadian Gas Association, the European Community, Norway, Japan and others.

It may become necessary to make revisions to this document in the future. Whenever any revisions are 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 has been included at the end of this report for that purpose.

# ACKNOWLEDGMENTS

From the initial data-collection phase through the final publication of this revision of the AGA Report No. 3, *Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids,* many individuals have devoted time and technical expertise. However, a small group of individuals has been very active for much of the project life. This group includes the following people:

H. Bean, EL Paso Natural Gas Company (Retired)
R. Beaty, Amoco Production Company, *Committee Chairman*
D. Bell, NOVA Corporation
T. Coker, Phillips Petroleum Company
W. Fling, OXY USA Inc. (Retired), *Project Manager*
J. Gallagher, Shell Pipe Line Corporation
L. Hillburn, Phillips Petroleum Company (Retired)
P. Hoglund, Washington Natural Gas Company (Retired)
P. LaNasa, CPL & Associates
G. Less, Natural Gas Pipeline Company of America (Retired)
J. Messmer, Chevron U.S.A. Inc. (Retired)
R. Teyssandier, Texaco Inc.
E. Upp
K. West, Mobil Research and Development Corporation

During much of the corresponding time period, a similar effort occurred in Europe. The following individuals provided valuable liaison between the two efforts:

D. Gould, Commission of the European Communities
F. Kinghorn, National Engineering Laboratory
M. Reader-Harris, National Engineering Laboratory
J. Sattary, National Engineering Laboratory
E. Spencer, Consultant
J. Stolz, Consultant
P. van der Kam, Gasunie

The American Petroleum Institute provided most of the funding for the research project. Additional support was provided by the American Gas Association and the Gas Processors Association. Special thanks is given to the Gas Research Institute and K. Kothari for providing funding and manpower for the natural gas calculations used in this project and to the National Institute of Standards and Technology in Boulder, Colorado, for additional flow work.

J. Whetstone and J. Brennan were responsible for the collection of water data at the National Institute of Standards and Technology in Gaithersburg, Maryland. C. Britton, S. Caldwell, and W. Seidl of the Colorado Engineering Experiment Station Inc., were responsible for the oil data. G. Less, J. Brennan, J. Ely, C. Sindt, K. Starling, and R. Ellington were responsible for the Natural Gas Pipeline of America test data on natural gas.

Over the years many individuals have been a part of the Chapter 14.3 Working Group and its many task forces. The list below is the roster of the working group and its task forces at the time of publication but is by no means a complete list of the individuals who participated in the development of this document.

R. Adamski, Exxon Chemical Americas – BOP
R. Bass
M. Bayliss, Occidental Petroleum (Caledonia) Ltd.
R. Beaty, Amoco Production Company
D. Bell, NOVA Company
B. Berry
J. Bosio, Statoil

J. Brennan, National Institute of Standards and Technology
E. Buxton
S. Caldwell
R. Chittim, American Petroleum Institute
T. Coker, Phillips Petroleum Company
H. Colvard, Exxon Company, U.S.A.
L. Datta-Barua, United Gas Pipeline Company
D. Embry, Phillips Petroleum Company
W. Fling
J. Gallagher, Shell Pipe Line Corporation
V. Gebben, Kerr-McGee Corporation
B. George, Amoco Production Company
G. Givens, CNG Transmission Corporation
T. Glazebrook, Tenneco Gas Transportation Company
D. Goedde, Texas Gas Transmission Corporation
D. Gould, Commission of the European Communities
K. Gray, Phillips Petroleum Company
R. Hankinson, Phillips 66 Natural Gas Company
R. Haworth
E. Hickl, Union Carbide Corporation
L. Hillburn
P. Hoglund, Washington Natural Gas Company
J. Hord, National Institute of Standards and Technology
E. Jones, Jr., Chevron Oil Field Research Company
M. Keady
K. Kothari, Gas Research Institute
P. LaNasa
G. Less
G. Lynn, Oklahoma Natural Gas Company
R. Maddox
G. Mattingly, National Institute of Standards and Technology
B. McConaghy, NOVA Corporation
C. Mentz
L. Norris, Exxon Production Research Company
K. Olson, Chemical Manufacturers Association
A. Raether, Gas Company of New Mexico
E. Raper, OXY USA, Inc.
W. Ryan, El Paso Natural Gas Company
R. Segers
J. Sheffield
S. Stark, Williams Natural Gas Company
K. Starling
J. Stolz
J. Stuart, Pacific Gas and Electric Company
W. Studzinski, NOVA/Husky Research Company
M. Sutton, Gas Processors Association
R. Teyssandier, Texaco Inc.
V. Ting, Chevron Oil Field Research Company
L. Traweek, American Gas Association
E. Upp
F. Van Orsdol, Chevron U.S.A. Inc.
N. Watanabe, National Research Laboratory of Metrology, Japan
K. West, Mobil Research and Development Corporation
P. Wilcox, Total of France

J. Williams, Oryx Energy Company
M. Williams, Amoco Production Company
E. Woomer, United Gas Pipeline Company
C. Worrell, OXY USA, Inc.

# CONTENTS

# PART 1 –GENERAL EQUATIONS AND UNCERTAINTY GUIDELINES

## 1.1 Introduction

### 1.1.1 SCOPE

This standard provides a single reference for engineering equations, uncertainty estimations, construction and installation requirements, and standardized implementation recommendations for the calculation of flow rate through concentric, square-edged, flange-tapped orifice meters. U.S. customary [Inch-Pound (IP)] and International System of Units (SI) are included.

### 1.1.2 ORGANIZATION OF STANDARD

The standard is organized into four parts. Parts 1, 2, and 4 apply to the measurement of any Newtonian fluid in the petroleum and chemical industries. Part 3 focuses on the application of Parts 1, 2, and 4 to the measurement of natural gas.

#### 1.1.2.1 Part 1 – General Equations and Uncertainty Guidelines

The mass flow rate and base (or standard) volumetric flow rate equations are discussed, along with the terms required for solution of the flow equation.

The empirical equations for the coefficient of discharge and expansion factor are presented. However, the bases for the empirical equations are contained in other sections of this standard or the appropriate reference document.

For the proper use of this standard, a discussion is presented on the prediction (or determination) of the fluid's properties at flowing conditions. The fluid's physical properties shall be determined by direct measurements, appropriate technical standards, or equations of state.

Uncertainty guidelines are presented for determining the possible error associated with the use of this standard for any fluid application. User-defined uncertainties for the fluid's physical properties and auxiliary (secondary) devices are required to solve the practical working formula for the estimated uncertainty.

#### 1.1.2.2 Part 2 – Specification and Installation Requirements

Specifications are presented for orifice meters, in particular, orifice plates, orifice plate holders, sensing taps, meter tubes, and flow conditioners.

Installation requirements for orifice plates, meter tubes, thermometer wells, flow conditioners, and upstream/downstream meter tube lengths are presented.

#### 1.1.2.3 Part 3 – Natural Gas Applications

The application of this standard to natural gas is presented, along with practical guidelines. Mass flow rate and base (or standard) volumetric flow rate methods are presented in conformance with North American industry practices.