# Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids—Concentric, Square-edged Orifice Meters

## Part 1: General Equations and Uncertainty Guidelines

American Gas Association

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## 1 Introduction

### 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. Both U.S. customary (USC), and international system of units (SI) units are included.

### 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.

#### 1.2.1 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 basis for the empirical equations are contained in other sections of this standard or the appropriate reference document.

In several sections of this revision of Part 1, identified errata have been changed relative to previous editions. In addition, this revision includes a change to the empirical expansion factor ($Y$) calculation for the flange-tapped orifice meters.

For all existing installations, the decision as to which expansion factor equation to use shall be at the discretion of the parties involved. However, the parties should be cognizant of the following:

1) If the calculated difference between previous revision (1990) Buckingham and Bean expansion factor equation (Annex C or API *MPMS* Ch. 14.3.3/AGA Report No. 3, Part 3, Annex G) and the new revised expansion factor equation is less than or equal to 0.25 %, then the expansion factor values produced by either expansion factor equation will be within the uncertainty of the new expansion factor database and the existence of any flow bias will be uncertain.

2) However, if the calculated difference between expansion factor equations exceeds 0.25 %, then a variable flow bias, which is a function of diameter ratio ($\beta$), isentropic exponent ($\kappa$), and $\Delta P/P_{f_1}$ ratio ($x_1$), will be experienced unless the new expansion factor equation is utilized.

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.

#### 1.2.2 Part 2—Specifications 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.

#### 1.2.3 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.

#### 1.2.4 Part 4—Background, Development, and Implementation Procedure and Subroutine Documentation

The coefficient of discharge database for flange-tapped orifice meters and its background, development, and limitations are presented.

Implementation procedures for flange-tapped orifice meters are presented, along with a set of example calculations. The examples are designed to aid in checkout procedures for any routines that are developed using the implementation procedures.

## 2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API *MPMS* Ch. 12.2.1, *Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors,* Part 1—*Introduction*

API *MPMS* Ch. 14.3.2/AGA Report No. 3, Part 2/GPA 8185, Part 2, *Concentric, Square-Edged Orifice Meters,* Part 2—*Specification and Installation Requirements* (2000 edition)

API *MPMS* Ch. 14.3.3/AGA Report No. 3, Part 3, *Concentric, Square-Edged Orifice Meters,* Part 3—*Natural Gas Applications*

API *MPMS* Ch. 14.3.4/AGA Report No. 3, Part 4, *Concentric, Square-Edged Orifice Meters,* Part 4—*Background, Development, Implementation Procedures and Subroutine Documentation*

API *MPMS* Ch. 14.6, *Continuous Density Measurement*

API *Technical Data Book—Petroleum Refining*

AGA Report No. 8 [1], *Compressibility Factors of Natural Gas and Other Related Hydrocarbon Gases*

[1] American Gas Association, 400 N. Capitol St., NW, Suite 450, Washington, DC 20001, www.aga.org.