

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

Part 2: Specification and Installation Requirements



American Gas Association

AGA Report No. 3
Part 2



AMERICAN PETROLEUM INSTITUTE

Manual of Petroleum
Measurement Standards
Chapter 14.3.2

American Gas Association
400 North Capitol Street, NW
Washington, DC 20001

American Petroleum Institute
1220 L Street, NW
Washington, DC 20005

FIFTH EDITION, MARCH 2016

An American National Standard

ANSI/API MPMS Ch. 14.3.2/AGA Report No. 3, Part 2

ERRATA 2, JANUARY 2019

ERRATA 1, MARCH 2017

Special Notes

This AGA/API publication necessarily addresses problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither AGA and API nor any of AGA's or API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither AGA and API nor any of AGA's or API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

Users of this publication should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

This AGA/API publication may be used by anyone desiring to do so. Every effort has been made by AGA/API to assure the accuracy and reliability of the data contained in it; however, AGA/API 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 for the violation of any authorities having jurisdiction with which this publication may conflict.

This AGA/API publication is published to facilitate the broad availability of proven, sound engineering and operating practices. It is not intended to obviate the need for applying sound engineering judgment regarding when and where this publication should be utilized. The formulation and publication of this AGA/API publication is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from either the American Gas Association, 400 N. Capitol St., NW, Washington, DC 20001 or API Publishing Services, 1220 L Street, NW, Washington, DC 20005.

Date of Issue: January 2019

Affected Publication: API Manual of Petroleum Measurement Standards, Chapter 14.3.2, *Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids—Concentric, Square-edged Orifice Meters—Part 2: Specification and Installation Requirements*, Fifth Edition

Errata 2

Page 32, Section 6.5:

The equation (in SI units) should read:

$$L = \left(\frac{F_m \times 4.38 \times OD \times 10}{S \times V} \sqrt{\frac{E}{\rho} (OD^2 + ID^2)} \right)^{\frac{1}{2}}$$

where

L is the probe length (mm);

F_m is the virtual mass factor—a constant to take account of the extra mass of the cylinder due to the fluid surrounding it and vibrating with it. For a gas, $F_m = 1.0$ and for water and other liquids, $F_m = 0.9$;

OD is the outside diameter of probe (mm);

ID is the **inside** diameter of probe (mm);

S is the Strouhal number, dependent on the Reynolds No. and shape of the cylinder, but can be taken as 0.4 for worst case or 0.2 as suggested by API MPMS Ch. 8.

V is the velocity of fluid (m/sec);

E is the modulus of elasticity of probe material (kg/cm²);

ρ is the density of probe material (kg/m³).

The equation (in USC units) should read:

$$L = \left(\frac{F_m \times 1.205 \times OD}{S \times V} \sqrt{\frac{E}{\rho} (OD^2 + ID^2)} \right)^{\frac{1}{2}}$$

where

- L is the probe length (inches);
- F_m is the virtual mass factor—a constant to take account of the extra mass of the cylinder due to the fluid surrounding it and vibrating with it. For a gas, $F_m = 1.0$ and for water and other liquids, $F_m = 0.9$;
- OD is the outside diameter of probe (inches);
- ID is the **inside** diameter of probe (inches);
- S is the Strouhal number, dependent on the Reynolds No. and shape of the cylinder, but can be taken as 0.4 for worst case or 0.2 as suggested by API *MPMS* Ch. 8.
- V is the velocity of fluid (ft/sec);
- E is the modulus of elasticity of probe material (psi);
- ρ is the density of probe material (g/cc).

Foreword

Nothing contained in this AGA/API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as API *Manual of Petroleum Measurement Standard (MPMS)* Chapter 14.3.1 and AGA Report No. 3, Part 1. Questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005. Questions concerning the interpretation of the content of this publication should be directed to the Director of Standards, American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005 and to the Vice President, Operations and Engineering, American Gas Association, 400 N. Capitol Street, NW, Washington, DC 20001, and shall be handled in accordance with API's *Procedures for Standards Development*. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the Director of Standards, American Petroleum Institute (as above) or the Vice President, Operations and Engineering, American Gas Association (as above).

This AGA/API publication is reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 1220 L Street, NW, Washington, DC 20005.

A catalog of AGA Operations and Engineering publications, which is published and updated as needed and can be obtained by contacting AGA Operations and Engineering Department, phone (202) 824-7000 or web site <http://www.aga.org/knowledgecenter>.

Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org or Operations and Engineering Department, American Gas Association, 400 North Capitol Street, NW, Washington, DC 20001, <http://www.aga.org/knowledgecenter>.

Contents

	Page
1 Scope	1
1.1 General	1
1.2 Construction and Installation Requirements	1
2 Normative References	1
3 Terms, Definitions, and Symbols	2
3.1 Definitions	2
3.2 Symbols/Nomenclature	4
4 Orifice Plate Specifications	6
4.1 General	6
4.2 Orifice Plate Faces	6
4.3 Orifice Plate Bore Edge	8
4.4 Orifice Plate Bore Diameter (d_m, d_t) and Roundness	8
4.5 Orifice Plate Bore Thickness (e)	10
4.6 Orifice Plate Thickness (E)	10
4.7 Orifice Plate Bevel (θ)	13
5 Meter Tube Specifications	13
5.1 Description	13
5.2 Orifice Plate Holders	17
5.3 Orifice Fittings Considerations	18
5.4 Pressure Taps	19
5.5 Flow Conditioners	21
6 Installation Requirements	23
6.1 General	23
6.2 Orifice Plate	23
6.3 Meter Tube	31
6.4 Acceptable Pulsation Environment	31
6.5 Thermometer Wells	32
6.6 Insulation	33
Annex A (informative) Research Projects and Tests Conducted Between 1922 and 1999	34
Annex B (informative) Orifice Meter Inspection Guidelines	53
Annex C (normative) Specific Installation Calibration Test	57
Annex D (normative) Flow Conditioner Performance Test	59
Annex E (normative) Maximum Allowable Orifice Plate Differential Pressure	63
Figures	
1 Symbols for Orifice Plate Dimensions	6
2a Orifice Plate Departure from Flatness (Measured at Edge of Orifice Bore and Within Inside Pipe Diameter)	7
2b Alternative Method for Determination of Orifice Plate Departure from Flatness (Departure from Flatness = $h_2 - h_1$)	7

Contents

Page

2c	Maximum Orifice Plate Departure from Flatness	7
3	Allowable Variations in Pressure Tap Hole Location.....	19
4	1998 Uniform Concentric 19-Tube Bundle Flow Straightener	22
5	Eccentricity Measurements (Sample Method).....	24
6	Orifice Meter Tube Layout for Flanged or Welded Inlet.....	27

Tables

1	Roundness Tolerance for Orifice Plate Bore Diameter, d_m	9
2	Linear Coefficient of Thermal Expansion	9
3	Orifice Plate Thickness and Maximum Allowable Differential Pressure Based on the Structural Limit	11
4	Example Meter Tube Internal Diameter—Roundness Tolerances Within First Mean Meter Tube Diameter Upstream of Orifice Plate	16
5	Example Meter Tube Internal Diameter Roundness Tolerances—All Upstream Meter Tube Individual Internal Diameter Measurements	17
6	Maximum Tolerance of Orifice Plate Bore Eccentricity (ϵ_x)	25
7	Orifice Meter Installation Requirements Without a Flow Conditioner	28
8a	Orifice Meter Installation Requirements With 1998 Uniform Concentric 19-Tube Bundle Flow Straightener for Meter Tube Upstream Length of $17D_i \leq UL < 29D_i$	29
8b	Orifice Meter Installation Requirements With 1998 Uniform Concentric 19-Tube Bundle Flow Straightener for Meter Tube Upstream Length of $UL \geq 29D_i$	30
E-1	Maximum Allowable Calculated Differential Pressure Across 304/316SS Orifice Plate at 150 °F	64

Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids— Concentric, Square-edged Orifice Meters Part 2: Specification and Installation Requirements

1 Scope

1.1 General

This document establishes design and installation parameters for measurement of fluid flow using concentric, square-edged, flanged tapped orifice meters.

1.2 Construction and Installation Requirements

This document outlines the various design parameters that shall 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.

For all existing installations, the decision to upgrade to meet the requirements of this standard shall be at the discretion of the parties involved. The parties should be cognizant that if a meter installation is not upgraded to meet this standard, measurement bias errors may exist due to inadequate flow conditioning and upstream straight pipe lengths.

Use of the calculation procedures and techniques shown in the API *MPMS* Ch.14.3.1/AGA Report No. 3, Part 1 and API *MPMS* Ch.14.3.3/AGA Report No. 3, Part 3, with existing equipment is recommended, since these represent significant improvements over the previous methods. The uncertainty levels for flow measurement using existing equipment may be different from those quoted in API *MPMS* Chapter 14.3.1/AGA Report No. 3, 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 API *MPMS* Chapter 14.3.1/AGA Report No. 3, 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; the user should consult the uncertainty section in API *MPMS* Chapter 14.3.1/AGA Report No. 3, 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 have to 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. The user shall determine the best meter selection for the application and the level of maintenance for the measurement system under consideration.

2 Normative References

No other document is identified as indispensable or required for the application of this standard.